

# Breeding Virtual Organizations in a Service-Oriented Architecture Environment

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**Abstract.** A Virtual Organization Breeding Environment (VOBE) is an accepted concept in the research area of collaborative networks. So far, existing VOBES are based on an infrastructure providing only limited support for efficient integration of VOBES members, and virtual organization partners on both technical and business levels. Thus, the Service-Oriented Architecture (SOA) has been proposed in this chapter as an approach to implement VOBES. A VOBES implemented in this way is called a Service-Oriented Virtual Organization Breeding Environment (SOVOBE). A SOVOBE is systematically organized around the concept of services, which are not limited to Web services, but which encompass also services performed by humans (organizations). In this chapter a set of core services is specified provided by SOVOBE to support SOVOBE members and virtual organizations throughout their lifecycle. The core services include Competence Management Service, Social Network Service, VO Collaboration Service, VO Creation Service, and VO Monitoring Service.

**Keywords:** Virtual Organization, breeding environment, SOA

## 1 Introduction

A *Virtual Organization* (VO) is defined as an operational structure consisting of different organizational entities and created for a specific business purpose, to address a specific business opportunity. Based on the above concept of VO, the concept of *Virtual Organization Breeding Environment* (VOBE, sometimes shortened to VBE in the literature) has been proposed as “an association of organizations and their related supporting institutions, adhering to a base long term cooperation

agreement, and adoption of common operating principles and infrastructures, with the main goal of increasing their preparedness towards collaboration in potential Virtual Organizations (VO)” [1]. The main aims of VOBES are: establishment of mutual trust among organizations to facilitate their collaboration in VOs, reduction of cost and time to find suitable partners for a particular VO, assistance in VO creation including reaching agreement between partners, and VO re-configuration aiming at adaptation to new business challenges and opportunities. To encompass general concepts of Virtual Enterprises, VOBES, and VOs, the term Collaborative Network Organization (CNO) has been coined [1].

While the concept of VOBES is currently widely accepted in the CNO research community, there is still no final consensus about the architecture and implementation of VOBES. So far existing VOBES have been created in an ad hoc manner and have an infrastructure allowing limited support for efficient integration of VOBES members and VO partners on business and technical levels. An appropriate IT infrastructure of a VOBES should provide at least the functionality associated with: collaboration and negotiation, interoperability, discovery and distribution of knowledge and resources, and integration of business processes. A discussion of IT solutions to support collaboration among VOBES members is presented in [2].

In [2] the Service-Oriented Architecture (SOA) has been suggested as a valuable approach to VOBES implementation. SOA has been defined by the OASIS group [3] as “a paradigm for organizing and utilizing distributed capabilities that may be under the control of different ownership domains. [...] In SOA, services are the mechanism by which needs and capabilities are brought together.” The OASIS definition emphasizes some characteristics of SOA shared with CNOs: CNOs may be seen as structures aiming at “organizing and utilizing distributed capabilities under the control of different ownership domains” [3].

The above works provide general guidelines, recommendations and general specification of services that should be provided by a VOBES. A systematic approach to breeding of virtual organizations in a SOA environment is still to be proposed, as well as a detailed specification and implementation of core services of VOBES.

In this chapter the concept of Service-Oriented Virtual Organization Breeding Environment (SOVOBE) is proposed. A SOVOBE is a VOBES organized systematically around the concept of a service. In SOVOBES, services are not limited to Web services, but they encompass services performed by humans. Core services supporting VOs and SOVOBE members are proposed in this chapter.

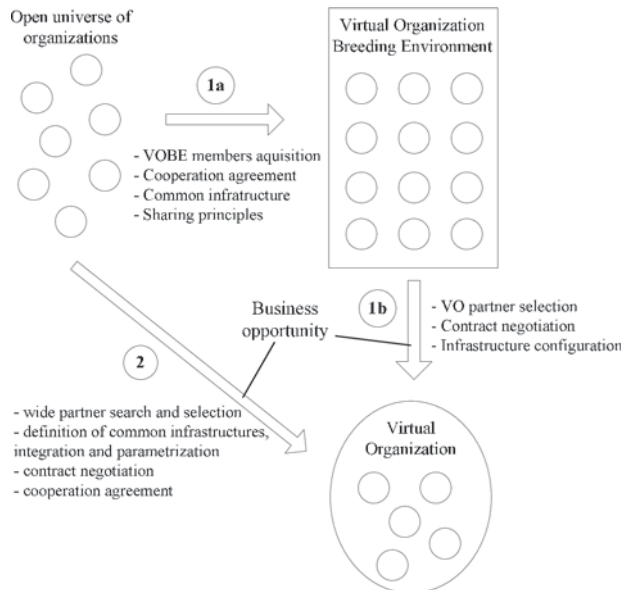
This chapter is organized as follows. In Section 2, the concept of VOBES is described being a foundation for further analysis. In Section 3, the Service-Oriented Virtual Organization Breeding Environment (SOVOBE) is presented. In Section 4, core internal services related with SOVOBE members are detailed, i.e., organization competence services and social network services. Next, internal SOVOBE services associated with the lifecycle of VOs, i.e., VO creation, collaboration and monitoring, are presented. Finally, Section 5 concludes the chapter.

