

# Modeling Competences in Service-Oriented Virtual Organization Breeding Environments

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**Abstract**—Support for organization competences is an important function of Virtual Organization Breeding Environments (VOBEs), allowing VOB members to publish and consult about the activities they may perform. In Service-Oriented VOBs (SOVOBs), organized systematically around the concept of services, existing competence models should be extended to support the service-orientation of SOVOBs. In this paper, a refinement of the 4-C competence model is presented. The main enhancements consist of 1) the redefinition of the concept of a service as regards competences 2) a clear distinction of the relations between activities, services, capabilities and competences, and 3) the introduction of contextual capabilities.

## I. INTRODUCTION

To promote itself and to be taken into account during virtual organization (VO) partner search processes, each Virtual Organization Breeding Environment (VOBE) member should provide detailed and up-to-date information about the activities it can perform and the services it can offer. This information should be “an accurate description of member capabilities, its free resources capabilities, the production costs for each of its products, as well as conspicuous proof of the validity of the provided information” [1].

The description of the competences of an organization is usually complex because of the diversity and multi-aspect character of competences. In medium and large VOBs, the amount of information concerning VOB members is significant. Additionally the continuous adaptation of VOB members to market needs causes a significant effort related with the maintenance of this information. As a consequence, computer support for management of organization description is required in medium and large VOBs, usually based on a *competence model*.

A *competence* in literature is defined in a various of ways: “the organization’s capability to perform (business) processes, tasks, having the necessary resources (human, technological, physical) available, and applying certain standards (practices), with the aim to offer certain products and/or services” [2] or “the ability to sustain the coordinated deployment of assets in ways that help a firm achieve its goals” [3]. In this paper, the term competence is to be understood as defined by Gallon [4] stating that a competence is:

*An aggregation of capabilities, where synergy that is created has sustainable value and broad applicability.*

Several works on competence modeling have been published [3], [5]. Recently, the 4-C model, based on former models by [6], [7], [8], [9], [10], [11], has been proposed by Ermilova and Afsarmanesh [1]. The main components in the 4C-model are: Capabilities, Capacities, Costs, and Conspicuities. The 4-C model is adapted to characteristics and needs of VOB, its members and Virtual Organizations.

Additionally, the competence model is usually an important element of tools provided by VOBs to support partner selection during the VO creation process [12]. An approach to VO partner search and selection based on information available in competence model is called *competence-based configuration of VO* or *competence-based VO creation* [1].

As a valuable approach for the architecture and implementations of VOBs and integration of cooperating organizations, the Service-Oriented Architecture (SOA) [13] has been suggested [14]. A VOB implemented in this way is referred in this paper as a *Service-Oriented Virtual Organization Breeding Environment (SOVOB)*. A SOVOB is systematically organized around the concept of services, which is not limited to Web services, but which encompasses also services performed by humans (organizations). In this paper, only SOVOBs are taken into account.

In SOVOBs, partner selection is strictly connected with service search and selection, with partner competences being considered as extension of service description. Currently, there is a multiplicity of approaches to service description that are elaborated in isolation from a number of already existing competence models. Proposed service and competence description models do not specify the actual relation among competences and services of an organization. The definition of the relation among these concepts is crucial for partner and service selection performed in SOVOBs that is based on both competence model and service description.

Furthermore many elements that are traditionally included in competence description models such as organization costs and capacities (in particular availability of resources) depend on circumstances (such as seasons, days, economic environ-

ment, client's country of origin, etc.) and changes dynamically over time. Thus competence description model should support description of these elements in particular circumstances and also support tracking the evolution of competences.

Existing competences models do not deal neither with circumstantial and multi-version competences, nor with concepts rooted in SOA. Even if the 4-C model is the closest to the needs of SOVOBEs, the refinement of already proposed concepts and the introduction of new ones are still needed for the 4-C model to support SOVOBEs.

As a consequence, the shift of VOBES to the SOA paradigm, centered on the concept of service, requires the development of novel competence models that can be applied within SOVOBEs, supporting the characteristics of both SOA ecosystems and VOBES.

