On management of 2nd generation Virtual Organizations Breeding Environments

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1. Introduction

In recent years large companies increasingly and continuously restructured their internal operations and information systems, and re-engineered their production processes in order to eliminate their waste, lower their costs and increase their opportunities and profit. But this extensive approach to change is not affordable by small and medium size organizations (SMEs). Alternatively collaboration within networks of organizations also called the CN (Collaborative Networks) has nowadays become very important for SMEs that strive to achieve a differentiated competitive advantage.

The CN paradigm supports these entities in achieving their common or compatible goals (Ivanov, Kaeschel, & Arkhipov, 2006). Of particular relevance to the CNs are the dynamic virtual organizations (VOs) that can be rapidly formed, when triggered by an opportunity (business-oriented or otherwise), and their special tailoring to the requirements of that opportunity. This notion of dynamic formation is frequently associated with requirement for agility, as well as being used as a survival mechanism in face of market/society turbulence (Franke, 2002; Goranson, 2006).

This paper adopts the following definition of VOs:

“VO is an association of (legally) independent organizations (VO partners) that come together and share resources and skills to achieve common goals, such as acquiring and responding to a market/society opportunity” (Afsarmanesh & Camarinha-Matos, 2005).

Working in collaboration implies on one hand sharing the opportunities and gained profits, but on the other hand also sharing the risks and losses, which in turn increase the survival chances of SMEs.

Dynamic creation of VOs however, as needed at the emergence of new opportunities, faces a large number of challenges far from being resolved, including: finding the most suitable partners at a local level or even worldwide, and establishing the needed commonality on concepts/models/infrastructure, among others.

Among others, some of the main obstacles in establishing VOs include the following. These obstacles have clear effects on the decision making process of the VO planner:

- Lack of the needed competency information, e.g. unavailability of catalogues with normalized and updated profiles/competencies of organizations.
- Lack of a common cooperation/collaboration infrastructure as well as common working and sharing principles.
• Lack of internal preparedness of organizations, to join the collaborative processes and to co-work (Jansson, 2005).
• Lack of advanced knowledge about performance of other potential organizations with whom to collaborate.

Both research and practice have shown that the pre-existence of long-term associations/clusters can greatly enhance the efficient creation of VOs, in response to emerged opportunities. Geographical closeness represented several advantages for collaboration, such as common adoption of the local culture and easier facilitating the creation of trust and “sense of community”. But, gradually the clusters could step beyond the geographical regions in order to access new competencies and new market opportunities, which is enabled by the development of more effective communication infrastructures. As such nowadays, long-term clusters/associations are not necessarily bound by geographical closeness.

The concept of Virtual Organizations Breeding Environment (VBE) is therefore introduced to address many new challenges involved in the establishment and management of these “strategic” long-term alliances. This paper adopts and applies the following definition of the VBE:

“One VBE is a strategic association/alliance of organizations and the 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” (Afsarmanesh & Camarinha-Matos, 2005).

Examples of early VBEs can be found in different parts of the world, including: IECOS (Mexico); CeBeNetwork (Germany) Helice network (Spain); NetworkA (Finland); Virtuelle Fabrik (Switzerland); Torino Wireless (Italy); etc. (Afsarmanesh & Camarinha-Matos, 2007). These cases are basically confined to specific geographical regions and still use little support from ICT tools and are governed by a limited conceptual framework, constituting what we could call the 1st generation VBEs. Through close interaction with many of these networks, it has been possible to collect a large amount of empirical knowledge and requirements that constituted the base to establish a new model and conceptual framework for VBEs as well as for dynamic creation of VOs within the VBEs and corresponding advanced support ICT infrastructures and tools, leading to the 2nd generation VBEs.

In the remaining of this paper, the results achieved in EU funded ECOLEAD integrated project, addressing both the support for establishment and management of 2nd generation VBEs and fluid formation and creation of VOs, are classified into the following five key aspects:

- Reference framework
- Value systems and trust management
- VBE management system
- VO creation framework
- Contract negotiation wizard

In Sections 2–6 below, we briefly address the achievements for each of these key aspects, while Section 7 concludes the paper.