## 2 Virtual Organization Breeding Environments

### 2.1 Rationale of VOBs

VO partners possess complementary skills and competences, and cooperate by the use of information and communication technology. While partners theoretically can be identified and recruited from the open universe of available organizations (path 2 in Fig. 1), such an approach meets a number of questions that need to be answered [4]:

- how to quickly define the agreements on the roles and responsibilities of each partner, to reflect sharing of tasks and the rights on the produced results?
- how to know about the mere existence of potential partners in the open universe and deal with incompatible sources of information?
- how to acquire basic profile information about organizations, when there is no common template or standard format?
- how to quickly and reliably establish an interoperable collaboration infrastructure, given the heterogeneity of organizations at multi-levels, and the diversity



**Fig. 1.** Two approaches to virtual organizations creation [5]

of their interaction systems?

- how to build trust among organizations, which is the base for any collaboration?
- how to quickly develop and agree on common principles of sharing and working together?

These questions are difficult to be answered if the open universe of available organizations is assumed. As a consequence, in this case the process of VO creation is time-consuming and complex, discouraging organizations from taking advantage of a sudden business opportunity and from adapting to new business needs. To overcome the above problems, the concept of Virtual Organization Breeding Environment has been developed.

A Virtual Organization Breeding Environment (VOBE) (cf. Section 1) is forcing its members to share common principles, standards and solutions, and thus facilitates the process of VO creation (path 1 in Fig. 1).

## **2.2 Functionality of a VOBE**

The following VOBE functions are supporting the establishment of VOs:

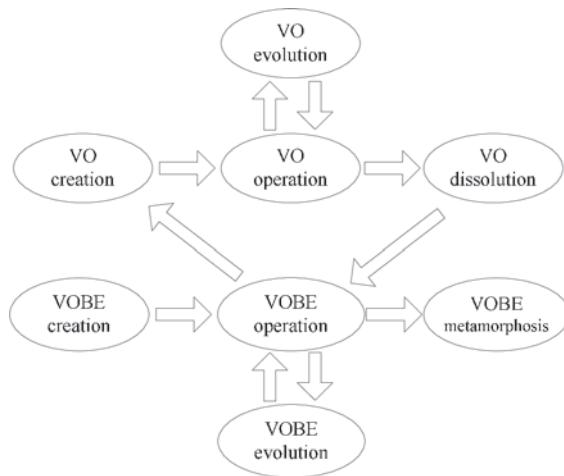
- providing access to information not available in the open universe, such as information about the past performance of VOBE members, providing a standardized description of partner profiles, competences and services;
- supporting the potential partner search and selection;
- providing methods and tools for analysis and evaluation of present and future cooperation performance;
- providing necessary information for trust building among selected members;
- providing software to support collaboration of partners within newly created VOs.

A VOBE facilitates the VO creation by standardizing required information and exchanged data, by creating an environment for the integration of partners, and by providing a set of information not available in the open universe. As a consequence, time and complexity of VO creation, as well as business risk associated with the participation in a VO, are reduced, therefore increasing the number of seized business opportunities.

A VOB provides also support for VO operations in the other phases of the VO lifecycle [5]:

- in the operation phase: support for communication and exchange of documents, infrastructure for integration of heterogeneous information systems, management of common infrastructure, guidelines for standardized data formats, data storage facilities, information about changing environment (context) of collaboration, reuse of artifacts elaborated by other VOs (in particular business process models, best practices), information about new collaboration opportunities, etc;
- in the evolution phase: mechanisms supporting adaptation such as redefinition of business processes and goals, new partner search, support for negotiation, etc;
- in the dissolution phase: knowledge inheritance, i.e., the capturing and reusing of former experience gained during the operation of VOs.

