A Semantic Web Service-Oriented Model for Project Management

Shahriar Mohammadi , Ali Khalili
IT Group - Faculty of Industrial Engineering
K. N. Toosi University of Technology, Tehran, Iran
smohammadi40@yahoo.com , ali@ajaxian.ir

Abstract

Project Management (PM) plays an important role in any organization for saving money and utilizing time efficiently. With growing number of methods and tools for project management, need for an integrated environment to facilitate project planning, execution and control according to project stages seems crucial. Management of changes that happen in various stages of project is another challenge of project management. In this paper, we propose a semantic web service-oriented model for project management, aiming to integrate different project management-related web services and provide flexible project management by using a central decision making component. The proposed model is based on Web Service Modeling Ontology and its execution environment (WSMX), furthermore we use PROMONT as our reference ontology to represent project management domain.

1. Introduction

In recent years, with proliferation of the Internet, companies are increasingly leveraging the Internet to achieve competitive advantage [1]. Using web services as distributed computational entities that are accessible via web, many projects can be performed and managed in a geographically distributed fashion, where project managers and team members are located in different cities, states and countries. Many related PM services (such as procurement management, risk management, quality management, etc.) are used at various stages of a project. Finding useful PM-related web services and integrating them as a single accessible web service, can potentially facilitate project management, save money, utilize time efficiently and expedite project delivery. By using semantic web services, we can enable integration of these web services and provide a machine-understandable environment for computer-aided project planning and evaluation to improve management decisions.

In this paper, we propose a semantic web service-oriented model for project management, aiming to integrate different PM-related web services and provide flexible project management by using a central decision making component.

The rest of the paper is organized as following. In section 2, we describe project management, importance of it and recent challenges around it. In section 3, we provide a general overview of the Web Services, Semantic Web, Semantic Web Services (SWS) and two prominent proposals for SWS. In section 4, we describe our proposed model for project management based on semantic web services. This architecture includes four layers: Infrastructure, Business Logic, Web Service and Application. We describe each layer in separated subsection.

2. Project Management

Project Management is the application of knowledge, skills, tools and techniques to project activities to meet specific project requirements [2]. Project management is accomplished through the application and integration of project management tasks of initiating, planning, executing, monitoring and controlling and closing. The project goals must be followed in terms of costs, time and quality [3].

In recent years the discipline of project management has changed its application dramatically to accommodate emerging management processes and philosophies related to implementation of organizational development and strategic change [4]. Theorists describe the emergent form of PM as being broader in its area of applicability than traditional PM [5]. Companies are increasingly seeking the way of effective product development and market expansion. Management by projects provides a disciplined approach to gaining competitive advantage by getting

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the right product, in time, to market through designated management of innovation, knowledge and skills [4].

As shown in Figure 1, a typical project includes not only scheduling information but also cost, resource, organization and other information [1].

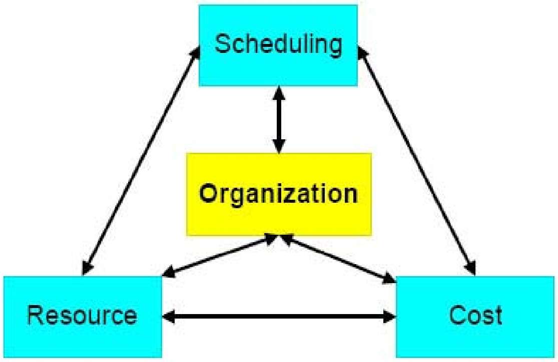

Figure 1. Information flow in a project

In the tough, competitive, dynamic and demanding world of today, project management deals with many challenges. Changes in scope of the project are the most important challenge that organizations face in managing projects. Scope management often requires adjustments to cost, time, quality, risk or other project deliverables. On the other hand, projects usually compete for resources (people, money, time, etc.). In this dynamic environment, Change Management is a vital duty of project management.

Also many related software applications can be employed at various stages of a project, at different locations and for disparate purposes [1]. We need to use different applications to fulfill the project goals according to different conditions of project. Integrating these tools can help to extend the capabilities of individual software applications.