The main contribution of this paper is a competence model for SOVOBEs. The presented model may be considered as a refinement of the 4-C model taking into account the service-orientation of SOVOBEs. The model is a work in progress and is thought to be validated as a component of the ErGo system developed within the ITSOA project [15]. The ErGo system is envisioned to be used in the Polish construction sector for a SOVOBEs gathering SMEs cooperating with a real-estate development company. The proposed model consists of a competence description model and a competence verification method. Specific aspects of the model include: (1) modeling a *context* for capabilities resulting in many possible *capability variants* (2) versioning of competences, capabilities and capability variants (3) modeling the nature of relations among *competence*, *capability*, *activity* and *service*, with special emphasis on a clear distinction between the concept of competence and capability in context of service provision, (4) refinement of the definitions provided in 4-C model, (5) modeling the multiplicity of relations among all the concepts added to 4-C model.

This paper is organized as follows. In Section 2, the general overview of competence model and its components is presented. In particular competence description model is introduced in Section 2.1 and competence verification method is presented in Section 2.2. In Section 3, the competence profile as part of competence description is presented in detail. Section 4 outlines the intended application of the model in the construction sector. Finally, Section 5 concludes the paper.

## II. OVERVIEW OF THE COMPETENCE MODEL

A competence model should provide exhaustive information about an organization, competences and its services. Beside this information, a model should encompass methods of verification of competence description relevance. Therefore, the proposed *competence model* consists of both a *competence description model* and *competence verification method*.

### A. Competence description model

The competence description model consists of three types of profiles:

- Competence profile,

- Service business profile, and
- Organization profile.

1) *Competence profile*: A competence profile is organized around five main concepts: *competence*, *capability*, *capability variant*, *capacity* and *conspicuity*. The structure of competence profile is described in more detailed in Section III.

These concepts are directly linked to the concepts of *service* and *activity* that are a part of a *service profile*.

2) *Service profile*: In SOA, standards supporting Web service description such as WSDL [16], OWL-S [17], WSMO [18] and others have been developed to provide information necessary to find a service and interact with it. These standards permit: service discovery, service invocation, service composition and interoperation [17]. On a business level, the scope of relevant information that is included in service description should be more exhaustive. The business service profile includes *business characteristics of a service*, free of technical aspects, i.e., service reference to organization strategic goals, strategy of service, formal requirements, etc. [19], [20]. A set of information relevant for service profiles has been partially developed within the ECOLEAD project [2].

A service provider can provide complex services due to its competences. Thus, in a proposed approach, a service is connected with a 1:1 relation with a competence. A service is a mechanism allowing an access to a set of capabilities defined as competence.

3) *Organization profile*: The description of organization profile should include non-service specific information such as: history of collaboration, past performance, formal certificates, recommendations, membership in associations, localization, financial capital, contact information, steering managerial board, etc. A scope of information relevant of organization profile was developed within the ECOLEAD project [2].

### B. Competence verification method

To be reliable, the information provided by an organization should be confirmed or verified against other sources of information about this organization. The competence description model allows organizations for initial verification of data reliability based on *conspicuities* (cf. Table III).

In addition to conspicuities that are usually provided by a particular SOVOBE member, the SOVOBE itself stores various sets of data that can enable the verification of information provided in the competence description model. These sets of data include: information about all its member organizations, their history of collaboration, efficiency of collaboration, former and existing problems, etc. (cf. Table I).

A mechanism for the verification of self-declared organization competences in partner selection process with the use of performance indicators [23] together with a set of services for competence management have been implemented as module of the ErGo system.

## III. COMPETENCE PROFILE

To our best knowledge, among all the proposed competence models, the 4-C model is the closest to the needs of SOVOBEs.