The link between a VOB and a VO throughout the VOB lifecycle is presented in Figure 2. Once a VOB is created, its main goal is to support VOs, in particular VO creation. VOB evolves during its lifetime, modifying and adapting its infrastructure, and policies to new needs of its members. Finally, a VOB can be a subject of metamorphosis leading to potentially new forms of organization. As VOBs usually possess large amount of information, and knowledge, as well as infrastructure and social capital, it is unusual for VOBs to dissolve.



**Fig. 2.** VOB and VO life cycles

### 3 Service-Oriented Virtual Organization Breeding Environments

#### 3.1 Rationale of SOVOBEs

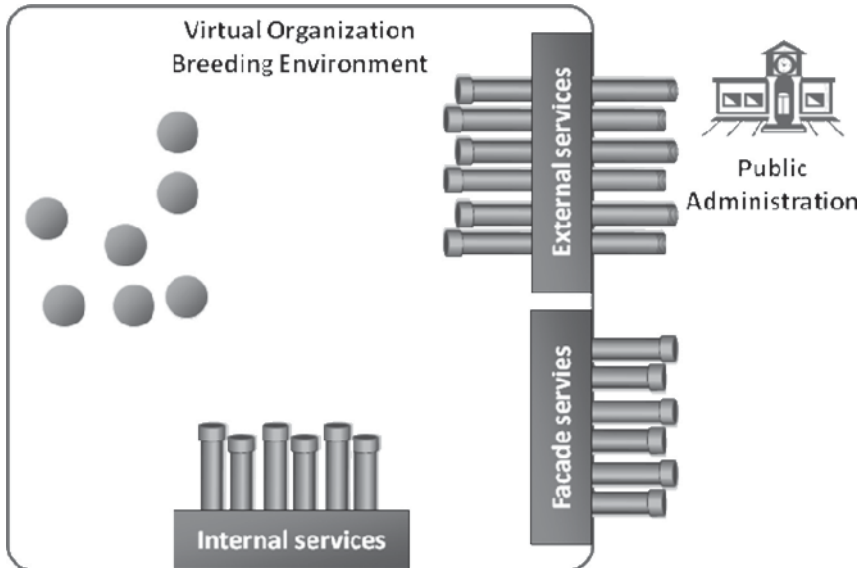
While VOBES are implemented in an ad hoc manner, *Service-Oriented Virtual Organization Breeding Environments* (SOVOBEs) are organized systematically around the concept of a service. As a consequence, concepts underlying SOA may be applied at the coarser level to organizations within the context of SOVOBEs:

- *service reuse* — a given organization may provide the same service within many VOs;
- *service abstraction* — the details of the implementation of services offered by a given organization within a VO are usually hidden for other organizations, because the implementation of the core business services is associated with the know-how capital that gives the organization business advantage over competitive organizations;
- *service discoverability* — services provided by organizations in a SOVOBE are described so that both services and associated organizations may be identified as potential VO partners for a given business opportunity;
- *service composition* — a complex service provided by a VO is the result of composition of services provided by VO partners and eventually by the SOVOBE.

#### 3.2 SOVOBE Architecture Overview

A SOVOBE is a VOBES organized in a systematic way around the concept of a service. Services may be Web services, potentially integrated by an Enterprise Service Bus (ESB), as well as services performed by humans (organizations). Depending on the type of service providers and consumers, the following classification of services is proposed (cf. Fig. 3):

- *business services* — services provided by SOVOBE members for chosen VO partners;
- *internal services* — services provided by the SOVOBE and consumed by its members. This set of services includes services for partner and business service selection, tools for social protocol modeling, social network modeling, performance estimation, and competence modeling;



**Fig. 3.** Services provided by a SOVOBE for its members and the outside world

- *external services* — services provided by organizations operating outside the SOVOBE, but offered by the intermediation of SOVOBE to its members. External services facilitate interactions between external organizations (e.g., public administration units) with SOVOBE, its members and VOs;
- *façade services* — services provided by the SOVOBE to organizations outside the SOVOBE. Façade services provide external organizations with access to information about the SOVOBE and allow the submission of information to the SOVOBE. This set of services includes services for providing information about the SOVOBE and its members' profiles, and service for announcing business needs.

#### 4 SOVOBE Core Internal Services

The number of internal services that a SOVOBE may offer to its members is theoretically unlimited. In this section, a set of internal services common to all SOVOBEs, i.e., *core internal services*, is proposed. SOVOBE core internal services focus on management of either SOVOBE members, or VOs. Other internal services, e.g. trust or security-related internal services, are not addressed in this paper,

neither is the important issue of SOVOBE management, including the management of the core internal services.

First, two core internal services focusing on the management of SOVOBE members are presented: the competence management service provides means for structured description of SOVOBE members, while the social network service addresses relations among SOVOBE members. Second, three core internal services focusing on the management of VOs: the VO creation service, the VO collaboration service, and the VO monitoring service are proposed.

