Agile Service-Oriented E-Business in a Collaborative Networked Environment

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ABSTRACT

The goal of this chapter is to explore potential IT support for collaborative networked organizations encompassing both the service and network orientations of e-business environments. First, it is argued that the main reason for collaboration among organizations is the need for competitive advantage, leading to the concept of Collaborative Networked Organization (CNO) proposed as an appropriate organizational structure supporting the collaboration of organizations. Then, the concept of Service-Oriented Virtual Organization Breeding Environment (SOVOBE) is presented as a means to support CNO creation and operations, while emphasizing both the network and service orientation of SOVOBEs. Next, a feedback loop encompassing adaptation, business processes, monitoring, and networks is proposed as a means to provide SOVOBE members with support for agile collaboration within CNOs. Finally, implementation concerns are discussed, with an introduction of the *ErGo* system supporting organizations willing to cooperate in an agile service-oriented manner in collaborative networked environments

INTRODUCTION

Currently two main trends may be observed in IT: cloud computing and service orientation. The purpose of cloud computing is the networked provision of functions which may be shared by a large set of organizations and/or individuals. In this approach, an information system located in the cloud should provide its customers with a large set of functions and let the customers tailor the system to their needs with the help of metadata. In a cloud computing approach, a single information system available in the cloud is available to many cloud clients, even if the information system may be highly customized to address the needs of each individual client. As an example, Salesforce.com (http://www.salesforce.com/) provides a set of functions related with customer relationship management (CRM) in the cloud. Depending on the chosen set of functions, two pricing options are available: /user/month or by data volume.

Service orientation is about the building of complex applications as the integration of smaller bricks potentially originating from various providers. Providers specialize themselves on narrow functions while consumers assemble various services in more complex applications, picking up the service implementation that matches best their requirements. It is an “open market, on-demand” approach: when a consumer needs a particular service to be performed, potentially many implementations may be already available. In a service orientation approach, many service providers are assumed to serve many service consumers: first, a service is usually available to many consumers and may be integrated to various complex applications. Second, a service consumer usually integrates many services to obtain the required functionality of the complex application. Finally in a service oriented approach, actors, i.e., service consumers and providers, are usually in a rather balanced power situation in which an actor is frequently both a service consumer and a service provider at the same time. As an example both UPS and FedEx, two global courier companies, provide as set of comparable services, these services being targeted to a large set of consumers worldwide. At a technical level, both UPS (United Parcel Service of America, 2011) and FedEx (FedEx, 2011) provide access to their services as a set of interfaces.

Works on both cloud computing and service orientation have lead to important results for the technical infrastructure underlying e-business. Customization and resource centralization are definitively two major features of cloud computing, while decentralization and specialization are two major features of service orientation. An interesting common feature of both cloud computing and service orientation is a new set of business models based on a “pay per use” approach, instead of the “pay per installation host” traditional approach.

While cloud computing and service orientation represent a solid base for the development of an IT infrastructure for e-business, IT support for the collaboration of organizations for e-business is still to be developed. BPEL, WS-* are focusing on the IT infrastructure layer and do not address the human element of collaboration of organizations. Even BPEL4People and WS-HumanTask, which aim at integrating tasks performed by humans in executable business process models, are only partially addressing the importance of humans in the collaboration among organizations.

Two main aspects of the collaboration among organizations are usually eluded, or at least are insufficiently supported: agility and social aspects. In this chapter, the word *agility* refers to the capabilities of a group of individuals and/or organizations to change the way they are collaborating, during the collaboration itself. Individuals are usually agile, adapting continuously their behavior to their context. Organizations are usually less agile than individuals. However support for agility for the collaboration of organizations is usually low.

Social aspects, i.e., relations among individuals and organizations, often play a major role in the collaboration among organizations, from the choice of potential partners which is usually related with former collaborations and the social capital which has been then created, to the interactions among organizations that lead to modifications of the relations among the individuals involved in the collaboration process. IT support for social aspects is usually limited for two reasons: first the relations among individuals and organizations, being usually implicit, are difficult to capture. Second, the most social relations are hardly modeled, e.g., trust and reputation.

However, recent developments have lead to the wide adoption of websites focusing on social aspects, the most famous example being Facebook. It should be noted that not only relations between individuals are supported by these platforms, but organizations are also taking advantage of these platforms to build and develop their networks. It should be noted that the support provided by social network websites is usually limited as regards support for collaboration among organizations. While organizations may maintain an explicit track of their social relations with other organizations, the IT support for collaboration, based mainly on business process management (BPM), usually does not take advantage of these social relations.

In this chapter, it is argued that IT support for dynamic service-oriented e-business should be built on both collaborative and networked aspects of business environments. The two current trends formerly mentioned, i.e., cloud computing and service orientation, do not provide an appropriate support for e-business in collaborative networked organizations. Cloud computing focuses on common needs of various organizations and does not support collaboration among these organizations as a key element of modern e-business. Service orientation focuses on collaboration among organizations with concepts such as *service orchestration* and *service choreography* proposed to structure potentially cross-organizational business processes. However, service orientation does to acknowledge the importance of social networks in e-business environments, abstracting from interpersonal and inter-organizational relations, besides the importance of these social aspects with regard to the agility of organizations.

The goal of this chapter is to explore potential IT support for collaborative networked organizations encompassing both the service and network orientations of e-business environments. A service-oriented virtual organization breeding environment in which, we argue, networks should play a central role, is proposed in this chapter.

In the first section, the rationale for collaboration among organizations is given, leading to the definition of the concept of Collaborative Networked Organization (CNO). In the second section, the concept of Service-Oriented Virtual Organization Breeding Environment (SOVOBE) is proposed as a means to support CNO creation and operations, while emphasizing both the network and service orientation of SOVOBEs. In the third section, a feedback loop encompassing adaptation, business processes, monitoring, and networks is proposed as a means to provide SOVOBE members with support for agile collaboration within CNOs. In the fourth section, concerns associated with the implementation of IT systems providing support for organizations willing to cooperate in an agile service-oriented manner in collaborative networked environments are discussed, as well as the implementation of the *ErGo* system which is an example of such a system.

COLLABORATIVE NETWORKED ORGANIZATIONS

It is argued in this section that collaboration among organizations is a key element of e-business environments. Second, a systematic approach to collaboration among organizations leads to the definition of new emerging organizational structures: *collaborative networked organizations*.

The main reason for collaboration among organizations is the need for competitive advantage. The first theoretical framework that may be used to understand the fundamental need for collaboration among organizations has been proposed by David Ricardo (1817) in his seminal book “Principles of Political Economy and Taxation”. David Ricardo has proposed the concept of *comparative advantage* referring to the ability of an organization (or an individual) to produce a particular good or service with the highest relative efficiency given all the products that it could produce. D. Ricardo has argued that, if organizations focus on the production for which they have a comparative advantage, and if they trade the rest of the products or services they need, the global production may be cheaper and more efficient than when trading does not occur. D. Ricardo has explained that the former statement is true even if some organizations are able to produce all the goods and services more efficiently than the remaining organizations.