TABLE I

DATA SOURCES FOR THE VERIFICATION OF COMPETENCE DESCRIPTIONS

Data source	Description
Continuous monitoring of collaboration	Monitoring of current service consumption and provision, progress in running collaboration processes, conformance to requirements etc.
History of collaboration	Information restored from the historical data about partners' performance and collaboration within SOVOBE
Opinions of SOVOBE members	Information provided by SOVOBE members concerning to other members' competences and services
Social network	Information about relations among organizations (i.e., recognition, trust) available in SOVOBE's social network [21], [22]

However, the refinement of already proposed concepts and the introduction of new ones are still needed for the 4-C model to support SOVOBEs. Newly introduced concepts are presented in Table II. Concepts existing in the 4-C model by refined or redefined for SOVOBEs are presented in Table III. Finally, concepts added to the 4-C model and associated with contextual competences are presented in Table IV.

#### A. Core concepts

The core concepts of the proposed model are *activity*, *service* (cf. Table II), *competence*, and *capability* (cf. Table III).

While the *service* is a type of a *product* in the 4-C model (cf. Table III), the proposed model is based on a different approach to *service* concept, leading to significant changes in the relations among the concepts of *service*, *activity*, *competence* and *product*. An activity (a piece of work that delivers a certain product) can be performed by an organization presenting the associated capability (the ability to perform an activity). A competence aggregates one or more capabilities, and eventually other competences. A service is a mechanism to provide external organization with an access to competences.

As an example, let us consider a software company. The company has a number of capabilities, for instance *server administration*, *computer network configuration*, *information system modeling*, *software requirements gathering*, *Java programming*, *software testing*. Each capability is associated with an activity that results in a product: for instance the software company is capable of performing the *software requirements gathering* activity resulting in the product *software requirement specification document*. Capacities may further be aggregated into competences, e.g., capabilities *information system modeling*, *software requirements gathering* are aggregated into the *software requirements engineering* competence. A competence may also consist of competences: the competence *system development* is a compound competence composed of the *software requirements engineering* competence, and the *Java programming* and *software testing* capabilities. Finally, a competence may be externalized with an appropriate service: the *software requirements engineering* competence may be externalized as a service that may be then consumed by customers.

TABLE II

CORE CONCEPTS OF THE PROPOSED COMPETENCE MODEL

Concept	Proposed model
Activity	A piece of work that forms one logical, self-contained whole. The output of an activity is a product. An activity may be a manual activity or automated and requires human and/or machine resource(s) to support its execution [24]. As stated in [24], a task is a synonym of activity.
Service	A mechanism to enable access to one or more capabilities, where the access is provided using a prescribed interface and is exercised consistent with constraints and policies as specified by the service description [13]. An access to a set of capabilities is possible with the concept of a competence.
Compound service	A service that is an aggregation of services. Aggregation of services creates new, more complex service.
Compound competence	A competence that is an aggregation of competences. Complex competences may be defined as aggregation of other competences.
Product	The output of the activity.

Note that some capabilities described in competence description model may not be externalized by an organization as a part of a competence. The description of capabilities referring to activities that are not externalized is justified, e.g. for private, internal enterprise architecture modeling, for collaboration opportunity spotting, or competence gap analysis [1].

Organization's competences are in 1:1 relation with organization's services meaning that every competence is externalized by none or exactly one service (cf. Figure 1). Over time organization may provide more complex services that are created not only as a composition of activities the organization is able to perform due to its capabilities, but also as an aggregation of other services. Such services are called *compound services* (cf. Table II). Similarly, competences may be aggregated into *compound competences* (cf. Table II) to provide more complex, possibly compound services.

Following the above key definitions of competence, capability, service and activity, some components of 4-C model should to be refined as presented in Table III.

In Table III, definitions proposed in 4-C model are presented in column "Definition", with a critic of the proposed definitions given in the column "Comment". The refined or redefined definitions are presented in the column "Proposed model".

Concepts presented above and relations existing among them are presented in Figure 1 in a form of UML diagram.

The concepts presented in Figure 1 are further grouped in organization, service, and competence profiles. Note that organization and service profiles may be extended as needed. From a competence modeling perspective, the key elements of the proposed competence model are 1) the concepts of the competence profile and, 2) the relations between the core concepts the organization and service profiles (presented in Figure 1) and the competence profile concepts.