2. Reference framework

While the definition and modeling of VBEs has become more formalized during the last five years, “reference models” for VBEs are yet to be established. Such models shall address the structural, componential, behavioral, operational, topological, cultural, and legal aspects of VBEs, among others (Afsarmanesh & Camarinha-Matos, 2008). In the ECOLEAD project a first attempt contributing to the definition of a “reference framework” was made, addressing the fundamental elements of the VBEs (Afsarmanesh, Camarinha-Matos, & Msanjila, 2007). This framework was further validated through empirical trials by a number of international industry-based VBE networks involved in this project, as well as a few others outside. This section summarizes the main aspects of the VBE reference framework.

The main elements of the VBE reference framework are characterized in ECOLEAD (Camarinha-Matos & Afsarmanesh, 2008), including: the main concepts, entities, and actors of the VBEs, as well as their inter-relationships. Also different stages of VBE life cycle and its working and sharing principles are defined.

The main elements of a VBE include (Afsarmanesh & Camarinha-Matos, 2005):

- **VBE members**: The organizations that are registered at the VBE, including: (i) Business entities that wish to get involved in the VOs to gain quantitative profit; (ii) Non-profit institutions (e.g. academic/research institutes) that get involved in the VOs to gain qualitative profit; (iii) Support institutions, e.g. insurance companies, and training institutes.
- **Roles**: A variety of roles can be assumed by VBE actors, examples of VBE roles include: (i) VBE-member; (ii) VBE-administrator; (iii) Opportunity-broker; and (iv) VO-planner, and (v) VO-coordinator; among others.
- **Life cycle**: Representing the stages that a VBE may go through, from its creation (initiation/recruiting and foundation) stage, to its operation, evolution, and possible dissolution and metamorphosis.
- **Assets**: Representing valuable elements produced/collected during the VBE life cycle, such as the processes, tools, information/knowledge, lessons learned, etc. The collection of such assets constitutes the VBE “bag of assets”.

VBEs working and sharing principles refer to the organizational and governance principles of the VBE (Irigoyen, Galeano, Guerra, & Molina, 2006; Romero, Galeano, & Molina, 2008b). They include elements such as:

- **Main and auxiliary processes** that take place during the VBE life cycle.
- **Governance rules**, procedures and principles.
- **Organizational structures**, which are closely related to roles, interactions and governance principles.
- **Value systems**, which “define” or guide the VBE behavior.

2.1. VBE topologies

To investigate the specific needed components (e.g. actors, roles rights and responsibilities), the functionality (e.g. for managing their information/knowledge) and the behavior (e.g. to assist the decision making in such networks) for each type of VBEs a systematic study of the wide variety of existing and emerging VBEs is performed.

Further to the literature study on the state of the art on VBEs, we have conducted in depth investigation of six running European industry-based clusters/networks of SMEs that operate as VBEs. Based on the achieved results, a systematic approach for the specification of the VBE semi-typology is defined. More details on this topic can be found in (Afsarmanesh & Camarinha-Matos, 2007).

Based on the perspective considered as dominant, more than one typology can be defined for the VBEs. Three main perspectives are identified as more dominant for the definition of a VBE typology, namely the perspectives focused on the following:
different categories of the domains of VBE activities
• different drivers for the main collaboration in VBEs
• different orientation/value system adopted by the VBEs

Applying each perspective to the definition of VBE typology will result different types of VBEs. As an example to develop the VBE typologies based on the categories of activity domains for VBEs, we have identified the following four types of VBEs:

• Type 1: Stable products/services domain
• Type 2: Stable one-of-a-kind domain
• Type 3: Emerging domain
• Type 4: Innovation driven domain

2.2. VBE ontology

The success of every VBE, very much depends on proper ICT-based modeling as well as the management of the VBE knowledge.

The ontology for VBEs represents the unified and formal conceptual representation of the heterogeneous knowledge internal to the VBE environments. It continuously evolves and needs to be easily accessed by and communicated among both human users and application systems. The developed VBE ontology in ECOLEAD (Afsarmanesh & Ermilova, 2008) aims at supporting the following challenging tasks related to the VBE’s instantiation, operation, and management:

• Establishment of a common semantic subspace for VBEs.
• Instantiation of VBE knowledge repositories for VBEs from different domains/business areas.
• Automated processing of VBE knowledge by software tools in dynamic VBEs.
• Enabling inter-organizational learning and co-working.
• Integration of VBE knowledge with other existing standard ontologies.