Table 1. Ricardo’s example of comparative advantage based on the trade of wine and cloth between England and Portugal

		Wine		**Cloth**		**Sum**	
		Men	Production	Men	Production	Men	Production
Autarky	England	120	1	100	1	220	1W+1C
	Portugal	80	1	90	1	170	1W+1C
	Sum	200	2	190	2	**390**	**2W+2C**
Free-Trade	England	0	0	220	2.2 *(220/100)*	220	2.2C
	Portugal	170	2.125 *(170/80)*	0	0	170	2.125W
	Sum	170	2.125	220	2.2	**390**	**2.125W+2.2C**

The following example, originally proposed by Ricardo (1817), illustrates the concept of comparative advantage and the importance of free trade leading to global and local improvements (cf. Table 1 for a summary of the key figures): two countries, England and Portugal, may produce wine and cloth. England needs 120 men to produce yearly one unit of wine, and 100 men to produce yearly one unit of cloth. Portugal is more efficient and needs only 80 men to produce yearly one unit of wine, and only 90 men to produce yearly one unit of cloth. Therefore, Portugal is more efficient than England for both wine and cloth production. However, both England and Portugal may improve the global production of both wine and cloth if they focus on the production for which they have a comparative advantage: if England focuses on the production of cloth, and only cloth, then 220 / 100 = 2.2 units of cloth may be produced yearly with the same number of men, i.e., 120 + 100 = 220. If Portugal focuses on the production of wine, and only wine, then 170 / 80 = 2.125 units of wine may be produced yearly with the same number of men, i.e. 80 + 90 = 170. Focusing on the production for which they have a comparative advantage, the total yearly production of England and Portugal is 2.125 units of wine and 2.2 units of cloth, instead of 2 units of wine and 2 units of cloth in autarky. The conclusion of Ricardo is the following: England should focus on the production of cloth, Portugal on the production of wine, and they should trade both wine and cloth, even if Portugal is more efficient than England in both wine and cloth production. Therefore, Ricardo legitimate the collaboration of countries and/or organizations, as a means to improve global efficiency.

The concept of comparative advantage has been extended by Porter (1985) with the concept of *competitive advantage* defined as an advantage over competitors gained by offering consumers greater value. Porter has proposed two types of competitive advantage: competitive advantage may result from lower prices, or from the provision of greater benefits and service that justifies higher prices. While comparative advantage focuses on natural and human resources, the concept of competitive advantage takes into account any feature or combination of features that allows an organization to be more competitive than its competitors. Among these features, the use of information systems and the social capital may be encompassed in competitive advantage while they are usually not encompassed in comparative advantage. Porter (1980) has proposed three basic strategies to create and/or keep a competitive advantage: market segmentation (or focus), cost leadership and differentiation. All these three strategies lead to *specialization* of the organization based on the competitive elements of the value chain. Barney (1991) has proposed that “a firm is said to have a competitive advantage when it is implementing a *value creating strategy* not simultaneously being implemented by any current or potential player” (p. 102). Focusing on the resources and attributes which provide the competitive advantage to an organization has a deep impact on its performance outcomes, and therefore, should be a fundamental aspect in every business strategy. As a consequence, organizations should *specialize* to gain a competitive advantage.

As a consequence of specialization, competitive advantages tend to concern narrow areas. However, production and service provision currently require a large set of skills and resources that a given organization is usually not able to handle efficiently: no company has the skills and resources required to produce, pack, and deliver a simple object, such as a toaster, a toothbrush, or a book. It is therefore rather unlikely that a given organization has a competitive advantage covering the whole product or service provided to its consumers. Therefore, organizations should not only specialize, they should also *integrate* with other organizations. It should be remarked that the integration with other organizations may be supported by information systems: information systems are currently ubiquitous and provide means for data and process integration.

The combination of specialization and integration to obtain competitive advantage has been a fundamental constitutional element of many business-oriented organizational structures, such as middle-age guilds, partners clubs, and clusters. Various organizational entity supporting both specialization and integration have been intensively scrutinized:

- communities of practice, defined (Lave & Wenger, 1991) as “a set of relations among persons, activity and world, over time and in relation with other tangential and overlapping communities of practice”,
- virtual teams, defined (Lipnack & Stamps, 1997) as "a group of people who interact through interdependent tasks guided by common purpose" that "works across space, time, and organizational boundaries with links strengthened by webs of communication technologies" (p. 7),
- virtual enterprises defined as “a temporary consortium of autonomous, diverse and possibly geographically dispersed organizations that pool their resources to meet short-term objectives and exploit fast-changing market trends” (Davulcu et al., 1999),
- virtual organizations, defined as “a geographically distributed organization whose members are bound by a long-term common interest or goal, and who communicate and coordinate their work through information technology” (Ahuja & Carley, 1999).

As a potential generic organizational entity supporting both the specialization and the integration of organizations, the concept of *Collaborative Networked Organizations* (CNO) has been coined by Camarinha-Matos, Afsarmanseh, Galeano, and Molina (2009). A CNO is a *Collaborative Network* (CN) with “some kind of organization over the activities of their constituents, identifying roles for the participants, and some governance rules”. A CN is “a network consisting of a variety of entities – organizations and individuals – that are largely autonomous, geographically distributed, and heterogeneous in terms of their operating environment, culture, social capital and goals, which collaborate to better achieve common or compatible goals, and whose interactions are supported by computer networks”. The concept of CNO encompasses the formerly proposed concepts of community of practices, virtual teams, virtual enterprises, and virtual organizations.

The first section may be summarized as follows: within a CNO, organizations collaborate to respond to a business opportunity, integrating their competitive advantages originating from differentiation.

SERVICE-ORIENTED VIRTUAL ORGANIZATION BREEDING ENVIRONMENT

In this section, it is first argued that organizations that would like to collaborate with other organizations within CNOs face a set of challenges related with the creation of the CNO itself and the collaboration among its members. Second, the concept of virtual organization breeding environment (VOBE) is presented as a means to support both the creation and the operation of CNOs. Third, service-oriented virtual organization breeding environments (SOVOBE) are proposed to encompass both network and service orientations of current e-business environments.

Both the creation and operation of a CNO are usually complex processes. The decision to create a CNO is usually the consequence of the identification of a business opportunity. Therefore organizations that would like to collaborate with other organizations within CNOs should monitor their business environment to identify business opportunities. Business opportunities should then be analyzed and evaluated with regard to the competitive advantage of the organization and its potential collaborators. If a business opportunity is evaluated as interesting but requiring the involvement of other organizations, then the business opportunity leads to the creation of a collaboration opportunity.