TABLE III  
REFINED OR REDEFINED CONCEPTS FROM THE 4-C MODEL

Concept	4-C model		Proposed model
	Definition	Comment	
Competence	Competency is a compound object that cannot be represented by one textual value.	Too general definition	An aggregation of capabilities, where synergy that is created has sustainable value and broad capability [4].
Capability	An ability to perform an activity or task.	Missing discussion on a difference among “task” and “activity”. According to [24], “task” is a synonym of “activity”.	An ability to perform an activity.
Cost	Represent the cost of product/services provision in relation to one capability.	Missing clear definition	The monetary value of all the expenditures linked to activity addressed by particular capability, including the value of all the resources required by an activity.
Resource	Resource class represents the elements applied to business processes in the organization.	Missing clear definition	Physical or virtual entity of limited availability required by organization to perform activities and achieve organizational goals.
Capacity	The current availability of resources needed to perform one specific capability.	In this model, a capability is defined as “an <i>ability</i> to perform an activity”, resulting in “resources needed to <i>perform</i> one specific <i>ability</i> to perform activity” - the expression “performing an ability” makes this definition unclear.	The total amount of product that can be contained or produced.
Conspicuity	Represent means for the validity of information provided by the VBE members about their capabilities, capacities and costs.	Missing clear definition. Refers only to: capability, capacity and cost.	A formal or informal document justifying, confirming and explaining information provided in a competence description. Refers to: service, organization, competence, capability, cost, capacity.
Product	Represents both goods and services that belong to the output of the processes/activities represented by the member organizations’ capabilities.	Missing clear definition. Assumed in the proposed model concentration around the <i>service</i> concept requires the redefinition of the <i>product</i> .	The output of the activity.

## B. Contextual Capabilities

In addition to terms defined in 4-C model, a competence profile developed for SOVOBE introduces: *capability context*, *capability variant* and *versioning* (cf. Table IV).

Conditions under which an organization is able to perform some activity depend on circumstances. Those circumstances are referred as *context*. Depending on a context, cost and capacity may vary. This results in a number of *capability variants* of particular capability that are connected with a particular capability context, particular capacities and cost. Moreover the model includes versioning of competences, capabilities and capability variants. *Versioning* allows for tracking of organization evolution and adaptation to market needs and particular collaboration opportunities.

Continuing the previous example, the number of available *programmers* (considered here as resources) may be lower than usual in particular circumstances, such as *holidays*. This limitation results in different capability characteristics, for instance extended *system development time* or increased *general cost* of system development. These characteristics constitute a capability variant associated with a particular context (*holidays*).

TABLE IV  
CONCEPTS RELATED WITH CONTEXTUAL CAPACITIES

Concept	Proposed model
Capability context	A set of triplets (object, predicate, subject) describing circumstances in which a capability exists.
Capability variant	Cost and a set of capacities referring to particular capability and appearing in particular context.
Version	A number indicating a competence, capability or capability variant version

## IV. PLANNED APPLICATION OF THE PROPOSED COMPETENCE MODEL

The proposed competence model is envisioned as a part of a novel partner and service selection method. As a part of the method, the proposed competence model provides not only means for descriptions of the competences of SOVOBE members, but allows VO planners to define requirements for both organizations and services that are supposed to compose a VO business process. The envisioned requirements are based on the concepts proposed in the competence model described in this paper and may include: a list of required competences, a list of required capabilities with a clear statement of required capacity and optimal cost in particular circumstances defined by a context, a list of required conspicuities (certificates,