#### 4.1 Management Services of SOVOBE Members

Support for service selection is the main responsibility of a SOVOBE, which must provide methods and techniques facilitating this activity. Aspects taken into account during business service selection process are divided into:

- service description;
- service provider characteristics;
- business process context, in particular social context.

In SOA, standards supporting Web service description such as WSDL [6], OWL-S [7], and WSMO [8], have been developed to provide information necessary to find a service and interact with it. These standards permit [6]:

- *service discovery* — a process for location of services that can provide a particular functionality, while adhering to some client-specified constraints;
- *service invocation* — an invocation of a service by a computer program or a software agent, given only a declarative description of that service, as opposed to when the agent has been pre-programmed to be able to call that particular service;
- *service composition and interoperation* — a selection, composition, and interoperation of services to perform some complex tasks, given a high-level description of an objective.

In a business environment, where services are usually complex, the aim of business *service description remains* the same, but aspects going beyond service description have to be considered during service selection.

An important aspect of business service description is information about entities that may provide a required service. The characteristics of a candidate for a collaboration partner include its competences, certificates confirming competences,



capacities, former performance, realized projects, etc. In SOVOBEs, structured descriptions of SOVOBE members take the form of a competence model. Functionality of competence management and verification is provided by the *Competence Management Service*.

The second important aspect of business service description is the information about existing relations among service providers and service consumers, supported in SOVOBEs by the *Social Network Service*.

**Competence Management Service.** A *service provider* is an organization (in particular: company, public administration unit, business unit, team, person) that provides a given set of services.

*Competency* is defined as “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” [9]. *Competency-based VO creation* is an approach to VO partner search and selection based on information available in a SOVOBE in a form of structured competence description (competence requirements).

To promote itself to acquire new VOs and to be included in VO partner search, each SOVOBE member provides detailed and up-to-date information about the activities it is able to perform and the services it can offer. The information typically includes “an accurate description of member capabilities, its free resources capabilities, the production costs for each of its product, as well as conspicuous proof of the validity of the provided information” [9]. In small SOVOBEs, the competency description can perhaps be transmitted in an unstructured and oral way to VO planners and the SOVOBE administrator. In medium and large SOVOBEs, this approach is not effective because the amount of information to be maintained is significant and complex. Moreover, it changes dynamically over time as a result of adaptation to market needs. In such SOVOBEs, computer support for management of competence descriptions is required. In [9] the following approaches and standards for competence modeling are presented: core competence notion (the first time proposed in 1990), core competence hierarchy (1998), HR-XML competences schema (2001), core competencies in the manufacturing clusters (1999), competence cells (2006), s-a-r-C model (2005). Most of these models have been elaborated to be used in traditional human resources management. Finally, the 4-C model has been proposed in [9] which relies on four key concepts: competence, capability, cost, and conspicuity.

Taking into account the characteristic of SOVOBEs drawbacks of the 4-C model are:

- unclear distinction between the competence and capability concepts;

- poor service-orientation — in the 4-C model a service is modeled as a *product*, output of the activity or process represented by capability — there is one-to-one relation between a capability and a service and, as already mentioned, it is unclear how capability relates to a competence;
- limitation of the competence model to a competence description model — the model misses a method for evaluation of quality and relevance of information in competence description;
- missing concept of competence description change and versioning — competence description can change over time;
- missing clear distinction between competence and service description model;
- very limited model of a service description;
- missing context in the description of competence — competence details may depend on circumstances, especially organization capabilities; including *context* in a service description allow for more detailed specification, i.e., production capabilities and use of resources, delivery time may depend on the season, a price may depend on target market, etc.

Therefore, there is a need for a competence model tailored to the needs of SOVOBE. Such a model should include:

- competence description model consisting of:
  - organization profile;
  - competence profile;
  - service business profile;
- competence verification method;
- competence management method.

Competence description model should encompass methods of verification of competence description relevance. This aspect is, unfortunately, usually ignored. A set of services for management of competences should be included in the model. Such set of services defines possible actions SOVOBE members playing different roles may take.

In SOVOBE, partner selection is strictly connected with service selection. Moreover, a structured competency description creates a possibility of spotting new potential collaboration — joint partners' competences permit offering new services for consumers.

*Competence Description Model.* In the SOVOBE member competence description, it is reasonable to distinguish organization profile, organization competency profile and a business-level service description. Services should be also described on the technical level allowing their consumption, but this kind of description is out of the scope of the competence description model.