The next step toward the creation of a CNO is the identification and organization of skills and resources required to respond to the collaboration opportunity. It should be noted that many organizations may be

involved in this step and the identified set of skills and resources may be the result of a complex collaboration process among these organizations.
Next, a set of appropriate collaborators should be selected. Many various aspects should be taken into account during the process of collaborator selection: the set of chosen potential collaborators should obviously satisfy the identified skills and resources required to answer the collaboration opportunity. However, additional aspects, such as relations among the potential collaborators or constraints concerning the global performance of the planned CNO, may have an important influence on the process of collaborator selection (Paszkiewicz & Picard, 2010).
A next step is the definition and negotiation of the rules concerning the future collaboration among CNO members, usually explicitly expressed as contracts. Besides classical aspects of business negotiations, such as price, dates, or intellectual right property negotiations, negotiations among CNO members usually involve details concerning integration of the IT infrastructure and applications, eventually even their standardization. It should be noted that the negotiation phase may end either with the signature of a contract, if the CNO members bind an agreement, or with a lack of agreement. In this last case, it may be necessary to modify the set of selected potential collaborators and to start over the negotiation phase. In some cases, it may even be necessary to modify redefine the collaboration opportunity, i.e., redefine the set of skills and resources.
Finally, a CNO may start to operate when all the relevant partners have been identified and when contracts establishing the rules for collaboration among the CNO members have been signed. The collaboration among CNO members should be eased by the formerly negotiated integration and standardization of the IT infrastructure and applications. An important issue during the operation of the CNO is the monitoring of the interactions among CNO members, especially for intellectual right property management.

To summarize, the creation and operation of CNOs is a complex task, illustrated on Figure 1a). First, business opportunities should be identified, analyzed, evaluated and potentially selected. Next, the skills and resources required to respond to the selected business opportunity should be identified and organized, potentially in a collaborative manner with carefully chosen business partners. Based on the identified skills and resources, the appropriate collaborators should be found. Then, the rules concerning the future collaboration should be negotiated among collaborators, with potentially a standardization and integration of the IT infrastructure and applications among partners. Finally, the execution of the contracts signed among partners should be appropriately monitored.

As a consequence of globalization and the lesser importance of geographical distance, the number of potential business opportunities and potential partners is high. In globalized competitive business environments, the identification of business opportunities and the search of related appropriate potential partners are complicated processes that may consume many resources. The cost associated with the execution of these processes may be higher than the gain coming from the competitive advantage, leading to the conclusion that collaboration is economically not acceptable.

A potential solution to this issue is to share resources and potentially skills required to prepare and support collaboration within CNO among organizations interested in such a collaborative form of operation. It should be noted that, without an additional support, all the steps formerly described must be performed for each business opportunity. However, some steps are similar, if not identical, across CNO creation processes. As an example, the definition of a common architecture may be performed once, and reuse by a given set of organizations planning collaboration and participation to CNOs on the long term. Additionally, some steps may be speed up by appropriate a priori measures. As an example, the search for partners may be significantly improved if all the potential collaborators register their skills and resources before a business opportunity occurs.

The concept of Virtual Organization Breeding Environment (VOBE, often shortened to VBE in the literature) has been proposed by Camarinha-Matos, Afsarmanesh, and Ollus (2008), and is defined 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”.

A VOBE allows potential collaborators to prepare their future collaboration with other VOBE members before a business opportunity occurs. As illustrated on Figure 1b), the process of CNO creation and operation is a two-step process with a CNO: first, organizations join the VOBE and prepare themselves for future collaboration; second, organizations being members of the VOBE create CNOs. A VOBE enables partners to pre-identify interesting partners of a potential CNO from among the members of the VOBE, pre-define and agree on the principles ruling their potential cooperation within a CNO, standardize IT infrastructure and applications common to all the CNOs emerging from a given VOBE. When a business opportunity arises, a CNO may be created in an easier way as organizations being members of the VOBE are already prepared for cooperation. The creation of a CNO may be then reduced to the selection of appropriate partners from among VOBE members, the negotiation of a contract based on pre-defined cooperation rules, the adaptation of IT infrastructure and applications basing on the ones common to all the VOBE members. Therefore, within a VOBE, the creation of a CNO is speeded up and simplified as only aspects specific to a given business opportunity have to be defined during CNO creation.