Focusing on the variety of both owners/providers of the knowledge and its usage within different subsystems of the VBE management system, ten conceptual groups are identified in VBEs, as presented in Fig. 1; each representing a sub-ontology of the VBE ontology.

A short description of each sub-ontology is provided below:

1. **VBE-self** – knowledge that represents the general concepts about the VBE itself.
2. **VBE participant/member** – knowledge that represents the main concepts related to the characteristics of VBE member organizations.
3. **VO-self** – knowledge that represents the concepts about VOs that are configured within the VBE.
4. **Profile/competency** – knowledge that represents those knowledge classes that need to be collected from different VBE entities related to their profile and competency definitions.
5. **History** – knowledge that represents concepts related to the history of performance, collaboration and cooperation of VBE members.
6. **VBE Bag of Assets** – knowledge that represents the concepts addressing the assets structure in VBEs.
7. **VBE Management System** – knowledge that represents those concepts related to the functionalities and services supporting the VBE management.
8. **VBE Governance** – knowledge that represents the concepts related to the VBE rules, bylaws and culture.
9. **VBE Value System** – knowledge that represents the concepts describing VBE capitals and measures.
10. **VBE Trust** – knowledge that represents the concepts of trust elements, as well as the kind of data for measurable elements that need to be collected for assessment of the level of trust in organizations.

2.3. Profile and competency

Of specific importance to both successful operation as well as the marketing of the VBEs is the lack of uniform models for specification of VBE member organizations’ profiles and competencies. Due to this lack of common profile/competency definitions and models, in 1st generation VBEs, the accumulated profile/competency information was incomplete and there were no common understanding of the profile/competency concepts.

For the 2nd generation VBEs, the unified model is defined for the profile of VBE member organizations to represent all related information about each organization in the VBEs. Furthermore, in order to represent the qualification characteristics of VBE members, for the purpose of being selected for collaboration within VOs, a unified model is defined for competencies of the VBE member organizations, within the organization’s profile model, representing one of its fundamental elements.

According to (Ermilova & Afsarmanesh, 2007):

“VBE member organization’s profile consists of the set of determining characteristics (e.g. name, address, capabilities, etc.) about each organization, collected in order to: (a) distinguish and compare each organization with others, (b) analyze the suitability of each organization for involvement in some specific line of activities/operations.”

![Fig. 1. Conceptual groups of VBE knowledge.](image-url)
“VBE member organizations’ competencies represent up-to-date information about their capabilities, capacities, costs, as well as conspicuities, illustrating the accuracy of their provided information, all aimed at qualifying organizations for VBE participation, and mostly oriented towards their VO involvement.”

In our research on organization competence model for VBEs four specific characteristics of organizations are identified as both necessary and sufficient for selection of the best-fit organizations in VBEs for the purpose of VO creation. The unified competency model developed for the 2nd generation VBEs is called the 4C-model” (Ermilova & Afsarmanesh, 2008), due to the fact that the names of its four main elements, namely the: Capabilities, Capacities, Costs and Conspicuities. The main features that make the 4C-model unlike other models of competency for organizations, such as those addressed in (Allen, 2007; Boucher, Peillon, & Burlat, 2007), are the following: (1) The 4C-model is developed to facilitate the context of VO creation within VBEs. (2) The 4C-model constitutes the base for development of a competency database, as well as the system for cataloging and processing of VBE competencies.

We describe below each element of the 4C competency model briefly:

- **Capabilities** – represent the capabilities of organizations, e.g. their processes and activities. When collective business processes are modeled for a new VO, the VO planner has to search for specific processes or activities that can be performed by single organizations, an order to instantiate the model.
- **Capacities** – represent free capacities of the organizations’ resources needed to perform each capability.
- **Costs** – represent the provision of costs of products/services in relation to each capability.
- **Conspicuities** – represent means for the validity of information provided by the VBE members about their capabilities, capacities and costs.

### 3. Value systems and trust

Development of the VBE value system facilitates identification of the basic criteria for measurement of VBE’s performance, including the criteria to measure performance of VBE members, VOs, and VBE administration. While the identification and specification of VBE values was not clearly supported within the 1st generation VBEs they are considered important for the 2nd generation VBEs.

