

# Semantics Driven Development of Enterprise Software Based on Ontologies

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The National Institute of Advanced Industrial Science and Technology, in cooperation with Keio University, have been trying not only to enact various standards for towing the realization of e-government, but also to examine simultaneously utilization of the latest research result. This paper reports practice of a project focusing on the technologies of ontologies and software framework.

## 1. Introduction

Recently, various policy packages, including e-Japan and u-Japan, have been enacted and carried out in the area of information technology (IT). On the other hand, the essential scheme as a grand design has not been established to keep information security and system interoperation for the development of enterprise information systems about e-government. Therefore, the total optimal architecture, which includes a design, construction and management of information system, is required.

As technical issues which cause the situation, rapid shift of development environment has been pointed out. In other words, neither description framework nor development methodology has been caught up to today's enterprise software technologies of Web application based on the object-oriented technology.

The main factor of the above issues can be summarized that the discontinuity of technical components and information systems causes imbalance of framework and scale of software systems [2].

In order to tackle the gap between research and development, the National Institute of Advanced Industrial Science and Technology (AIST) has been trying to capture the two aspect of the research, named "Full Research". As the context of the Full Research, we have been paying attention to ontologies and the semantic Web technologies in the projects of the development of AIST intranet system. One of the goals of the project is to establish the standards for public procurement of information systems in cooperation with Keio University. Our standardization covers not only the framework of software architecture but also description framework and software processes. We are also working for the aim at technology transfer of these standards to local governments.

This paper describes our software framework and standards based on ontologies and the semantic Web technologies, followed by our project report of the large-scale enterprise software development focused on AIST intranet system development.

## 2. Approaches to Public Business Process and Its Management

### 2.1 Issues about Management of Public Business Process

In order to drive out costs or innovate in changing business environment, business process optimization is considered as central topic. However traditional IT development approaches and solutions have historically restricted organizations ability to change.

In order to provide organizations with a systematic approach to aligning software technologies (especially Web based application technologies) with business process and enterprise modeling, Enterprise Architecture (EA) has been proposed which support the top-down design of enterprise applications [3]. EA enables organizations to implement enterprise software identified with a comprehensive approach to management and development of IT environments. EA provides a lot of commercial product about enterprise system development.

By focusing public business process such as governments and local government, BPM framework and EA related products do not work completely. Since public processes are defined by law, we can not manage a work process according to frequency and coverage of workers' activities.

### 2.2 Issues about Web based Business Applications

Besides the peculiarity of public business process, the shift about business application implementation causes the gap between business process and enterprise information systems from server-client architecture to object-oriented technology based Web application. This rapid shift makes us hard to update description framework and development methodology to today's technologies.

As the above result, two main gaps between technologies and their use has been made: (a) development standards and software process and (b) the semantic Web technologies and their enterprise use. The following subsection describes the details of the above gaps.

### 2.3 Requirements of Development Standards and Process for Specification

One of the most major factors, which deviates business process and enterprise software, is lack of common framework shared by users and developers. Even the most common description based UML is difficult for users to understand as the semantics of business process on a work flow level. UML based framework enables us to describe development specification. Unfortunately, the specified description of UML is not very familiar for users to express work process but extremely precise for developers.

In fact, when describing what to develop as business application, a developer tends not to focus how to process business but to how to implement application environment such as user interface, database systems, networking function, and so on. In other words, most requirement specifications do not describe what sort of business process but what sort of computing environment.

In order to describe business process as requirement specification of information system development, we have to control requirements by taxonomies which are familiar to business experts. Therefore content description framework for business process is required.

### 2.4 Required Feature of Enterprise Semantic Web and Web Services

BPEL based script of Web services focuses on automated execution of services provided on soap protocols. When we execute work flow application, Web services framework is not enough since we have to collaborate with other work processes of different workers.

On the other hand, current technologies and standards of the semantics Web and the semantic Web services, requirements of user interface are not focused as important factors though there are a small number of works about the semantic Web browser. It is because a concept of the semantic Web is based on the Web for agents devised as machine processing method.

At the same time, the latest topic of the semantic Web services pay attention to search and loose

composition of services although service execution is not cared very much.

As to summarize the above, it is important for enterprise use to control an execution of work process through interaction with business applications.

### 2.5 Content Oriented Approach Based on Ontologies

As the same approach of other projects of the semantic Web, we employ ontologies as the key technology to deal with some semantics of enterprise software. In fact, ontology is not used as the top-down semantics for the meta data but the bottom-up construction for organized semantics of contents.