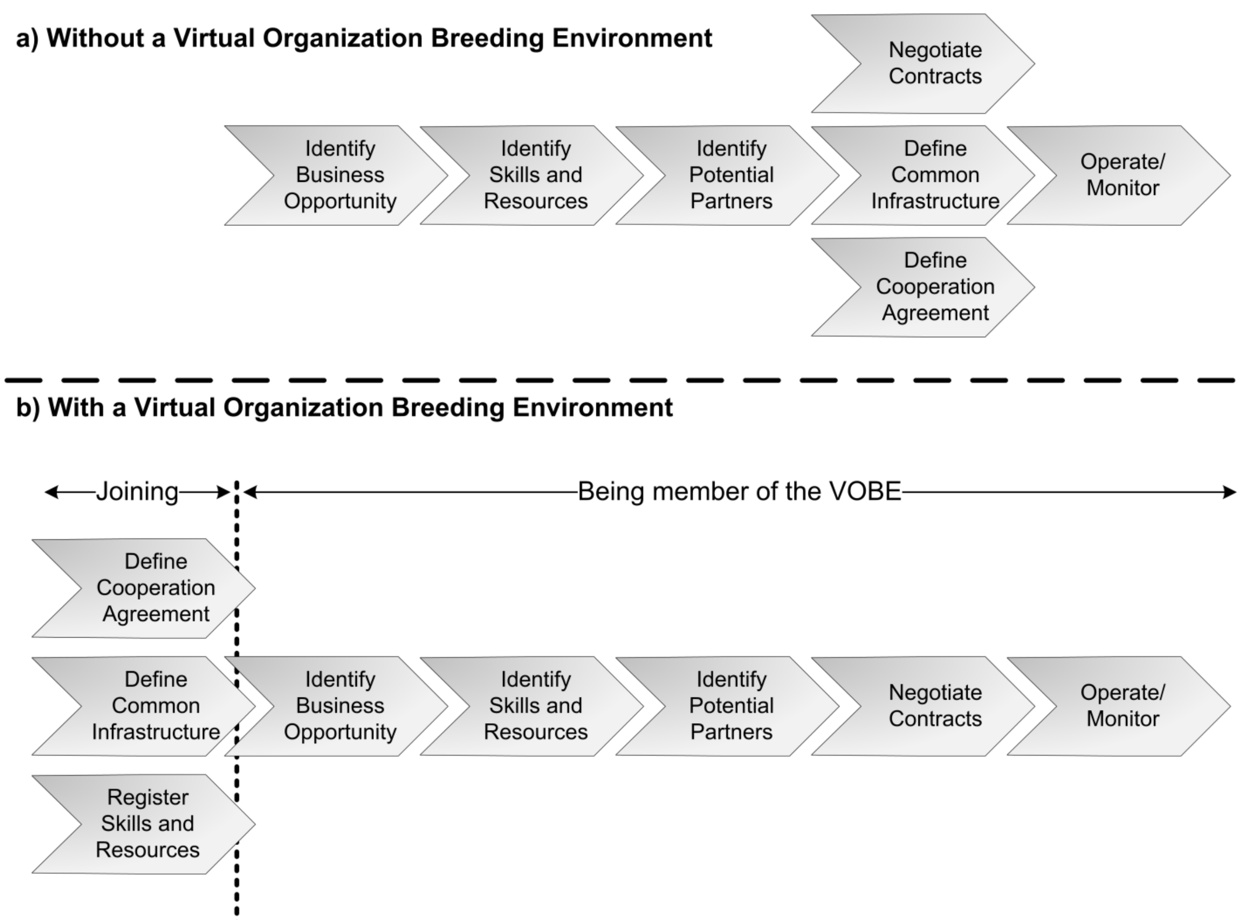

Figure 1. Creation and operation of CNOs a) without a virtual organization breeding environment (VOBE), and b) with a VOBE.

While the concept of VOBE 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 VOBE members and VO partners on business and technical levels. An appropriate IT infrastructure of a VOBE 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 VOBE members is presented in (Rabelo & Gusmeroli, 2008), in which the Service-Oriented Architecture (SOA) has been suggested as a valuable approach to VOBEs implementation. While VOBEs are usually implemented in an ad hoc manner, Picard, Paszkiewicz, Gabryszak, Krysztofiak, and Cellary (2010) have proposed to organize systematically VOBEs around the concept of a service, leading to the concept of Service-Oriented VOBEs (SOVOBEs).

In this chapter, SOA should be understood as defined by the OASIS group (MacKenzie, Laskey, McCabe, Brown, & Metz, 2006): "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" (MacKenzie et al. 2006).

In SOVOBEs, service provision and consumption are the basic constitutional element of interactions among organizations within a CNO, among organizations and the SOVOBE, among organizations and the environment of the SOVOBE, and finally among the SOVOBE and its environment. Picard et al. (2010) have identified four types of services in SOVOBEs, illustrated on Figure 2:

- *core member services* – services provided by SOVOBE members for chosen CNO partners;
- *internal services* – services provided by the SOVOBE and consumed by its members. This set of services includes services for partner and service selection;
- *external services* – services provided by organizations operating outside the SOVOBE, but offered by the intermediation of the SOVOBE to its members;
- *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 business opportunities to the SOVOBE.

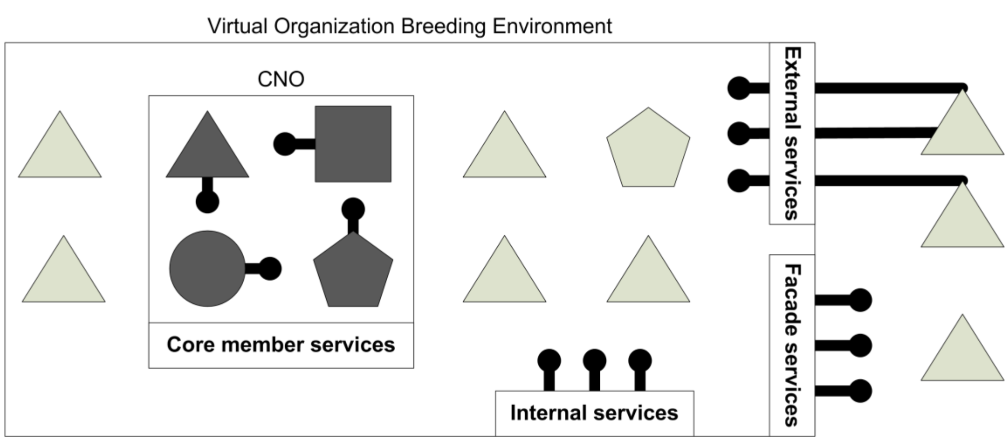

Figure 2. Services in SOVOBEs.

In a SOVOBE, the interactions among CNO partners may be represented by a direct graph modeling interactions among activities. An activity is a “piece of work that forms one logical step within a process” (WfMC, 1999). An activity may be automated work performed by information systems, e.g., creating invoices by a web service , or work performed by humans, e.g., making a decision by a senior executive. In a SOVOBE, the execution of an activity is equivalent to the consumption of a service by a member of the CNO. The interactions among CNO members may be represented as a partially ordered set of activities, where the service consumer associated with the executed activity is a CNO member, while the service provider does not have to be neither a CNO member, nor a SOVOBE member. As an example, within a CNO aiming at building a bridge, the activity “send the blueprints to the customer” may be performed by the architect, which is a CNO member, but the associated service provider may be UPS, which is even not a member of the SOVOBE. It should be noted that a CNO member may be responsible for various activities, i.e., may consume various services. Similarly, two different CNO members may consume the same service: for instance, both the architect and the customer may collaborate with UPS for document delivery. A CNO member may also be a service provider, in some cases it may even provides the service that it is consuming: for instance, UPS is probably delivering its own parcels.

Another important aspect of VOBEs in general, and SOVOBEs in particular, is the reduction of the set of potential partners to a finite subset of existing member organizations. As a consequence, the set of available data concerning organizations that are members of the SOVOBE tends to be more manageable. Among these data, a special role plays the data concerning former cooperation among SOVOBE members, and more generally data concerning networks. The recent rise of social networking websites, such as Facebook (http://www.facebook.com/), QZone (http://qzone.qq.com/), LinkedIn (http://www.linkedin.com/) or Twitter (http://www.twitter.com/), is not confined to interpersonal relationships but is just the expression of a larger trend concerning networks in general. While networks have been an important underlying element of many business environments, with various manifestations such as guilds, trade unions or business clubs, the rise of the Web 2.0 only has lead to the possibility to codify the relationships existing in business environments in a digital form using ubiquitous IT systems. Therefore, the networks underlying business environments currently have the potential to be made explicit, potentially leading to an appropriated IT support, especially in SOVOBEs.

Figure 3 illustrates the relations between the social network, the business process model and collaboration within a given CNO in the context of a SOVOBE. On the top part of Figure 3, activities are represented as two stacked squares: the top square is related with the service consumer, while the bottom square is related with the service provider and a given service. Arrows represent potential sequences of activities, while circles and the diamonds represent events and gateways as defined in BPMN (Object Management Group, 2011). On the bottom part of Figure 3, the social network of organizations is illustrated with a clear distinction between organizations which are CNO members, SOVOBE members, or members of the SOVOBE environment. Arrows between organizations represent relations among organizations. Finally, vertical dashed lines are linking shapes that represent the same organization in the contexts of social network, collaboration, and business process model.