#### 3.1. Value systems

The common value system of the network and the individual value system of its partners (Wet, 2006) influences the decision-making process in a collaborative network. Therefore, identification and characterization of these value systems is important for attempting to improve the collaborative processes.

Romero, Galeano, and Molina (2008a) refers to a value system as the ordering and prioritization of a set of values that a VBE (or its members) creates, holds, and exchanges. Since in principle, value is multidimensional, the value system in a VBE has to consider economic, ethical and cultural values. It also considers the identification and measurement of what is valuable for all VBE stakeholders. Ethical and cultural values in a VBE constitute part of its behavior, and support the creation of other values in the VBE. From a macroscopic perspective, the VBE value system includes the following four main elements (Romero et al., 2008a):

- Identification of the value generation objects or capitals that a VBE and its members own.
- Performance measurement system, to measure the value generation, and constituting the base to define the VBE incentives and sanctions schemas.
- Definition of the VBE ethical/cultural values.
- Trust building mechanisms within the VBE.

ECOLEAD has also generated formal approaches to characterize and model the value systems, and to model the network of benefits in a VBE, out of which a number of network-centric performance indicators are proposed (Abreu & Camarinha-Matos, 2007).

#### 3.2. Trust

Trust relationships among organizations in a VBE are necessary to smooth their cooperation. Considering that effective creation of VOs is the main aim of the VBEs, trust among organizations become even more vital, and the measurement of organization’s trust level facilitates the selection of partners for VO configuration and establishment. However, in medium to large size VBEs, whose members do not know each other, creating trust among organizations is challenging. In networks such as VBEs, especially if not regional, applying traditional approaches for creating bilateral trust among organizations, e.g. by reputation and recommendation, is difficult. Furthermore, it is hardly feasible to (rationally) reason on the trustworthiness of the organizations based on subjective data, thus difficult to maintain fairness in their evaluation for VO creation.

To support the creation of trust among organizations within VBEs, a rational (fact-based) approach is introduced. The introduced approach (Msanjila & Afsarmanesh, 2007a) characterizes trust among organizations as a multi-objective, multi-perspective, and multi-criteria subject (see Fig. 2), where values for trust criteria constitute the facts and past/present performance and achievements of organizations.

Formal mechanisms are then introduced to calculate/assess the fact-based trust level of organizations. As such organizations can trust each other rationally and based on facts about their trust level.

A set of generic trust criteria is defined for all VBEs presented in form of a wheel (Msanjila & Afsarmanesh, 2007a) as shown in Fig. 2. The wheel of trust represents the three layers of: trust perspectives (the internal layer of the wheel), trust requirements (the middle layer of the wheel), and trust criteria (the external layer in the wheel). The elements defined at each of these three layers are represented above in the table format. Trust assessment involves causal reasoning among the defined criteria, as addressed in details in the above referenced paper.

### 4. VBE management

To properly operate and facilitate their actors, it is necessary for VBEs to provide a set of functionalities and services. Some of these services need to be automated or semi-automated, to assist users with fluid creation of VOs within the VBE, namely the existence of a VBE management system (VMS) (Afsarmanesh et al., 2008).

A VBE passes through three distinct phases during its life cycle, namely, creation, operation/evolution, and metamorphosis or dissolution.

The creation phase constitutes two sub-phases of initiation and recruiting and foundation. During the initiation and recruiting sub-phase, the main activities include: setting up and running VBE management system and ICT-tools, loading existing ontology and thesaurus, setting up domain parameters and nodes, etc., by the VBE administrator. During the foundation sub-phase the main
activities include: adapting the VBE ontology, adapting database schema and creating repositories and interfaces for database access, entering administrative data, and registering founding members, etc., by the VBE administrator.

The operation/evolution phase constitutes the bulk of VBE’s life time and thus it is a much longer than the other two phases. During this phase main the management activities of the VBE administration address the support for acquisition and responding to potential VO related business opportunities, such as activities related to ensuring that competencies required in the market exist in the VBE, among others. Furthermore, during the operation sub-phase minor changes sporadically become required, e.g. inviting new member organizations to fill the gaps in competencies discovered in the VBE. Therefore, VBE undergoes some evolution during its operation phase.