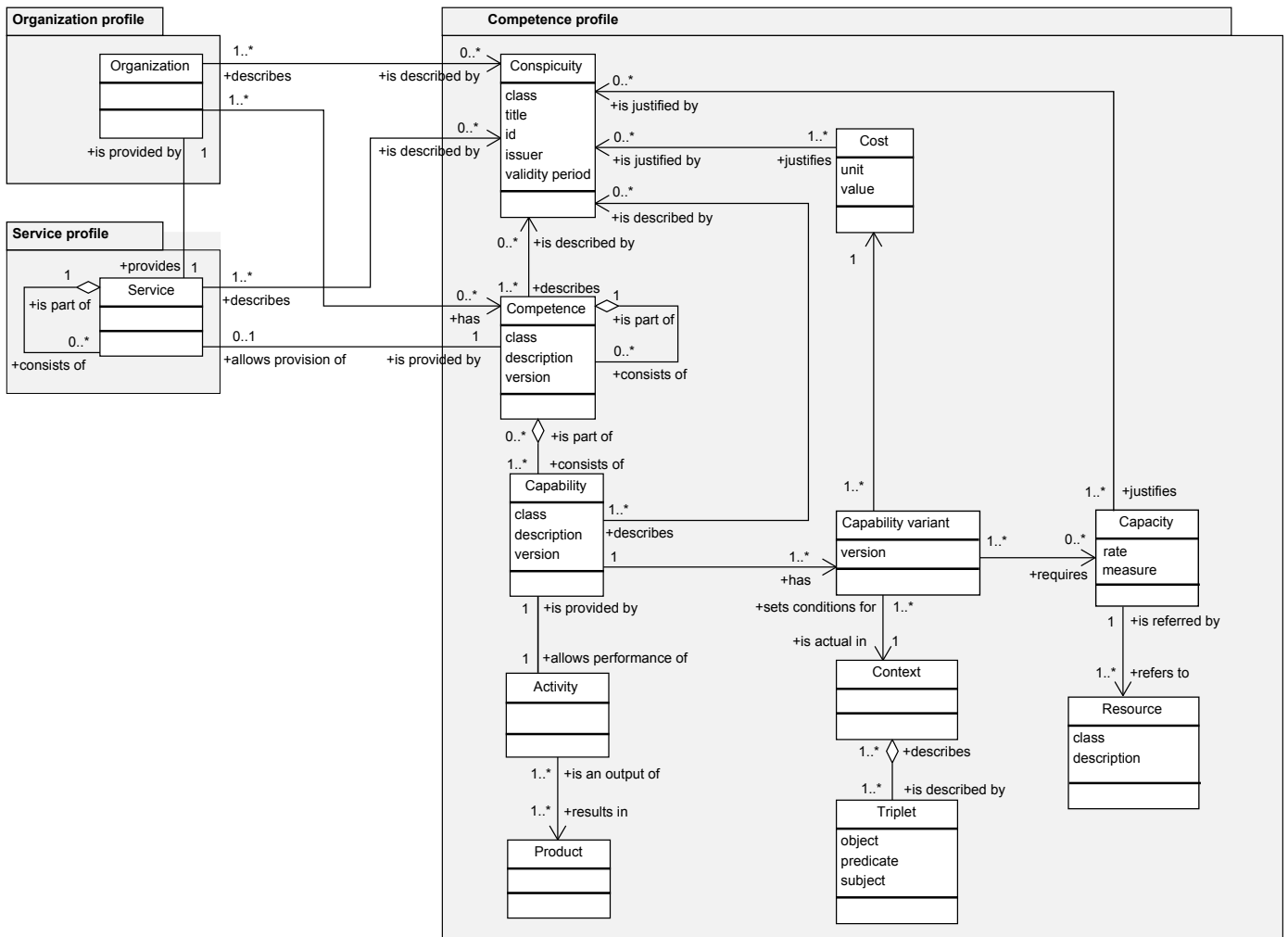


Fig. 1. Competence Description Model

diplomas etc.), etc.

The proposed competence model and relevant partner and service selection method have already been implemented as elements of the ErGo system. The ErGo system is envisioned to be used as a software platform for SOVOBEs. A first pilot is currently under testing in the construction sector, with a real-estate development company being a SOVOBE, providing the infrastructure and services for its subcontractors on the ErGo platform.

In the construction sector, the concept of *capability variants* is particularly relevant. The availability of partner's free resources, associated with capability costs, capability properties such as time associated with capability etc. depend strongly on the context that is: seasons of the year, weather conditions, day of week, hours, holiday period etc. As an example, the performance of teams working on roofs is usually lower in winter than in spring because of weather conditions. Thus the inclusion of capability variants in the description of organization's competences is crucial for the proper selection of organization for a given business process in the construction sector.