The social network is important, not only as a valuable source of data concerning friendship (as on Facebook) or collegiality (as on LinkedIn), but more generally interpersonal and inter-organizational relationships. As examples, the former cooperation between two organizations and its evaluation by both organizations may be stored in a social network; recommendation of an organization by another organization may be part of the social network; a last example of inter-organizational relations that may be stored in the social network is trust levels. Most internal services provided by the SOVOBE to its members can take advantage of data concerning networks in which the members are involved: for instance, the partner search service may take advantage of the past collaboration history or the mutual evaluations of partners by partners stored in appropriate networks. Therefore, services available in the

SOVOBE, especially internal and façade services, should take advantage of the existing interpersonal and inter-organizational relations stored in the social network. The example of a service supporting the brokerage of services encompassing both functionality and social requirements has been presented in (Świerzowicz & Picard, 2010).

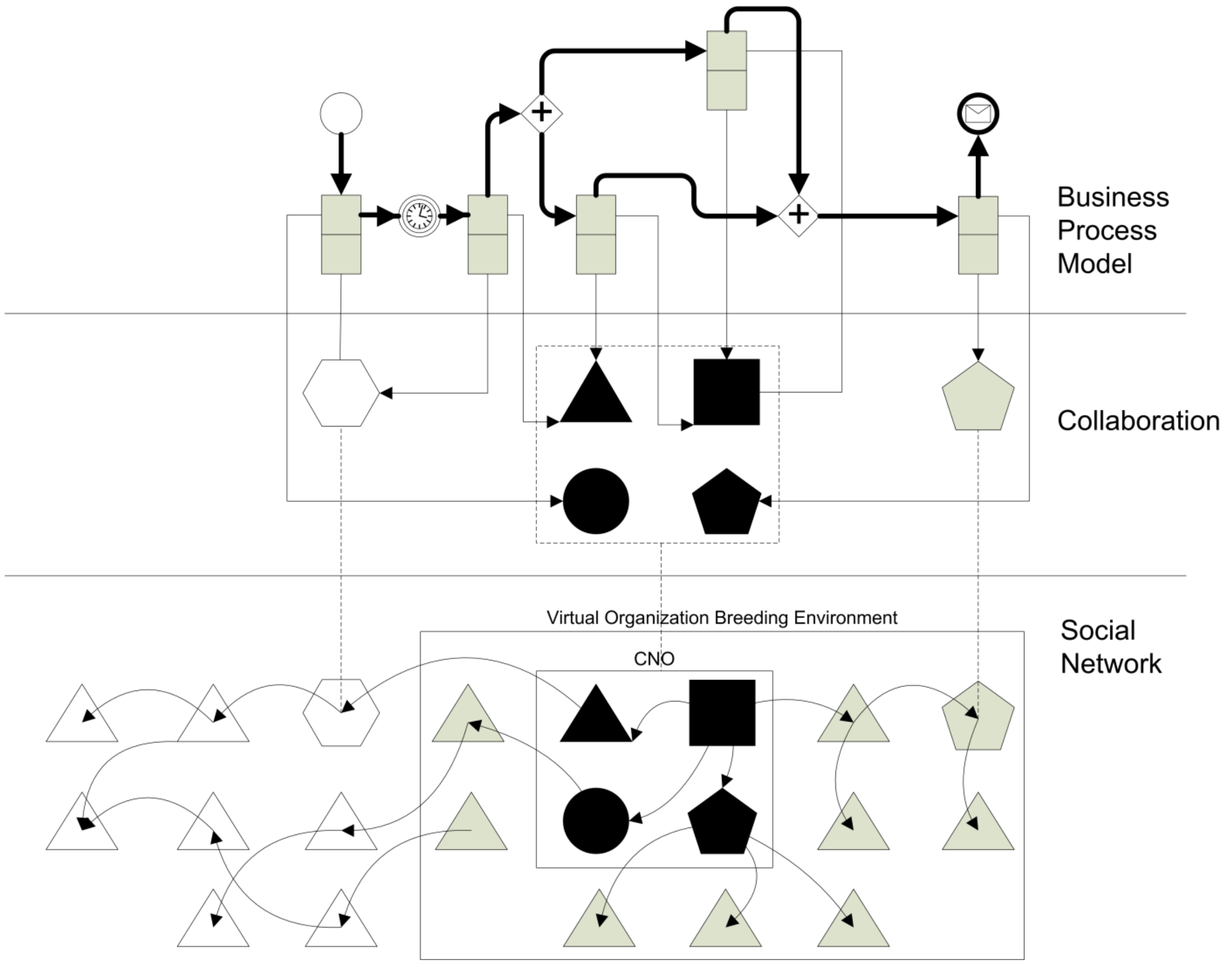

Figure 3. Relations between the social network and the business process model during collaboration among CNO members in a SOVOBE

The second section may be summarized as follows: in a networked business environment, SOVOBEs provide support to CNO creation and operations with the provision of network-based services.

AGILE SERVICE-ORIENTED E-BUSINESS

In this section, it is first argued that business process management, as the current approach to support interactions among CNO members, is not sufficient in the context of highly dynamic business environments. Second, the need for an IT support for agility of CNOs is justified. Third, a solution based on a feedback loop involving adaptation, business processes, monitoring, and social networks is proposed.

A preliminary remark in this section concerns the mismatch between a classical business process management (BPM) approach and highly dynamic business environments. In a classical business process management approach, two assumptions are made: first, it is assumed that the process model may be known a priori, i.e., it is possible to design a process model that is further instantiated and later on executed. Second, it is assumed that the business environment is rather static, which implies potential process repetition, i.e., a given process model may rule many process instances. In this section, it is argued that the two former assumptions are not necessarily observed in highly dynamic business environments. If a business environment is highly dynamic, with organizations continuously created, modified and disappearing at a high rate, it may not be possible to identify partners associated with needed skills or resources. As a consequence, as modeling process implies the availability of certain types of partners performing certain activities or tasks, it may not be possible to model properly a certain type of processes. For the same reasons, repeatability of certain processes may be challenged in highly dynamic business environments, with potentially different sets of organizations and services, altogether with the associated skills and resources, available in time.