In order to realize the above approach, we provide a model as semantics of a document by constructing primitives of domain ontology [1]. As is the same way, a process model, which corresponds to workflow and Web page action, is given by task ontology.

## 3. AIST Framework of Enterprise Software Development

### 3.1 Technical Features of Software Framework

In order to support a system development, we standardize a software framework as a development environment of software platform. The software framework is combined by open-source based Java native framework as shown in Figure 1.

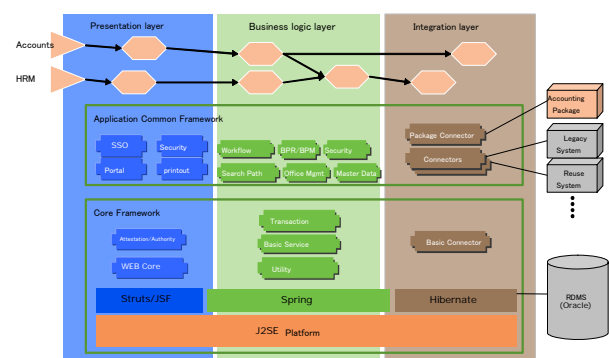


Figure1. Structure of AIST Software Framework

As is a common software framework like J2EE, our software frame work is based on three tiers architecture of presentation, business logic and integration layers. In contrast to J2EE, EJB (enterprise Java bean) is not employed but spring frame work is in order to perform unit test of correspondence between a software module and a semantic primitive. On the integration layer, hibernate framework is selected in order to keep independent from PL/SQL framework.

The combination of three tiers of struts, spring and hibernate framework is realized as a core framework

which restricts a development style of the upper framework. On the top of the core framework, the application common framework is provided which constitutes the public software modules in each layer: SSO (single sign on), security module and portals in the presentation layer, workflow engines and business process modules in the business logic layer and connectors to package software and Web services in the integration layer.

In order to perform unit test of primitive modules, the above framework is provided by DI (dependency injection) container technologies and POJO (plain old java object). This structure enables us to keep the software framework independent from a specific framework and to support native execution of Java objects. By clarifying the correspondence between ontology based semantics and Java objects, page action embedded in a Web page can be tested in terms of the semantics of Web application based business process.

### 3.2 Semantic Driven Development Based on Ontologies

In order to organize the primitive software modules to a business application, we employ FDD (feature driven development) as the basic methodology of development process. In FDD, a software module of development unit is given as a feature which provides the semantics primitives of use case description for requirement specification and the management primitives of WBS (work breakdown scheme) for the project management.

By keeping the correspondence between software modules and Web page actions based on ontologies, ontologies provide us the method of the design and constitution of features. As a result of introducing ontology based FDD, semantic specification drives the software development which we call semantic driven development.

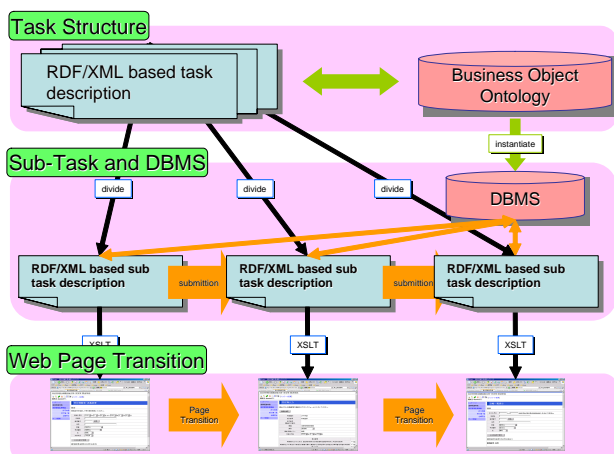


Figure2. Task Decomposition Framework for Web Application and Page Transition

In order to perform semantic decomposition of features for business application development, ontology based task description and domain structure is devised as shown in Figure 2.

Task structure is described by RDF/XML based on the combination of the domain ontology primitives. By corresponding domain ontology and DBMS primitive types, the task description is divided into sub-tasks of RDF/XML. XSLT enables us to transform each sub-task description of RDF/XML into a Web page.

At the same time, workflow as a part of business process is simply expressed as transition of Web pages. Furthermore, by reflecting between Java objects and RDF/XML based set of properties, the semantics of features is formalized by ontologies and embedded in a Web page.