Description of organization profile should include a 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.

Competence description consists of concepts referring to organization activities and processes an organization can perform, and their characteristic. Main concepts that should be modeled in SOVOBE as a competence profile, but which are not present or are understood differently in the 4-C model include:

- *service* — in the 4-C model, the term *service* refers to the output of a competence, while in SOVOBEs, the term *service* should be understood as in the SOA environment (cf. Section 1);
- *context* — is defined by a set of triplets:  $\langle object, predicate, subject \rangle$ ; context describes conditions under which a capability may deliver defined outcomes, with defined costs, use of resources, etc.;
- *capacity* — represents the amount of resources needed to perform a given number of processes and activities associated with a capability; a capacity depends on a context;
- *capability* — represents processes and activities of an organization whose many aspects depend on context including cost, capacity, and possible output;
- *competence* — every organization registered in SOVOBE must pose at least one competence; competence may be directly connected with services; a competence includes a non-empty set of capabilities connected with capacities depending on a context; in SOVOBE competences are in M-N relation with services (there is a number of competences needed to provide a given service, on the other hand a competence may be used in provision of many services);
- *product* — modeled as an output of a capability and may take a form of a product or service; in VOBEs this term Product is not used, and Service is a separate object being in M-N relation with Competence; also a concept of Output is introduced and represents the result of the activities represented by a competence;
- *version* — competence versioning allows for tracking of organization evolution and adaptation to market needs and particular collaboration opportunities;
- *visibility* — some competences may be a result of negotiation and adherence to a particular VO; this competence should not be visible for all SOVOBE members but data on such competences should be present in SOVOBE as it might be used for estimation of VO efficiency and other analysis; this issue strongly refers to data access management in SOVOBE.

The business service profile includes business characteristics of a service, free of any technical aspects, i.e., service reference to VO strategic goals, entities responsible for a service, strategy of service, formal requirements, etc. A number

of approaches to service description including business aspects has been proposed, including enterprise architecture modeling (TOGAF [10]), semantic-based approaches (WSMO [8]) and others [11].

*Competence Description Verification.* Information contained in competence description must be reliable. Information provided by an organization must be confirmed or verified against other sources of information about this organization. A competence description model allows for initial verification of data reliability with the use of conspicuities. Conspicuity is a formal or informal document justifying, confirming and explaining information provided in a competence description.

SOVOBE stores information about all organizations, history of collaboration, efficiency of collaboration, former and existing problems, etc. which creates possibilities for verification of information provided in competence descriptions. Sources of information existing in SOVOBE that can be used for verification of competence descriptions are presented in Table 1.

**Table 1.** Data sources for verification of competence descriptions

Category name	Description
1 Continuous monitoring of collaboration	Data provided by monitoring current provision of services and progress of running collaboration processes
2 History of collaboration	Data restored from the history of partners' performance and collaboration within SOVOBE
3 Description of competences	Conspicuities held in descriptions of SOVOBE members and competences
4 Social network	Data provided from social networks

*Competence Verification and Management.* SOVOBE must provide a set of services referring to competence management. This set should include: registration service, create, read, update and delete operations referring to profiles comprising competence description model, versioning services, search and compare services, competence verification and evaluation services, and storage services. Services referring strictly to competence include negotiation services. Access to appropriate services should depend on roles and defined restrictions.

**Social Network Service.** In SOA, interactions between service providers and service consumers are always performed within a *context*, in particular a *social context* defined by relations between them. A context is important as it has been noted by OASIS in the SOA Reference Architecture [13]: "The actions undertaken by participants, whether mediated by services or in some other way, are performed in a context that defines the meaning of the actions themselves. That context is

fundamentally a *social context* — a context that includes other participants. We can formalize that context as a social structure: the embodiment of a particular social context.”

In this section the role of social context in functioning of virtual organization breeding environments and virtual organizations is described.

*Support for VO Creation.* Social aspects play an important role during VO creation. The VO creation process is based on competence requirements and social requirements [14]. While competence requirements determine the competences needed for future VO partners’ cooperation (cf. Section 4.1), *social requirements* concern relations among future VO partners.

In a business environment, information referring only to a particular organization should be supplemented by information concerning relations among organizations. This information may come from sources different from the organization itself. This information concerns past performance, history, trust, recognition, etc. It may strongly influence the selection process. For instance, a VO planner may require candidates for VO partners to have a common successful cooperation history. Such requirement is strictly a social requirement, being in fact a requirement of a certain type of relation between organizations.