Since VBE is a long-term alliance, and considering its valuable bag of assets, including the sharable knowledge, resources, etc., gradually collected within the VBE; its dissolution phase – the closure of the VBE – is an unusual situation. It is much more probable that the VBE goes through the metamorphosis phase, where it can have a major evolution that changes its form and purpose.

A number of services/functionalities developed in ECOLEAD, which are fundamental for the VMS (see Fig. 3), are addressed below. Every function/system introduces a set of new concepts and methodologies and is implemented by a prototype. All developed sub-system prototypes include web-based interfaces and all interactions among different subsystems are achieved through web-services. Different subsystems of the VMS also interact with the specific VO-creation subsystems (addressed later in Section 5).

4.1. MSMS

Membership and Structure Management System (MSMS) supports the VBE administrator, the VBE members, and those organizations that want to become members, through providing functionalities to submit, store, access, delete, and modify the member’s company and contact information. Management of the structure of the VBE, and the company-related information about its members is a crucial cornerstone for supporting performing fundamental VBE related activities. Primary functions of VBE membership management are to register and delete members to and from the MSMS database; to reward members in case of proactive and positive behavior, and to manage the rights, roles, and responsibility of the VBE members (Sitek, Seifert, & Graser, 2007).

4.2. BAMS

Bag of assets management system (BAMS) supports the manipulation of the collection (the so-called bag) of assets in the VBE. This collection contains elements that are of common interest and useful for the VBE members (the so-called asset), and includes elements such as some general sharable information or data that can be provided as documents, the software tools for some common use, the lessons learned, etc. The Bag of Assets also includes the general information about the VBE itself, e.g. the VBE policies, etc. (Afsarmanesh & Camarinha-Matos, 2005).

4.3. ODMS

The 2nd generation VBEs requires common understanding of all their aspects by all involved stakeholders. The innovative function-
ality designed for Ontology Discovery and Management System (ODMS) aims to achieve objectives such as: providing common understanding of the VBE-related concepts for all VBE actors, facilitating the reusability of knowledge accumulated in one VBE with other VBEs, supporting knowledge interoperability both intra-VBE (to support varied forms of collaboration), and inter-VBEs (through sharing the unified models of knowledge) among others (see Fig. 4).

Furthermore, a number of functionalities are identified for the ODMS (Afsarmanesh & Ermilova, 2009), which are divided into two groups, namely the VBE ontology maintenance (OM) functionalities and the ontology-based functionalities for VMS support (VS).

4.4. PCMS

There is a need for the ICT-based submission and processing of the members’ profiles/competencies in order to facilitate VBE’s dynamism. Uniform structuring/modeling of the mostly textual content of profiles also enables their processing by other supporting VBE software (Ermilova & Afsarmanesh, 2007).

Profile and Competency Management System (PCMS) introduces an adaptable, replicable and sustainable system, supported by the ODMS component for management and semi-automation of the derivation/discovery of elements for organization’s profile and competency from on-line text corpora (Afsarmanesh & Ermilova, 2007).

4.5. TrustMan

Trust among organizations is handled in ECOLEAD considering its multi-dimensions, and the diversity of its related aspects. As such in TrustMan, identification and tuning of trust elements, modeling of trust relationships, assessment of trust level, and establishment and promotion of trust relationships constitute the main focus of the management of trust among organizations in VBEs.

Trust Management System (TrustMan) primarily aims to assist the VBE administration with performing tasks related to supporting the management of inter-organizational trust in the VBE, thus increasing the potential of collaboration among VBE member organizations (see Fig. 5). TrustMan supports variety of VBE users including: VBE member organizations, VBE administrator, trust experts, external stakeholders, and VO planner.

The TrustMan system is designed and implemented based on the formal models and mechanisms for trust analysis and measurement. This system provides services to assist the VBE administration and other actors with handling tasks related to the management of trust among organizations in the VBE. The services that TrustMan system provides include (Msanjila & Afsarmanesh, 2007b):

- Assessing base trust level of organizations (Fig. 5),
- Evaluating specific trustworthiness of organizations,
- Establishing trust relationships among organizations,
- Managing trust related data,
- Creating trust to the VBE,
- Managing the assessment mechanisms, and
- Analyzing history of trust level for organizations.