### 3.3 Development standards and development process

In order to keep a quality of business application development based on AIST software framework, we provide development standards constituting various policies of design and coding. For the software quality, it is important to review the output of the development process and to test the corresponding software module.

In fact, it is difficult to expect an effect of development standards. At the same time, in terms of public procurement, even review process must be embedded in the public procurement process. Therefore, we standardize a development process and clarify the employment of a review in the process.

As the above consideration, AIST standards of software development constitutes of the following items.

- Procurement
  - Procurement Description
  - Requirement Description of Business Operation
  - Requirement Description of System Operation
- Development Process
  - Requirement Analysis Process Definition
  - Development Process Definition
  - Document Templates in Development Process
  - Peer Review Operation Guide
  - Process Tailoring Guide
- Development Standards
  - Coding Regulation
  - Naming Regulation
  - Message Logging Regulation
  - UI Design Policy
  - DB Design Policy
  - Organization of Development and Management
- Software Frameworks
  - Development Environment Framework

- User's Guide of Development Environment Framework
- Software Framework
- User's Guide of Software Framework

In order to update the document framework to the latest technology of Web application based on object oriented technology (Java), we employ use-case description and conceptual class diagram based on E-R model which enables us to estimate a cost of total development based on a number of Web pages and embedded actions.

## 4. Project Status and Related Work

### 4.1 Status of AIST Project and Standards

Scalability of the software framework has been tested in Aichi Expo 2005 Japan as the framework of information support system for approximately eight thousands people per day for six months. The framework has also been applied to two sort of back office application of a local government. The resulted screen shot of the application is shown in Figure 3.

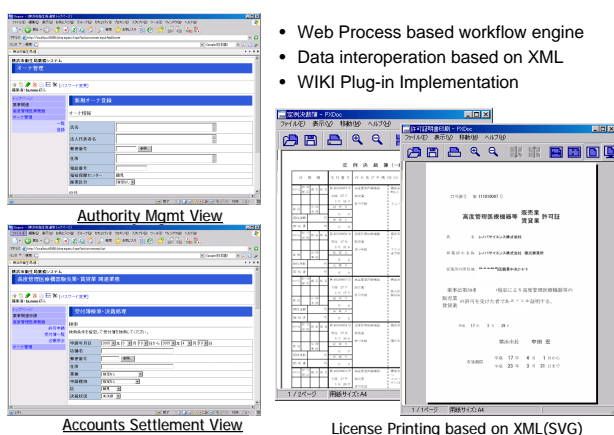


Figure 3. Local Government Application Developed

AIST development standards and development process shifts the current stage to proofing experiments of the development of large-scale enterprise software. As an actual proof experiment, they are under verification in AIST intranet development.

AIST framework is under the technology transfer to a local government. In order to perform it, a new development project has been initiated in the local government with AIST in cooperation with Keio University.

### 4.2 Related Projects in AIST

In contrast to AIST development standards that aim at standardizing the latest technologies, the project for further technology research has been initiated in the program of "AIST Industrial Transformation Initiative" [4]. The project is called AIST-SOA for short. As a

concept of the government's initiation, the project aims at project-driven enhancement of industry-academia-government collaboration for the best utilization of advantage of leaving our status as government official. AIST-SOA is tackling fusion of ontology based semantic technology and grid based computing infrastructure. The overview of project is shown as a big picture in Figure 4.

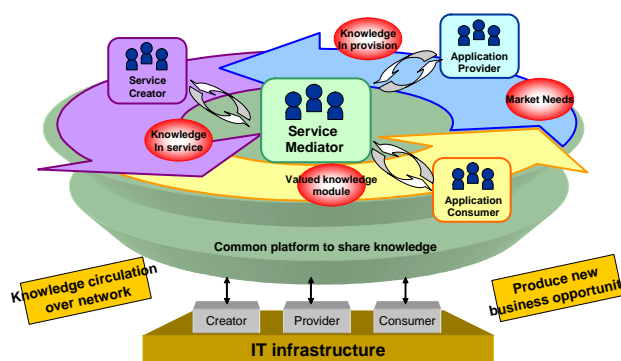


Figure 4. Big Picture of AIST-SOA

## 5. Summery

This paper introduced standardization activities of AIST and Keio University that are related to procurements of public organizations. Our technical approach based on ontologies was introduced. As a long-term political activity, the development projects of enterprise software in AIST and a local government were outlined.

AIST and Keio University have also been tackling semantic content management and tool development of content oriented semantic Web tools. The results and demos would be introduced in another opportunity.

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