*Support for VO Agility.* The social context is significant for VO *agility* [15]. A VO is said to be *agile* if it can rapidly and cost effectively adapt the way it is functioning to changes [15, 18]:

- due to events within a virtual organization, e.g., when a VO partner bankrupts;
- due to events in the environment a VO is functioning in, e.g., when a natural disaster prevents some tasks to be realized.

The adaptation of a VO to new conditions can be simplified by using the social context of VO partners. Adaptation to changes often requires new resources. In a situation when performance of a VO partner suddenly decreases, a possible solution is to search for another organization, which may substitute or complement the current VO partner. The social context of VO partners may be a good place to search at first.

*Social Context Services.* The following social services are proposed in this chapter as SOVOBE core internal services:

- *social context structure management services* — services responsible for creating, reading, updating and deleting information about organizations within SOVOBE and relations among them;
- *social requirements definition services* — services used to define social requirements during VO creation and evolution;

- *social requirements validation services* — services used for validation of social requirements during VO creation and evolution;
- *social context properties calculation services* — services providing properties of social context; these properties can be used in monitoring of social context within SOVOBE or within VOs.

Social context can be modeled as a *social network*. A social network (SN) is a graph in which nodes represent social actors and edges reflect relations among those actors [16, 17].

In SOVOBEs, social contexts are represented by social networks in which actors are SOVOBE members and relations are social relations among SOVOBE members. Changes in a social context imply changes in the social network that represents the context, and in the graph modeling the social network. This way of social context modeling permits to apply well developed tools of graph management to provide computer support for social context services.

*Social Network Metrics.* *Social network analysis* (SNA) methods, based on the graph theory and matrix algebra, are mature and well described in the literature [16, 17]. SNA methods focus mainly on relations and on the overall structure of a social network. The most common social network metrics are [14, 16, 17]:

- *size* — the number of actors of the network;
- *average path length* — the average distance between all pairs of actors;
- *density* — the proportion of relations in a network relative to the total number of possible relations;
- *degree* — the number of relations of an actor;
- *closeness* — the inverse of the sum of the shortest distances between each actor and every other actor in the network;
- *eccentricity* — the maximum of the shortest paths to other actors in the network; eccentricity indicates how far a given actor is from the furthest one in the network;
- *neighborhood size* — the number of other actors to which a given actor is adjacent, i.e., has a direct path;
- *reciprocated ties density* — the ratio of the number of relations that are bidirectional to the neighborhood size.

*Social requirements.* Social requirements concern the nature, structure and characteristics of the relations among organizations in a social network. Social requirements are usually expressed as a set of social network metrics with associated expected values. An example of a simple social requirement concerning a future VO is “the VO must have five partners and one VO leader”, while the associated social network metrics are: the size of the social network and the neighboring size of

one actor, associated respectively with expected values six and five. Social requirements are usually at a high, business level of abstraction, whereas social network metrics are at much lower level of abstraction, focusing on the raw structure of a social network.

To provide computer supported social context services in SOVOBEs, social requirements have to be translated to social network metrics. The process of requirements translation is a complex issue because of difficult expression of usually soft social requirements. It may involve usage of complex techniques such as natural language processing. It needs more attention and investigation [14].

## 4.2 Management Services of Virtual Organizations

**VO Collaboration Service.** The concept of a *social protocol*, on which the VO collaboration service relies, is proposed in this chapter as an attempt to link process models to the social context within which the processes are instantiated.

Process models capture the structure of interactions among persons, organizations and software entities. The social context within which a given process model may be instantiated is not part of the process model.

*Process model.* An important characteristic of social protocols is the potential support for any type of process model. Therefore, social protocols may be based on various types of process model, e.g., Finite State Machines (FSM), Petri Nets, BPEL, and BPMN.

The main requirement imposed on process models is the possibility to extract a *service-oriented* summary of a given process model, which consists of:

- a set of *process roles* — each process role defines a set of rights to consume some services;
- a set of *service providers* — each service provider is associated with a set of services descriptions;
- a set of associated *service descriptions* — each service description consists of a set of attributes as pairs (name, value).

*Social network schema.* Additional requirements for elements of the service-oriented summary may concern:

- necessary characteristics of process roles, service providers, or service descriptions;
- necessary characteristics of relations among process roles, service providers, and service description.