4.6. DSS

The Decision Support System (DSS) prototype, developed in ECOLEAD project, basically provides two means for assisting users
in their decision and management processes: (1) Data analysis—processing the data stored in the VMS and providing user with easy to understand results, and (2) Pro-active notification - the DSS can automatically perform selected data analysis regularly and notify the user (e.g. by email) when the results of analysis require user attention. DSS covers the following three areas in VBEs:

(i) **Warning for lack of performance**: Analyzes the progressive performance of member organizations in the VBE and sends warning message when and if the performance of some VBE member organization falls below certain threshold.

(ii) **Warning for emerging VBE competency gap**: Aims at comparing the required competencies in the market, e.g. observing those
competencies that are frequently required by the collaboration opportunities that are suitable for the type of VBE activities, against those available within the VBE through its member organizations. VBE’s strategic competency plan is used for this purpose to assess the planned VBE competencies versus the actual competencies available in the VBE at a certain point in time.

(iii) Warning for low organization’s trustworthiness. Analyzes organizations progressive trustworthiness. This tool provides an automated scheduled calculation of the trust level by executing the service for assessing trust level provided by TrustMan system. Based on progressive results the tool will send a warning message to organizations whose trust level has fallen beyond the specified threshold.

5. VO creation

The underlying rational in the VBE is the possibility of rapidly forming a consortium triggered by a business opportunity and specially tailored to the requirements of that opportunity. Implicit in this idea is the notion of agility, allowing rapid adaptation to a changing environment. In order to make this possible, a VO creation process is designed in the VBE context. When the contract for a new collaboration opportunity is already “guaranteed", the VO creation process includes three main phases, namely: Preparatory planning, Consortia formation, and VO launching (Camarinha-Matos, Silveri, Afsarmanesh, & Oliveira, 2005).

1. The preparatory planning phase includes the following two steps:
   - **Collaboration opportunity identification and characterization**: involving the identification and characterization of a new Collaboration Opportunity that will trigger the formation of a new VO. A collaboration opportunity might be external, originated by a customer and detected by a VBE member acting as a broker. Some opportunities might also be generated internally, as part of the development strategy of the VBE.
   - **Rough VO planning**: involving the determination of a rough structure of the potential VO, identifying the required competencies and capacities, as well as the organizational form of the VO and identification of corresponding roles. At this stage it is important to define the partnership form, which is typically regulated by contracts and cooperation agreements.

2. The consortia formation phase departs from the previous characterization and rough planning and mainly includes the following three steps:
   - **Partners search and suggestion**: which is perhaps one of the most addressed topics in past research; this step is devoted to the identification of potential partners, and their assessment and selection.
   - **Negotiation**: which is an iterative process to reach agreements and align needs with offers. It can be seen as complementary to the other steps in the process and runs in parallel with them. The results of a successful negotiation will be represented in a VO agreement.
   - **VO composition**: in which the organizational structure and assignment of roles to VO members are defined.

3. The VO launching phase includes the following three steps:
   - **Detailed VO planning**: once partners have been selected and collaboration agreements are reached, this step addresses the refinement of the VO plan and its governance principles.
   - **Contracting**: it involves the final formulation and modeling of contracts and agreements as well as the contract signing process itself, before the VO can effectively be launched. In other words, this step is the conclusion of the negotiation process.

   - **VO set up**: it is the last phase of the VO creation process, i.e. putting the VO into operation, is responsible for tasks such as configuration of the ICT infrastructure, instantiation and orchestration of the collaboration spaces, selection of relevant performance indicators to be used, setting up of the VO governance principles, assignment and set up of resources, activation of services, notification of the involved members, and manifestation of the new VO in the VBE.

Based on the processes and requirements described above, and as a result of extensive interaction with industry end-users, the following VO creation framework is developed in ECOLEAD focused on the following tools (see Fig. 6):

- Collaboration opportunity (CO) finder (coFinder),
- CO characterization and VO rough planner (COC-Plan),
- Partners’ search and suggestion (PSS),
- Agreement negotiation wizard (WizAN).

These tools work in close interaction with the VBE management system. Their main characteristics are addressed in the following sub-sections.