Additionally, Swenson (2010) has identified the problematic case of processes related with knowledge work, e.g., emergency rescue, financial audit or bridge construction engineering, for which he argues that a new approach is needed, referred to as adaptive case management (ACM). An important case of processes related with knowledge work are collaboration processes within CNOs. Among various characteristics of these processes, Swenson distinguishes three aspects: processes related with knowledge work are not repeatable, unpredictable, and emergent. The *non-repeatable* aspect of CNO collaboration processes refers to the impossibility to apply a sequence of tasks that works in a given process instance to another process instance. A main reason for non-repeatability is usually the unique character of the object on which the collaboration process focuses, e.g. a given emergency rescue situation, a given organization financial situation, a given bridge. The *unpredictable* aspect of CNO collaboration processes refers to the impossibility to plan a-priori a sequence of tasks to reach an expected goal. A main reason for unpredictability is the high dynamics of the business environment. Finally, the *emergent* aspect of CNO collaboration processes refers to the influence of the execution of a process on the process itself. During an emergency rescue, the way a given injured person is rescued depends on his/her state. Therefore, execution of the rescue process may be a reason of its change: the identification of a myocardial infarction during the examination of the injured person at a countryside-located accident may imply reanimation and immediate helicopter transportation, instead of the usual ambulance transportation.

The *non-repeatable* aspect of such collaboration processes has been at the core of the rationale for CNOs, and is therefore supported by SOVOBEs with the provision of services related with the creation and configuration of CNOs. However, both the *unpredictable* and the *emergent* aspects of CNO collaboration processes are usually not supported by SOVOBEs which assume a classical business process management approach.

In ACM, a fundamental idea is that a process may not be modeled a priori (as in BPM), but the design of a process model should be performed at run-time, while the human interactions are ruled by the process model. A similar idea has been largely studied by Harrison-Broninski (2005). Harrison-Broninski has identified that many human interactions are based on flexible, innovative, collaborative human activity. While social relations are mentioned a few times in (Harrison-Broninski, 2005) as a potential information that may be relevant for flexibility and innovation, the weakest point of both Swenson's and Harrison-Broninski's works remains the lack of clearly articulated solutions to the very well presented set of issues.

From a more technical perspective, Picard has proposed the concept of *social protocol* (Picard, 2006), based on the concept of collaboration protocol (Picard, 2005). The concept of social protocol originates from the idea that, during collaboration, not only the set of possible sequences of activities matters, but also the social context, i.e., the set of collaborators, the role they play and their relations, is an important aspect of the collaboration. Therefore, a social protocol consists of a process model, a model of a social subnetwork containing the collaborators, and links between the process model and the social network model. A generic extended version of the concept of social protocol, including elements related with the modeling of the social environment, has been formally presented in (Picard, 2009b). Recently, the concept of social requirements has been studied as a basic element of social protocol.

The adaptation of social protocol has been presented in the context of CNOs in (Picard, 2009a; Picard, 2009c). Adaptation refers to the capability of a CNO to “modify at run-time the model ruling its interactions” (Picard, 2009a) While Picard has presented both the importance of social networks for the collaboration among CNO members (with the concept of social protocol), and negotiation-based techniques for adaptation of social networks, the relations between adaptation, business processes, and social networks are still to be established.

It is argued in this section that a feedback loop encompassing business processes, monitoring, and social networks may improve adaptability. As a consequence, the proposed feedback loop may provide support to both unpredictability and emergence of collaboration processes.

In the proposed loop, besides the elements formerly discussed, i.e., business process and networks, the critical issue of monitoring is introduced as a key element of the feedback loop. In a SOVOBE, monitoring is usually a key internal service provided by the SOVOBE to its members. A SOVOBE provides support to the collaboration among members of a given CNO with the provision of services related with business process management. A SOVOBE may provide its members with a service-oriented IT infrastructure, such as an Enterprise Service Bus (ESB), to provide common interoperability means at the IT level. A SOVOBE may then monitor the collaboration among CNO members to control the “health” of the CNO. Moreover, a SOVOBE should monitor its resources, such as the collaboration preparedness of its members and the availability of resources they may provide within CNOs. Finally, a SOVOBE may monitor external resources using its external and façade services. Summarizing, a SOVOBE should monitor not only the collaboration within a given CNO, but also the whole environment of the CNO.

The introduction of monitoring in SOVOBEs is needed to address the agility of CNOs, defined as the capacity of the CNO members to rapidly and cost efficiently adapt the way they interact to changes that may occur:

- either in the CNO (e.g., an organization may merge with another organization or acquire new resources), or
- in the environment of the CNO (e.g., weather may prevent the execution of a planned activity).

The detection of changes requires, first, the monitoring of the condition of the CNO and its environment, second, the specification of changes leading to adaptation of the CNO. A classical means for the detection of changes is the definition of key performance indicators (KPI) to specify aspects of the CNO or its environment that may lead to adaptation, e.g., number of workers involved in the CNO. Next, thresholds may be associated with KPIs to define the conditions in which a modification of the value of a KPI implies an adaptation by the CNO members.

In this section, the relations between adaptation, monitoring, business processes, and social networks are analyzed from a control theory perspective. A main goal of control theory is to provide support for the behavior of dynamical systems, often aiming at stabilizing these systems. A fundamental element of control theory is the feedback loop presented in Figure 4a). In this loop, a *system* generates an output based on its own state and its inputs. Next, a *sensor* measures the system output, potentially filters and transforms it to generate an associated measured output. The measured output is further compared with a *reference*, which is related with the expected system output. The result of the comparison (often performed as a simple subtraction) represents the *measured error*. Finally, the *controller* modifies or creates system inputs to reduce, eventually to suppress, the measured error.

In a similar manner, illustrated in Figure 4b), a SOVOBE may inform the members of the CNO that some previously defined conditions defining a healthy state of the CNO – similar to the reference in classical control theory – are not satisfied anymore. As examples, weather conditions may have important influence on the building of a bridge, an anesthesiologist may be needed in the rescue helicopter, a firefighter may have been injured and not be able to perform his/her job.

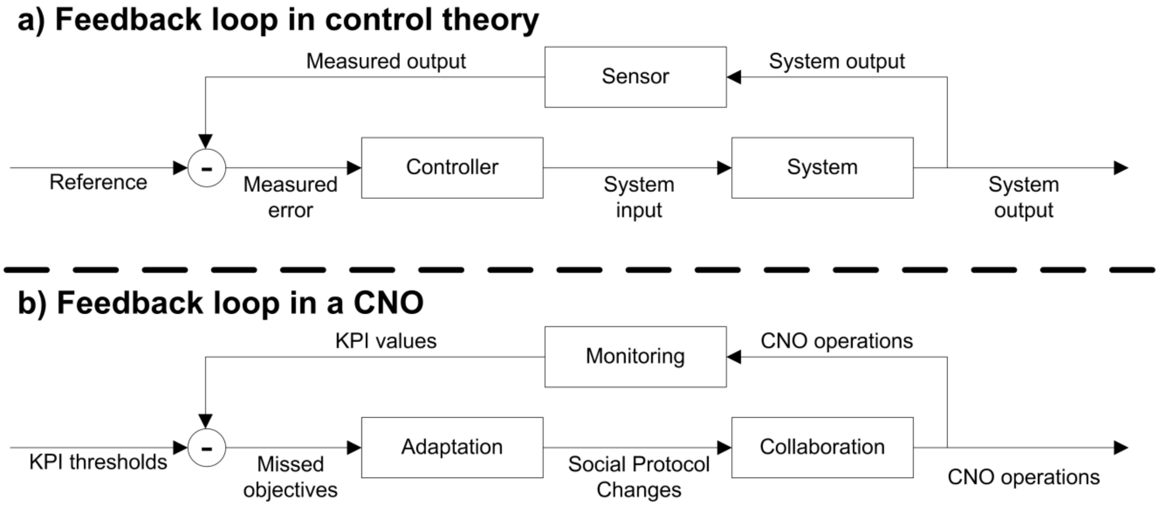

Figure 4. Feedback loop a) in control theory, b) in a CNO.