3. Semantic Web Services

Web services are loosely coupled software components which are published, located and invoked across the web, and accessible via standard web protocols [6]. They offer an interoperability model that abstracts from the idiosyncrasies of specific implementations [7]. Web Services are based on the following industry standards: Simple Object Access Protocol (SOAP), Web Services Description Language (WSDL), and Universal Description, Discovery, and Integration (UDDI).

SOAP is an XML based lightweight messaging protocol intended for exchanging structured information between applications in a decentralized, distributed environment. WSDL is the W3C recommended language for describing the service interface. As services become available, they may be registered with a UDDI registry, which represents a set of protocols, can subsequently be browsed and queried by other users, services and applications [8].

Today's web was designed primarily for human Interpretation and use. The semantic web is an extension of the current web in which information is given well-defined meaning, better enabling computers and people to work in cooperation [9]. The main element of semantic web is Ontology. Ontology is defined as a "formal, explicit specification of a common conceptualization" [10]. In other words, Ontology is a conceptualization of an application domain in a human-understandable and machine-readable form, and typically comprises the classes of entities, relations between entities and the axioms which apply to the entities in that domain [8].

Adding semantic web annotations to web services will enable the automation of various kinds of tasks, including discovery, composition, and execution of web services in an open, unregulated, and often chaotic environment (that is, the web)[6].There are several approaches to define semantic web services, the most prominent proposals are OWL-S and WSMO.

OWL-S specifies a set of ontologies for the description of web services. Web services ontologies based on OWL-S are composed of service profile, service model, service grounding [11].

The service profile tells "what the service does", in a way that is suitable for a service-seeking agent (or matchmaking agent acting on behalf of a service-seeking agent) to determine whether the service meets its needs.

The service model tells a client how to use the service, by detailing the semantic content of requests, the conditions under which particular outcomes will occur, and, where necessary, the step by step processes leading to those outcomes.

A service grounding ("grounding" for short) specifies the details of how an agent can access a service. Typically grounding will specify a communication protocol, message formats, and other service-specific details such as port numbers used in contacting the service.

Web Service Modeling Ontology (WSMO) defines the modeling elements for describing semantic web services based on the conceptual grounding set up in the Web Service Modeling Framework (WSMF) [12], wherein four main components are defined: ontologies, web services, goals, and mediators. WSMO inherits these four top elements, further refining and extending them [13]:

- Ontologies represent a key element in WSMO since they provide (domain specific) terminologies for describing the other elements. They serve a twofold purpose: defining the formal semantics of the information, and linking machine and human terminologies.

- Web services describe the functional behavior of an actual web services.
- Goals specify objectives that a client might have when consulting a web service, i.e. functionalities that a web service should provide from the user perspective.
- Mediators describe elements that aim to overcome the mismatches that appear between the different components that build up a WSMO description.

In this paper, we choose to use WSMO as our semantic model because of its explicit support of mediators and ontological separation of service requestors (Goals) and service providers (web services) roles. We aim to solve problems related to integrating different project management applications on the web by using semantic web services.

4. The Proposed Model

Our proposed model as shown in Figure 2, consists of 4 layers: Infrastructure (this layer includes our reference ontology), Business Logic, Project Management Web Service and Application layer.

4.1. Infrastructure

In this architecture, we use PROMONT [14] as our reference ontology. It helps to build a common understanding of project related terms and methods thus providing supports for computer-aided project planning and evaluation to improve management decisions in a control circuit for project management [14].

In open and distributed environments, handling heterogeneity-related problems that arise naturally is an important issue. In this layer, we use WSMO data mediator to enable mediation between heterogeneous data sources.

OO (Ontology-Ontology) mediators resolve mismatches between ontologies and provide mediated domain knowledge specifications to the target component. The central mediation techniques for the data level are semantically enabled information integration techniques such as Ontology mapping, Ontology alignment and Ontology merging [15]. Using OO mediator, PROMONT and Suggested Upper Merged Ontology (SUMO) [16] we aim to accomplish data mediation between heterogeneous ontologies exist in business logic layer.