## V. CONCLUSIONS

In the context of globalization and dynamic markets, collaboration among enterprises allows them to face the socio-economical challenges related with high dynamism and ever changing clients' needs. A key element for agile collaborative enterprises is a sound computer support for competence management, providing tools for partner and service search based on competence description. While the paper focuses on the modeling of competences with the introduction of a competence description model, algorithms for partner and service search based on competence requirements are out of the scope of this paper. However, both a model for competence requirement definition and a set of partner and service searching algorithms taking advantage of this model have already been implemented.

The main contribution presented in this paper is the competence model consisting of competence description model and verification method. Extending the 4-C model, the proposed concept of competence profile clarifies the relation between activities, services, capabilities and competences, as well as

introduces the idea of contextual capabilities.

The proposed description of competences takes into account the needs of SOVOBE. As a result it reorganizes the 4-C model by redefinition of concepts of *competence*, *capability*, *resource*, *capacity*, *cost*, *resource*, *conspicuity* and *product*. Also new concepts are introduced: *capability context*, *capability variant*, *compound competence* and *version*.

Among future works, a method for competence aggregation, suited to the proposed model, is to be proposed. Such a method should take into account the contextual aspect of capabilities. Within the IT-SOA project [15], further development of the proposed model and its verification is planned with a pilot application in the construction sector.