As a consequence, CNO members should adapt, modifying the way they interact. Adaptation is a controller. Among various possible reactions, members of the CNO may search for organizations and services, either to perform new activities or to support already performed ones. A major source of organizations and services is the networks of the members of the CNO. Therefore, the first attempt to find rapidly and in an agile manner the needed partners and services is based on the networked-based search services provided by the SOVOBE. When the partners and services are identified, the process model ruling the collaboration among members of the CNO is adapted to support the newly introduced organizations and services and the replacement ones.
As a consequence, the CNO, the process model that rules the collaboration among its members, as well as the environment of the CNO will be modified. The CNO and its environment correspond to the system in the feedback loop from Figure 4a). Modifications of both the business process and social network aspects of the CNO and its environments may lead to changes in the evaluation of the health of the CNO, i.e., may lead to a different system output, closing the feedback loop.

The third section may be summarized as follows: in a networked business environment, support for agile CNO may be based on a feedback loop encompassing adaptation, business processes, monitoring, and social networks.

IMPLEMENTATION CONCERNS

In this section, it is first argued that each element of the feedback loop in a CNO presented in the former section is the object of many research works, rising important implementation issues. Second, a system—the *ErGo* system—aiming at implementing a SOVOBE supporting agile service-oriented e-business in collaborative networked environments is presented. Third, the implementation of each element of the feedback loop in the *ErGo* system is discussed.

The feedback loop in a CNO presented in the former section is based on highly abstract concepts: adaptation, business processes, monitoring, and social networks. Each of these concepts are related with a set of functions, methodologies, and tools that have been proposed, as well as a set of issues that are still currently under research. As an example, the concept of social networks have been the object of intense research works for decades; tools supporting social networks, such as Facebook, have been developed.

Among issues related with social networks still under research, the establishment and propagation of trust among organizations may be serve as an example.

However, the implementation of IT systems supporting organizations willing to cooperate in an agile service-oriented manner in collaborative networked environments requires each of these abstract concepts to be implemented. The main issue related with the implementation of appropriate IT support is the lack of standards for these abstract concepts: while standards have been widely accepted in the industry in given IT areas, such as relational databases for data storage, no standard has been currently defined and accepted for adaptation, business processes, monitoring, and social networks. Even the implementation of the concept of business processes, for which a set of standards have been proposed in the past decades, such as BPEL or BPMN, is risky for the simple reason of the multitude of proposed solution and the lack of consensus about one single accepted standard. As a consequence, the implementation of IT systems supporting organizations willing to cooperate in an agile service-oriented manner in collaborative networked environments is currently a challenge, especially when the sustainability of the implementation is a strong requirement.

Such IT systems may however be implemented. The *ErGo* system may be given as a proof of the feasibility of the implementation of such IT systems. The *ErGo* system—from the Greek word έργο, meaning „task", "work"—implementing the presented concepts is currently under development (http://ergo.kti.ue.poznan.pl/). The chosen application area is the construction section, in which organizations are usually working within CNOs in a very agile manner. A main client of the developed system are real-estate development organizations, which are creating CNOs to answer business opportunities. Real-estate developers are usually delegating most of the construction activities and focus on coordination activities. An original aspect of the *ErGo* system is the business process models used to control collaboration among CNO members, i.e. subcontractors of the real-estate developer: in the *ErGo* system, business processes are modeled as a set of contracts between the real-estate developer and subcontractors. The execution of the contracts may further be monitored with KPIs, as well as the whole CNO and its environment. If the realization of an investment meets an obstacle, the CNO members may start adaptation, i.e., may modify the set of members of the CNOs and/or the contracts related with the investment.

The number of internal services—services provided by the SOVOBE and consumed by its members—that a SOVOBE may offer to its members is theoretically unlimited. However, a set of internal services common to all the SOVOBEs, i.e. core internal services, proposed may be identified: SOVOBE core internal services focus on management of either SOVOBE members, or VOs. The *ErGo* platform consists of a set of SOVOBE Core Internal Services on which a SOVOBE tailored to the needs of a particular group of cooperating organizations or a particular sector may be built. Besides aspects related with the technical integration of various internal services and tools, the *ErGo* platform is organized around 5 core internal services. First, two core internal services focus on the management of SOVOBE members: 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 focus on the management of VOs: the VO creation service, the VO collaboration service, and the VO monitoring service.

The general architectural assumptions for the *ErGo* encompass the following:

- *extensibility* – adding new functionality and integration of new system functions must be easy to conduct;
- *replacement* – the parts of the system that provide a particular functionality may change overtime;

- *robustness* – some system functions may be temporary unavailable and this fact must not result in system failure;
- *adaptability* – system must be easy to adapt to future changing requirements that are difficult to predict; appearing new requirements may result in change of desired system functionality and in change of implementation of any system function.

To meet the specified assumptions, among all the architectural decisions, the following two most important should be mentioned:

- *modularity* – system functions are grouped and implemented as separate system modules; each module is a separate standalone set of functions that may be used in separation from other components; the main motivation for this approach is the fact that modularity facilitates system modification; easy module replacement facilitates system extension and adaptability.
- *communication based on events* – system components communicate using events; the events triggered by any system component – both *ErGo* applications and system modules – should be broadcasted to other components interested in receiving information about an event of a particular type; event based communication support separation of components – event source component does not need to know who may be interested in an event, this responsibility should be on a side of a listening component; event-based communication supports extensibility, adaptability of the system as well as changeability and replacement of system components.

OSGi has been selected as the framework used in the development of the **modular** *ErGo* system. Equinox has been selected as the default OSGi container for the ErGo system, because of the seamless integration of Equinox with the Eclipse IDE.

The communication based on events in the *ErGo* system is based on an application of the EventAdmin standard libraty of OSGi that allow modules—bundles in an OSGi vocabulary—to communicate in both a synchronous and asynchronous way in a **decoupled** manner. In this approach, the bundles are not communicating directly: if a bundle A wants an action to be performed, it creates an *event* that describes the request to be performed; next, the event is sent to all the bundles in the OSGi container; then, if a bundle B is able to process the event, it does so. A key characteristics of the communication based on events is the decoupling between the bundle A and the bundle B: in other words, the bundle processing a request does not need to know the bundle that has sent the request. Similarly, the bundle sending a request does not know a priori the bundles that may process the event.