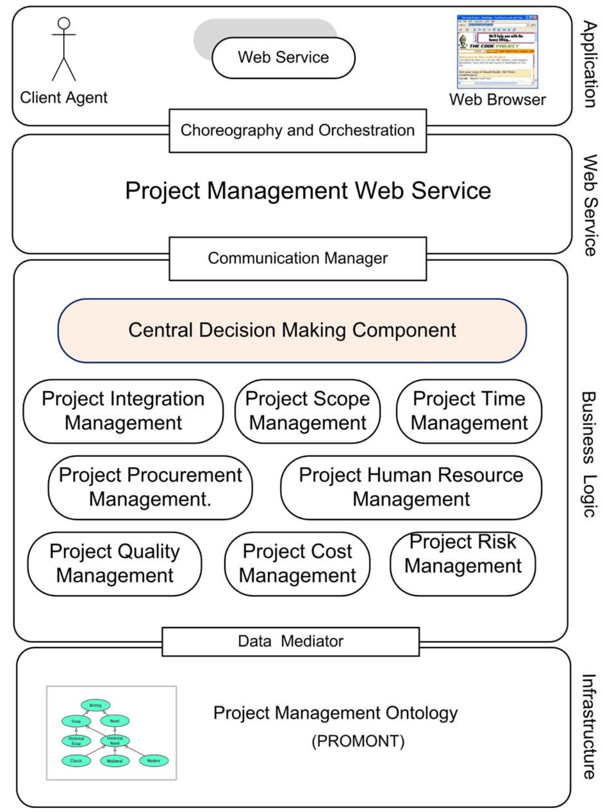

Figure 2. A semantic web service-oriented model for project management

4.2. Business Logic

This layer is responsible for integrating different aspects of project management such as Time Management, Cost Management, Risk Management, etc. and making decisions about changes according to state of the project.

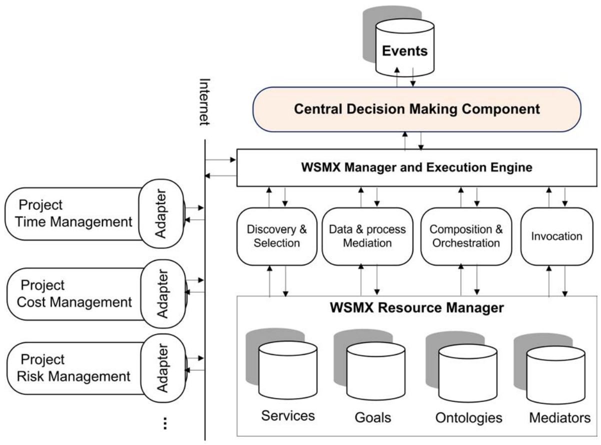

Figure 3. Business Logic layer

For implementing business logic layer, we use Web Service Execution Environment (WSMX) that is a reference implementation for WSMO, designed to allow dynamic discovery, invocation and composition of web services. WSMX offers complete support for interacting with semantic web services. In addition, WSMX supports the interaction with non-WSMO, but classical web services ensuring that a seamless interaction with existing web services is possible [7]. Main components of this layer as appears in Figure 3 are:

4.2.1. Resource Manager

The Resource Manager is responsible for management of repositories to store definitions of web services, goals, ontologies and mediators.

4.2.2. Discovery and Selection

Service Discovery is a two-phase process. Given a requester's goal, capabilities of services stored in the repository are matched with the goal. A number of services satisfying the goal could be returned from this step, thus selection of the best or optimal service will be performed [17].

4.2.3. Data and Process Mediation

We introduced OO Mediators in section 4.1.WSMO consists of three other types of data mediators (Figure 4) that solve problems related to data-heterogeneity in distributed environments:

GG (Goal-Goal) mediators connect WSMO Goals, WW (Web Service-Web Service) mediators connect web services that interact but are not compatible a priori, and WG (Web Service-Goal) mediators connect web services and goals when a web service is not usable for solving a goal a priori [15].

Another heterogeneity-related problem that occurs during interaction with web services is process-heterogeneity.