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#### REFERENCES

- [1] E. Ermilova and H. Afsarmanesh, "Competency modeling targeted on boosting configuration of virtual organizations," *Journal of Production Planning & Control: The Management of Operations, special issue on Engagement in collaborative networks*, vol. 21, no. 2, pp. 103–118, 2010.
- [2] —, "Competency and profiling management in virtual organization breeding environments," in *Network-Centric Collaboration and Supporting Frameworks*, L. M. Camarinha-Matos, H. Afsarmanesh, and M. Ollus, Eds. Springer, NY, 2007, pp. 131–142.
- [3] R. Sanchez and A. Heene, "Reiventing strategic management: New theory and practice for competence-based competition," *European Management Journal*, vol. 15, no. 3, pp. 303–317, 1997.
- [4] M. Gallon, H. Stillman, and D. Coates, "Putting core competency thinking into practice," *Research Technology Management*, vol. 38, no. 3, pp. 20–29, 1995.
- [5] G. Pepiot, N. Cheikhrouhou, J. Furbringer, and R. Glardon, "UECML: Unified enterprise competence modelling language," *Computers in Industry*, vol. 58, no. 2, pp. 130–142, February 2007. [Online]. Available: <http://dx.doi.org/10.1016/j.compind.2006.09.010>
- [6] C. Prahalad and G. Hamel, "The core competence of the corporation," *Harvard Business Review*, vol. 68, no. 3, pp. 79–91, 1990.
- [7] M. Javidan, "Core competence: What does it mean in practice?" *Long Range Planning*, vol. 31, no. 1, pp. 60–71, 1998.
- [8] HR-XML Consortium, "HR-XML website," <http://www.hr-xml.org/>, 2010, [Online; accessed October 2010].
- [9] A. Molina and M. Flores, "Exploitation of business opportunities: The role of the virtual enterprise broker," in *Proceedings of the IFIP TC5/WG5.3 Second IFIP Working Conference on Infrastructures for Virtual Organizations: Managing Cooperation in Virtual Organizations and Electronic Business towards Smart Organizations*, L. M. Camarinha-Matos, H. Afsarmanesh, and R. Rabelo, Eds. Deventer, The Netherlands, The Netherlands: Kluwer, B.V., 2000, pp. 269–280.
- [10] E. Müller, "Production planning and operation in competence-cell-based networks," *Production Planning & Control: The Management of Operations*, vol. 17, no. 2, pp. 99–112, 2006.
- [11] X. Boucher, S. Peillon, and P. Burlat, "Towards decision support for a collaborative increase of competences within networks of firms," Ecole de Mines de Saint-Etienne, Research Report G21-EMSE 2005-600-009, 2005.
- [12] L. M. Camarinha-Matos, H. Afsarmanesh, and M. Ollus, "Ecolead and cno base concepts," in *Methods and Tools for Collaborative Networked Organizations*, L. M. Camarinha-Matos, H. Afsarmanesh, and M. Ollus, Eds. Springer US, 2008, pp. 3–32.
- [13] J. A. Estefan, K. Laskey, F. McCabe, and P. Thornton, "Reference Architecture Foundation for Service Oriented Architecture Version 1.0," OASIS Committee Draft 02, 14 October 2009, <http://docs.oasis-open.org/soa-rm/soa-ra/v1.0/soa-ra-cd-02.pdf>, Oct. 2009, [Online; accessed October 2010].
- [14] R. J. Rabelo and S. Gusmeroli, "The ECOLEAD collaborative business infrastructure for networked organizations," in *Pervasive Collaborative Networks*, L. M. Camarinha-Matos and W. Picard, Eds., vol. 283. Springer, NY, 2008, pp. 451–462.
- [15] ITSOA Project, "ITSOA website," <http://www.soa.edu.pl/>, 2010, [Online; accessed October 2010].
- [16] D. Martin, M. Burstein, O. Lassila, Massimo, Paolucci, T. Payne, and S. McIlraith, "Describing web services using OWL-S and WSDL," <http://www.daml.org/services/owl-s/1.1/owl-s-wsdl.html>, 2005, [Online; accessed October 2010].
- [17] D. Martin, M. Burstein, E. Hobbs, O. Lassila, D. McDermott, S. McIlraith, S. Narayanan, B. Parsia, T. Payne, E. Sirin, N. Srinivasan, and K. Sycara, "OWL-S: Semantic Markup for Web Services," <http://www.daml.org/services/owl-s/1.1/overview/>, November 2004, [Online; accessed October 2010].
- [18] D. Fensel, H. Lausen, J. de Bruijn, M. Stollberg, D. Roman, and A. Polleres, *Enabling Semantic Web Services : The Web Service Modeling Ontology*. Springer, Berlin, 2007.
- [19] K. Boukadi, L. Vincent, and P. Burlat, "Modeling adaptable business service for enterprise collaboration," in *Leveraging Knowledge for Innovation in Collaborative Networks*, L. M. Camarinha-Matos, I. Paraskakis, and H. Afsarmanesh, Eds. Springer, NY, 2009, pp. 51–60.
- [20] The Open Group, "Togaf version 9. Enterprise Edition," <http://www.opengroup.org/togaf/>, 2009.
- [21] J. Świerczowicz and W. Picard, "Social requirements for virtual organization breeding environments," in *Leveraging Knowledge for Innovation in Collaborative Networks*, L. M. Camarinha-Matos, I. Paraskakis, and H. Afsarmanesh, Eds. Springer, NY, 2009, pp. 614–622.
- [22] W. Picard, "Social protocols for agile virtual teams," in *Leveraging Knowledge for Innovation in Collaborative Networks*, L. M. Camarinha-Matos, I. Paraskakis, and H. Afsarmanesh, Eds. Springer, NY, 2009, pp. 168–176.
- [23] Z. Paszkiewicz and W. Picard, "Reference model for performance management in service-oriented virtual organization breeding environments," in *Leveraging Knowledge for Innovation in Collaborative Networks*, L. M. Camarinha-Matos, I. Paraskakis, and H. Afsarmanesh, Eds. Springer, NY, 2009, pp. 505–513.
- [24] Workflow Management Coalition, "Terminology and glossary," Document Number WfMC-TC-1011, Issue 3.0, 1999, [http://www.wfmc.org/standards/docs/TC-1011\\_term\\_glossary\\_v3.pdf](http://www.wfmc.org/standards/docs/TC-1011_term_glossary_v3.pdf), Feb. 1999, [Online; accessed October 2010].