Communication based on events simplifies drastically monitoring. The evolution of the system may be captured by a bundle that would process all the events sent by all the other bundles. Such an implementation has been chosen for the monitoring of the *ErGo* system. Monitoring in *ErGo* is based on Key Performance Indicators (KPIs). Based on KPIs it is possible to evaluate key factors for SOVOBE and the aspects taken into account in selecting potential organizations for CNOs. The KPIs are defined by a function, which allows for its value calculation. The function includes parameters which have to be assigned to the data sources, taken not necessarily from the KPI module. These may be data sources retrieved from the social network module, or the competence description module which are also the parts of the *ErGo* system. The parameters with their associated data sources are called the attributes which are calculated by assigning the arguments used in their composition to the specific values. Finally, basing on the function the value of the KPI is calculated, which measures an actually studied aspect. Additionally, new data sources can be added as needed to the KPI module and be dynamically used to define new

indicators. KPIs can be reused and used for calculation of more complex formulas – this imposes the concept of the hierarchy of KPI.
KPIs are also used for monitoring the processes within the *ErGo* system. The idea of KPI monitoring is to react on appearing deviations from the accepted level of performance. KPIs may be associated with value boundaries within which their values should be held. If a KPI value is out of the associated boundaries, a special event is fired. As a result the set of KPIs can be defined and then used for monitoring the values which are in fact the values of these KPIs.

Social network modules of the *Ergo* system are responsible for creation and management of the social network within the VOBE. Social network is a graph in which nodes represent actors and edges represent relations among the actors. In the *Ergo* system actors are mainly organizations, services and users existing in the SOVOBE.

The concept of a *social protocol*, on which the VO collaboration service relies, has been proposed and implemented in the *ErGo* system as an way to link process models to the social context within which the processes are instantiated, supporting both the concepts of adaptation and business models.
While 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. In social protocols, the requirements for the social context 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 social context, while relations capture characteristics of the relations between these elements. The concept of social protocol has been detailed in (Picard et al., 2010).

The fourth section may be summarized as follows: while the implementation of IT systems supporting organizations willing to cooperate in an agile service-oriented manner in collaborative networked environments is a challenge, the currently available technology enables the development of such systems, with the *ErGo* system as a proof of feasibility.

CONCLUSION

The landscape of e-business has changed drastically in the past 15 years, from silos of information to the current Web 2.0 environment. Amazon.com (http://www.amazon.com/) may serve as an example: from an electronic bookstore, Amazon has evolved to a e-business platform for other organizations, providing services such as storage features with Amazon S3 (Amazon, 2011a) and computing power with Amazon EC2 (Amazon, 2011b). eBay (http://www.ebay.com/) has follow a similar evolution, offering access to most of its services via specialized application programming interfaces (APIs) (eBay, 2010). This evolution towards cloud computing is well adapted to repetitive cases, e.g., some specialized APIs of eBay are tailored to answer the repetitive needs of large merchants. Support for repetitive cases are also a major reason for the large number of developments related with BPM in the past decade: BPM aims at providing support to repetitive activities structured with business process models.

Besides repetitive cases, which will with no doubt still be present in the future, a new class of cases have already been identified by Swenson and Harrison-Broninski. These cases may be characterized by three main traits: they are not repeatable, unpredictable, and emergent. A typical example of such a case in an e-business environment is the organization of a meeting: each meeting has a different context (not repeatable), it is difficult, not to say impossible, to forecast all the steps required to find the final meeting time (unpredictable), and finally the next steps to find the meeting time may usually only be identified during the establishment of the meeting time (emergent).

In this chapter, it is argued that the collaboration of organizations, forced by the obligation to focus on their competitive advantage, requires a new organizational structure and associated IT support. The concept of SOVOBE has been proposed as such an organization structure fostering the creation of CNOs. An important contribution presented in this chapter is the integration of a social network to a SOVOBE, which already encompasses service orientation. The proposed solution provides organizations with advanced means for collaboration based on both a social network and a business process model. The integration of a social network to a SOVOBE would be probably more and more important as social websites are becoming ubiquitous.

A second contribution presented in this chapter is the proposed IT support for agility of organizations in the context of a CNO. Contrarily to most current solutions in which the model of the collaboration is first designed and then executed, with no possibility to modify the model at run-time, the proposed solution includes a feedback loop to enable adaptation of collaboration among CNO members. The feedback loop is based on control theory, originally focusing on the behavior of dynamic systems. The controller of the feedback loop provides adaptation to the social protocol, i.e., both the members of the CNO and the business process model ruling the collaboration may be modified at run-time.

Among future works, the relations that may exist between the concept of competitive advantage, social network and business processes are still to be defined. It would be very valuable to be able to prepare a collaboration strategy based on social interpersonal and inter-organization relations, and the activities to be performed in the chosen business process model. Another important task is the validation of the proposed concepts with real cases. The development of the *ErGo* system and its planned application to the construction sector is a first step in this direction. Another area for future investigation concerns potential implementation of the controller part of the feedback loop. An interesting approach would be to evaluate how the proposition of control theory concerning implementation of the controller may be transpose to the CNO context. For instance, a classical implement of the controller is the proportional-integral-derivative controller. In this implementation, the controller tries to correct the measured error by creating a system input encompassing 1) the present error, i.e., the proportional part, 2) the accumulation of the past errors, i.e., the integral part, and 3) a prediction of the future, i.e., the derivative part. Such an implementation may be transpose to the CNO context: the adaptation mechanism should then be a collaborative process leading to a modification of the CNO members and/or the business process model ruling the collaboration among CNO members, based on decision making tools taking into account 1) historical data concerning past collaboration, 2) the current situation of the CNO, and 3) simulation tools supporting a prediction of the consequences of proposed changes.

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KEY TERMS AND DEFINITIONS

Adaptation: the capability of a CNO to modify at run-time the model ruling its interactions.

Agility: the capability of a group of individuals and/or organizations to change the way they are collaborating, during the collaboration itself.

Collaborative Networked Organizations: an organization consisting of a network of largely autonomous organizations and individuals, which collaborate to better achieve common or compatible goals, supported by computer networks.

Service: a mechanism to bring together needs and capacities, either human or computed ones.

Social Network: a dynamic graph in which nodes represent individuals and organizations, and edges represent interpersonal and inter-organizational relations.

Social Protocol: a model of collaboration encompassing both a business process model and a social network model.

Virtual Organization Breeding Environment: an organization supporting organizations willing to collaborate within CNOs, by increasing their preparedness towards collaboration.