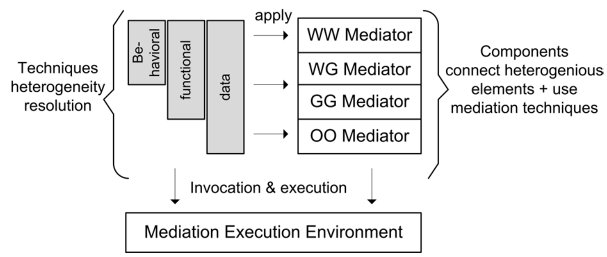

Figure 4. Dimensions of mediation in WSMO

Mismatches at the process level can occur in every interaction that a web service is involved in. The role of the Process Mediation is to mediate between requester's and provider's choreographies. Choreography of a service defines its communication pattern, that is, the way a requester can interact with it. Requester of a service has its own communication pattern and only if two choreographies match precisely, a communication between a requester and a provider of a service can happen. These heterogeneities can be resolved by analyzing of two given choreography instances and compensate possible mismatches that may appear, for instance, grouping several messages into a single one, changing their order or even removing some of the messages in order to facilitate the communication between the two parties. [15][17].

4.2.4. Composition and Orchestration

In today's web, web services are created and updated on the fly. So, human can not generate the composition plan manually and On-the-fly composition of services should be performed automatically based on selected services satisfying requesters' goal. With web service composition, a business can provide value-added services through composition of basic web services. Workflow and AI planning are two major methods for composition of web services [17] [6].

Composition of services in WSMX is addressed through orchestration engine.

4.2.5. Invocation

Service invocation is a process of executing selected web services with respect to service composition (orchestration) and choreography used by a service provider and a service requester. During service invocation, data and process mediation can be performed, if data semantics or service choreographies don't match [6].

4.2.6. Adapter

Adapters address problems related to communicating with WSMX. They transform format of a received message or even extracted data from an API (Application Programming Interface) into the WSML compliant format understood by WSMX. WSML messages are encapsulated to WSDL and sent using SOAP protocol to WSMX. We call this transformation grounding.

4.2.7. WSMX Manager and Execution Engine

Execution management has the role of coordinating the execution of the application services in a meaningful scenario. Such scenarios are called "Execution Semantics", and they can be seen as low-level projections of the requirements of the application layer.

The execution semantics define the way the application services have to work together to complete a useful scenario. Having the execution semantics as a separate concept in the architecture is the first step towards a highly decoupled system [15].

4.2.8. Central Decision Making Component (CDMC)

This component works in conjunction with WSMX Manager to control execution of the project and define strategies for project management based on project states. CDMC saves events that occur about different aspects of a project in Events repository (Such as lack of budget, time or changes in human capital of the project and etc.), then by analyzing these events and current resources of project, defines appropriate execution scenario and sends it to WSMX manager for execution.

This component and WSMX manager need reasoning of heavy semantic descriptions for service discovery, selection, composition, any required mediation and decision making. We can use Triple Space Computing (TSC) [18] to overcome synchronous communication problems of current protocols like SOAP (Simple Object Access Protocol).

TSC defines the technologies and settings needed to develop a new paradigm for web service communication that complies with the basic principles of the web, i.e. stateless communication of resources, persistent publication of resources, unique identification of resources and non-destructive read access to resources [18].

4.3. Web Service

This layer includes project management web service and acts as a gateway to business logic layer. PM web service abstracts capability of business logic layer into a single web service. Interactions between PM web service and business logic are handled by Communication Manager.

Communication Manager handles the various invocations that may come from PM web service and retrieves the results of these invocations from Business Logic (this could happen either as a consequence of a synchronous call or by a separate invocation of Business Logic in case of asynchronous calls)[7].

Capability of proposed PM web service can be divided into 4 general PM processes:

- Project Structuring: Designing Work breakdown Structures (WBS), PERT, CPM, Bar charts and etc.
- Project Planning: Designing a collection of plans that detail how different conditions, scenarios, and actions will be managed.
- Project Organizing: Assigning tasks to team members, Authorizing overtime, Hiring/laying off staff, Expediting and etc.
- Managing Team Members: Designing Meetings, Rewarding/disciplining, Monitoring activities and etc.

Furthermore project managers can use PM web service as a consultant for change management.

4.4. Application

Different types of requestors can employ our PM web service: Web Applications that provide PM-related services for project team members, Another web services in organizations that need PM services especially in ERP systems and Client Agents that want to automate PM services for specific purposes. Furthermore, "Anytime, anywhere" access and platform independence of PM-web service offers collaborative capabilities far beyond those delivered by traditional PM-related software applications. It provides the facility to use mobiles and defining Wireless-Based project management.