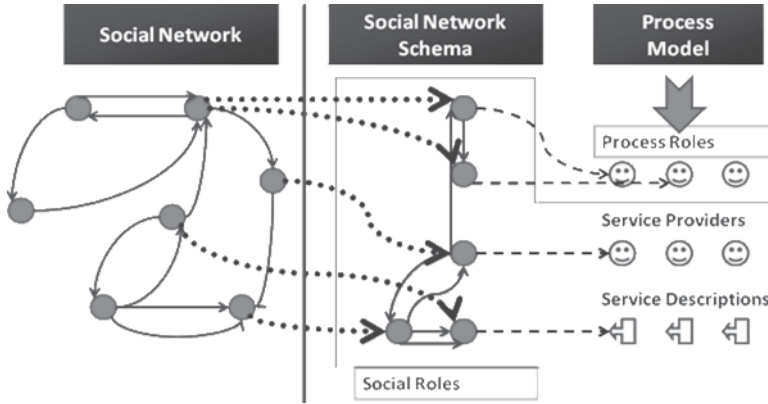


Fig. 4. Social Protocols

In social protocols, the requirements for elements of the service-oriented summary are modeled as a *social network schema*. A social network schema (SNS) consists of nodes and relations. Nodes capture the characteristics of elements of the service-oriented summary, while relations capture characteristics of the relations between elements of the service-oriented summary.

*Mapper and Implementer.* A *Mapper* is the link between the service-oriented summary and the SNS. A Mapper associates process roles, service providers and service description with nodes of the associated SNS. A Mapper is represented by dashed lines in Figure 4.

While process roles capture the rights to perform some activities, the Mapper captures *obligations*: elements of the service-oriented summary associated with nodes of the SNS have to satisfy requirements defined in the SNS node and its associated relations.

An *Implementer* associates nodes of the SNS with actors of the social network. An Implementer is represented by dotted lines in Figure 4.

An Implementer instantiates a social protocol by assigning actors of the SOVOBE social network, i.e., real persons, organization or software entities, to social roles.

**VO Creation Service.** Partner search and selection is a key part of VO creation. A SOVOBE provides its members with a service supporting searching for partners and services suitable for a particular cooperation process. The selection of partners and services on the business level is a complex task that can hardly be automated. It encompasses the following aspects:



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- determination of requirements by VO stakeholders;
  - determination of particular requirements for VO partners and their business services, processes, and services offered to the VO clients;
  - identification of SOVOBE members able to play a particular role in a business process or fulfill a particular task;
  - negotiation and settlement of cooperation rules and conditions;
  - analysis of possible VO variants in terms of conformance to requirements and efficiency of cooperation.

The selection should include various viewpoints:

- subjective viewpoint of a VO planner;
- objective aspects contained in history of collaboration stored in SOVOBE;
- opinions of SOVOBE members represented in a social network;
- anticipated efficiency of collaboration estimated basing on both objective and subjective sources of information;
- requirements imposed on a potential VO by SOVOBE.

Therefore, various services, providing such functionalities as SOVOBE members comparison, VO variants comparison, and support for analysis and filtering of organizations, should be a part of SOVOBE core services supporting partner search and selection.

*Requirements for VO Creation Service.* The VO Creation (VOC) Service is proposed in this chapter as a SOVOBE core internal service. The following are requirements for the VOC service:

- conformance with virtual organization breeding methodology defined in [12];
- human control over the process — in context of complex business processes such search and selection cannot be fully automated, so human control over the process is vital;
- multi aspect and multi criteria process of search and selection:
  - inclusion of social aspects;
  - competence-based approach (cf. Section 4.1);
  - requirement-based approach — social and non-social requirements coming from many sources (SOVOBE, VO planner, potential VO customers, etc.) defined for various elements of virtual organization (process, partner, etc.);
  - definition of preferences referring to requirements and taken into account in VO variant evaluation;
  - multi-variant analysis — evaluation of various partner and service compositions to maximize requirements satisfaction;

**Table 2.** Outline of the partner search and selection procedure implemented in the VOC service

Category name	Description
1 Definition of requirements and preferences	Social requirement extraction from social roles defined in social protocols Requirement definition for VO partners, services, processes, subgroups of partners and services Preference definition Policy formulation
2 Partner selection for social roles	Search for partners satisfying requirements defined for each social role
3 VO variant analysis	Generation of possible VO variants and their validation against requirements and preferences
4 Partner selection for process roles	Alignment of partners to process roles Verification of requirements
5 VO inception	Registration of the created VO Update of SOVOBE repositories: competence model repository and the social network

- collaborative partner search and selection;
- persistency — processes of VO creation must be monitored and recorded for further reuse and analysis.