5.1. coFinder

Collaboration Opportunity Finder (coFinder) service is aimed at facilitating the work of a VO broker. The prototype (Demsar, Mozetic, & Lavrac, 2007) uses the same approach that is usually carried out manually by the broker: comparing potential collaboration opportunities (CO), identified from Calls for Tenders (CfTs), with the actual competencies available at the VBE, stored in the PCMS (which is part of the VBE Management System). The coFinder service needs comparable structure of information contained at both sides, to be aligned and matched with each other in order to detect similarities and consequently detect possible collaboration opportunities. The matching in the coFinder tool is based on the comparison of textual descriptions of CfTs and VBE competencies. Once the CfTs’ descriptions and competencies have been provided, coFinder is able to compute their similarity in order to estimate the interestiness of CfTs and identify the most promising ones, and finally to propose them to the broker as potential VO collaboration opportunities for the VBE.

![Fig. 6. VO creation support tools.](image-url)
5.2. COC-Plan

The Collaboration Opportunity Characterization and VO Rough Planning (COC-Plan) service consists of two modules: (a) One component which supports the COC process with the aim of assisting the opportunity broker—in designing the VO and deciding which roles and partners best fit with the VO structure; and (b) a second component which supports the VO-RP process with the aim of assisting the VO planner and/or VO coordinator with the mapping of the tasks to be carried out during the VO operation phase.

The COC process supports the characterization of the COs, focusing on the identification of the main features of a collaboration opportunity which is either needed to be developed such as a product that needs to be manufactured, or needed to be executed, such as a project. This process characterizes COs from its most complex items (assemblies/activities) to the simplest ones (component/sub-activities), plus the specification of collaboration opportunity’s competency-related information (per item) that is required to carry out the partners’ search and selection for VOs (Concha et al., 2008).

The VO-RP component supports the Rough Planning of the VO. The main tasks supported in this module, and carried out either by the VO planner and/or VO coordinator, include identification of the collaboration opportunity modality, and design of a rough plan for the VO.

5.3. PSS

Partner search and suggestion (PSS) (Baldo, Rabelo, & Vallejos, 2007) aims to assist the VO Planner in selection of the most suitable members for a VO regarding the requirements of a given CO. The requirements are received from the previous VO creation phase, which provides a VOs macro-structure, concerning the CO work-breakdown structure, the tasks assigned to each part of the CO, as well as the competencies and resources necessary to fulfill each task.

PSS tool generates a set of potential VO configurations, including the configurations’ expected performance with respect to the specified criteria. These possible VO configurations are presented to the VO Planner for a further decision making and final VO composition.

Besides traditional elements for partner selection like price, delivery date and quality level the set of criteria also includes performance indicators. These criteria are applied both in the searching (filtering inadequate partners) and in the suggestion steps (electing the ones that better fit the desired indicators), in order to achieve faster and potentially better results.

The agreement negotiation wizard that complements the VO creation support tools is discussed in the next section.

6. Agreement negotiation

Negotiation is a critical activity that encompasses all stages of the VO creation process. Particularly, negotiations are needed during the selection of partners, determination of their roles and task allocation, definition of the operating conditions of the VO, etc. A synthesis of the results of the negotiation activity can be represented by an agreement among the partners that will participate in the VO. In order to facilitate and ease the process of reaching such agreements, the negotiation wizard component is proposed.

Creating a new VO is not only a matter of planning and selecting partners. In fact, the final structure of the VO will depend on the agreements reached among all participants during a negotiation process. Negotiation is, thus, an activity that encompasses all other stages of the VO creation process.

The agreements negotiation wizard runs in parallel to all the other tools of the VO Creation Framework, and is aimed at assisting human actors during negotiation processes towards the VO establishment. The full negotiation process involves a number of elementary negotiations in order to reach the necessary agreements with the purpose to accomplish VO internal agreement. Given so, the internal consortium agreement is the result of all agreements established among the participants of the VO being created and that will regulate their collaboration (Camarinha-Matos & Oliveira, 2006). WizAN comprises four main functionalities:

- CTR (Contract Templates Repository) that is a collection of agreement templates and clause templates to support the agreement creation;
- CE (Contract Editor) that uses the CTR and agreed negotiation topics to add new clauses to agreements;
- VNR (Virtual Negotiation Room) that is a virtual “place” where the negotiation participants can access the various negotiation topics and can “discuss” in order to reach the necessary agreements; and
- SAE (Support for Agreement Establishment) with facilities for agreement signing and notification of relevant parties, and repository/archive for its storage (a kind of e-notary);

In fact, as illustrated in Fig. 7, WizAN provides a framework to integrate the various steps of the VO creation process. During this process, several aspects need to be negotiated and agreed on.