5. Conclusion

In this paper, we introduced a semantic web service-oriented model for project management. The purpose of this architecture is to integrate different project management-related web services as a single web service and to handle changes that occur in projects by using a central decision making component. The proposed model is based on WSMO and its execution environment that called WSMX. Result of this work is a project management web service that is usable by project managers to facilitate planning and evaluation of projects.

We envisage further evaluation of our model by defining some meaningful scenarios in project management and testing usability of our framework.

References

[1] J. Cheng, K. Law, and B. Kumar, “Integrating Project Management Applications as Web Services”, 2nd International Conference on Innovation in AEC, Loughborough University, 2003, pp. 367-76.

[2] D. I. Cleland, and W. R. King, *Project Management Handbook*, Van Nostrand Reinhold, NY. USA, 1988.

[3] Sommerville, Software Engineering, Addison Wesley, 7th Edition ,2004.

[4] S. J.K. Cicmil, “Critical factors of effective project management”, The TQM Magazine Volume 9, MCB University Press, 1997, pp. 390–396.

[5] D. J. Bryde, “Project management concepts,methods and application”, International Journal of Operations & Production Management Vol. 23 No. 7, MCB University Press, 2003, pp. 775-793.

[6] E. Paikari,J. Habibi, and S. H. Yeganeh, “Semantic Composability Measure for Semantic Web Services”, Proceedings of the First Asia International Conference on Modelling & Simulation (AMS'07) , Thailand, 2007, pp. 88-93.

[7] A. Haller,E. Cimpian, A. Mocan,E. Oren, and C. Bussler, “WSMX - a semantic service-oriented architecture”, Proceedings of the 2005 IEEE International Conference on Web Services, USA, 2005, pp. 321- 328 vol.1.

[8] J. Zhou, J. P. Koivisto, and E. Niemela, “A Survey on Semantic Web Services and a Case Study”, 10th International Conference on Computer Supported Cooperative Work in Design, IEEE, 2007,pp. 1-7.

[9] T. Berners-Lee,J. Handler, and O. Lassila, “The Semantic Web”, Scientific American, 2001.

[10] T. R. Gruber, “A Translation Approach to Portable Ontology Specifications”, *Knowledge Acquisition*, Academic Press, Stanford University, 1993, pp. 199-220.

[11] W3C Web-Ontology Working Group, “OWL-S: Semantic Markup for Web Services”, http://www.daml.org/services/owl-s/1.1/overview/.

[12] D. Fensel, and C. Bussler, “The Web Service Modeling Framework WSMF”, Electronic Commerce Research and Applications Vol. 1, Elsevier B.V, 2002, pp. 113-137.

[13] C. Feier, D. Roman, A. Polleres, J. Domingue, M. Stollberg, and D. Fensel, “Towards Intelligent Web Services: Web Service Modeling Ontology (WSMO) ”. In Proc. of the Int'al Conf on Intelligent Computing (ICIC) 2005, Hefei, China, August 23-26, 2005.

[14] S. Abels,F. Ahlemann,A.Hahn,K. Hausmann, and J. Strickmann, “PROMONT – A Project Management Ontology as a Reference for Virtual Project Organizations”, *Lecture Notes in Computer Science*, SPRINGER-VERLAG, Germany, 2006,pp. 813-823.

[15] D. Fensel, H. Lausen, J. de Bruijn, M.Stollberg, D. Roman, A. Polleres ,and J. Domingue, *Enabling Semantic Web Services -The Web Service Modeling Ontology*, Springer Berlin Heidelberg, Germany, 2007.

[16] I. Niles, and A. Pease, “Towards a standard upper ontology”, *International Conference on Formal Ontology in Information Systems*, ACM , USA, 2001, pp. 2-9.

[17] T. Vitvar, “Advances in e-business collaboration: semantic Web services in SAP R/3 B2B integration”, Proceedings of the 2005 International Symposium on Collaborative Technologies and Systems, USA, 2005, pp. 290- 297.

[18] O. Shafiq, M. Zaremba , and D. Fensel, “On communication and coordination issues of Semantic Web Services”, IEEE International Conference on Web Services (ICWS 2007), USA, 2007, pp. 553 - 560.