In Table 2, general steps of the procedure implemented in the VOC service are presented. First, a set of functional and performance requirements identified. These requirements may refer to various VO components: partners, services, processes, subgroups of partners and services. Additionally social requirements are extracted from *social roles* defined in *social protocols* (cf. Section 4.2). Final definition of requirements includes specification of a method step in which the particular requirements will be used in (steps 2–4). Full definition of requirements constitute *VO specification*. Next, potential partners fulfilling requirements of social roles are chosen from SOVOBE members. As a consequence, a non-empty set of organizations is associated to each social role. In step 3, various VO variants are created and evaluated on the basis of above sets. Finally, the best VO variant is chosen and registered in SOVOBE. The whole process is accompanied with negotiations among the VO planner and potential VO members.

In every step, human action is possible and may take a form of requirements redefinition, preference modification, reconfiguration of tools, reordering and repetition of a step.

### 4.3 VO Monitoring Service

**Definition of Performance Measurement.** VO Performance Measurement (PM) is defined as a “systematic approach to plan and conduct the collection and monitoring of data for performance indicators. The Performance Measurement is focused on the process of data collection. The input are defined Performance Indicators (PI) including targets. For these PIs appropriate methods and tools of measuring have to be developed and planned. The collected data are then prepared into indicators. As a result, performance measurement produces reports that could be used for further analyses and interpretation to assess the performance and to derive measures for improvement” [19].

At a higher level of abstraction, PIs are usually combined to define Key Performance Indicators (KPIs). *Key Performance Indicator* (KPI) has been defined as “a performance indicator which represents essential or critical components of the overall performance. Not every performance indicator is vital for the overall success of a company. To focus attention and resources the indicators with the highest impact on performance are chosen as key performance indicators. [...] An *indicator* is a variable which is feasible to assess the state of an object in scope. Indicators could be as well quantitative as qualitative measures. They can not only consist of a single measure but also be aggregated or calculated out of several measures” [19].

VO PM is a difficult task, as it usually implies many KPIs based on data from multiple sources. In a SOVOBE, data for performance indicators may be supplied by most internal services, by business services, and by external services. Supporting the heterogeneity of data sources for PM is a challenge that requires a systematic classification of indicators, as proposed in [19], and providing means for the description and selection of suitable indicators and sources of data essential for their calculation.

**Reference Model for PM.** For SOVOBEs, a *Reference Model for Performance Management (RM4PM)* has been proposed in [19]. The goal of RM4PM is two-fold: on the one hand, the reference model defines a set of common terms that can be used to describe key performance indicators (KPIs). On the other hand, the reference model defines four taxonomies of KPIs, each taxonomy focusing on a given aspect of PM:

- availability and type of data sources;
- subject of measurement (e.g., a process or a VO);
- scope (e.g., a VO or the SOVOBE);
- collaboration characteristics (e.g., responsiveness or flexibility).

**KPIs Calculation.** In SOVOBE, KPIs calculation is based on a function that may be defined in any programming language supported by the Java Scripting technology [20], e.g., AWK, Java, Javascript, PHP, Python, Scheme, SmallTalk. As a consequence, the learning curve is reduced as the probability that the user willing to define a KPI already knows one of the supported programming languages is rather high.

Various data sources may be associated with the parameters of the KPI function, e.g., a KPI may aggregate data coming from the competence management service and the social network service.

**Application of KPIs.** Performance anticipation and monitoring are the two applications of KPIs. The performance of VO variants may be anticipated due to calculated KPIs. Then, VO variants may be ranked according to their anticipated performance.

In the case of KPIs monitoring application, changes in data sources lead to recalculation of the appropriate KPIs. Then the results of the recalculated KPIs are compared with a threshold value associated with a given KPI. If the threshold is reached, a special event is fired to associated services responsible for proper reaction.

## 5 Conclusions

The concept of Service-Oriented Virtual Organization Breeding Environment (SOVOBE) presented in this chapter proves that the Service-Oriented Architecture (SOA), which has its roots in the research area of information system integration, may be applied at the coarser level of organizations. In particular, concepts such as service reuse, service loose coupling, service abstraction, etc. may be referred to virtual organizations.

The main advantage of building SOVOBE systematically around the concept of a service is separation of SOVOBE core services functionality from their implementation, which facilitates changes of SOVOBE service implementations. Changes of service implementations usually follow from SOVOBE member needs to adjust to evolving business environment. Concluding, application of SOA to VOB significantly contributes to VOB agility.

As a target of future works, detailed comparison studies are planned concerning SOA concept application at the Web services and virtual organizations levels. It has been noticed that while concepts used in the communities working independently at both levels are often similar, the terms used to refer to these concepts are usually different. Detailed analysis of similarities and dissimilarities of SOA

implementations at both levels may help to reuse solutions developed by one community in the other community that focused on other aspects of the problem, and vice versa.

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