At a macroscopic level two important stages of the negotiation steps lead to different negotiation “focus” : (1) The negotiation towards the selection of partners to compose the VO, and (2) The negotiation of the details of the VO (i.e. the negotiation topics) among the selected partners, once the consortium is defined.

The process of VO creation is not a linear/sequential process rather in fact several iterations and parallel activities may take place. At every phase of the VO creation process, there is a flow of information that passes from each phase of the process; and in parallel with the entire process, the tasks of creating the internal VO agreement are spawned. As a result various iterations might be needed. The negotiation phase is an iterative process to reach agreements and align needs with offers. It is typically seen as complementary to the partners’ selection process and might in fact require going back to the previous step(s) if a solution cannot be found with the current configuration of partners.

Therefore, the full VO negotiation process involves a number of elementary negotiations that include reaching agreements on a number of “negotiation topics”. A “negotiation topic”, for example definition of the schedule and location for delivery of a prototype, once agreed by all involved parties, will become part of the global agreement. An example of screen from the WizAN is represented in Fig. 8.

The critical negotiation activities inside VBEs and in relation to the VO creation consist of the following:

- Reaching agreements concerning coordination aspects, e.g. who will be responsible for the VO.
- Reaching agreement concerning the sharing of risks among the involved partners. It also relates to the amount of impact that a problem in a task performed by one partner can cause in the whole VO. Moreover, agreement about the amount of budget retained to cope with possible problems is needed.
- The contract should follow a basic set of standard templates: It is important to depart from common templates, selected for each kind of CO, and extend the selected template to cope with the detailed agreement specifications using “add-on” clauses.
- Reaching agreements on the detailed activities and scheduling.
Information exchange agreement: i.e. how should information be exchanged among partners, and also which kind of information should be exchanged. These agreements have also a close relationship with the detailed scheduling of activities; detailed costs agreement, i.e. discuss and agree with each partner the value of the part that it will produce or the service it will perform.

Support for privacy of proposals, where only the involved partners have access to the information being negotiated.

Taking into account this list, it is evident that these types of agreements require fundamental decision making by human actors rather than a fully automated decision-making system. In this case, what is addressed is not a complex e-contracting process where the system is capable of automatically generate, interpret, execute, and manage a contract, but to a certain extent, the system should store and receive inputs into an electronic source for later interpretation, guiding the user through the process.

7. Conclusions and further challenges

VOs represent mostly temporary consortia of geographically dispersed organizations that share their resources, capabilities and knowledge/information in order to achieve common goals. In order to enhance the formation and creation of VOs, VBEs are established as long-term “strategic” coalitions of organizations, providing the conditions and mechanisms necessary to prepare their member organizations, for dynamic and fluid establishment of potential opportunity-based virtual organizations.

Addressing different aspects of the VBEs a summary of the key conceptual and technological innovations and results, generated in
the ECOLEAD project is presented in this paper. It has specifically addressed the VBE management subsystems and the VCO creation mechanisms and tools developed in this project. Among others, some of the innovative achieved results include:

- Comprehensive characterization of VBE models and construction of VBE ontology.
- Prototypes supporting the semi-automated discovery and management of VBE ontology, competencies, modeling and management of inter-organizational trust and management of performance measurements.
- VO creation process in the case of acquired opportunity, simple and realistic VO planning methods and matchmaking algorithms.
- Distributed negotiation support for VO creation in the context of Virtual Organizations Breeding Environment.

While ECOLEAD has made substantial contributions to the VBE area of research, it also identified many new challenges to be addressed by future research. Among others, we can mention the need to design and develop advanced functionalities for organizations’ trust level forecasting, clustering competencies, mining of historic performance data, members’ readiness assessment and enhancement (Rosas & Camarinha-Matos, 2008), incentive systems and reward/sanction mechanisms, and other bag of assets management and promotion and enforcement of governance principles and rules. Also as conceptual/methodological research challenges we can mention: VBE’s value systems—addressing relevant variables and their inter-relationships and the combination of different value systems; VBE’s business strategy, marketing and branding; VBE’s Legal framework; and VBE’s Emergence models and self-organizing collaboration forms.

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References

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