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VBE REFERENCE FRAMEWORK

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Defining a comprehensive and generic "reference framework" for Virtual organizations Breeding Environments (VBEs), addressing all their features and characteristics, is challenging. 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. As such, identification/specification of the fundamental set of activities and functionalities associated with the VBEs, namely what needs to be supported by a VBE management system is also lacking. In the ECOLEAD project a first attempt contributing to the definition of a "reference framework" was made, addressing the fundamental elements of the VBEs. 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 chapter addresses the VBE reference framework and analyzes its fundamental elements, as classified into its characteristics and features, its reference modeling framework, its ontology, and addressing the VBE semi-typology that identifies an approach for its categorization.

1. INTRODUCTION

The Virtual organizations Breeding Environment (VBE) represents a long-term "strategic" alliance, cluster, association, or pool of *organizations* that provides the necessary pre-conditions for cooperation among its member organizations and facilitates the fluid establishment of Virtual Organizations (VOs) in response to the emerging collaboration opportunities in the market / society (Camarinha-Matos, Afsarmanesh, 2004a). Traditionally, earlier forms of VBEs, namely clusters / associations are established within given geographic regions, taking advantage of having common business culture and sense of community, and typically focused on one or a few specialty sectors of the region. Nowadays, the challenge is mainly directed to removing those restrictions, and finding solutions to extend and boost these associations with enhanced VBE "support-environments". These 2nd generation VBEs apply effective Information and communication infrastructures, tools and services to provide common grounds for organizations' interaction / collaboration, facilitate the configuration and establishment of VOs, assist with the needed evolution of VOs, introduce new approaches and mechanisms to build trust, define a collaboration business culture, establish the common value systems and working/sharing principles among independent organizations, and support multi-

regional VBEs among others. In this chapter we consider the following definition for the 2nd generation VBEs:

"VBE is an association 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)."

While the basic VBE characteristics can be observed and identified from the empirical observation of various case studies (e.g. Virtuelle Fabrik, Switzerland; IECOS, Mexico; CeBeNetwork, Germany; Helice network, Spain; NetworkA, Finland; Torino Wireless, Italy; Treviso region, Italy; etc.) (Afsarmanesh et al, 2007) and improved futuristic scenarios as addressed in Figure 1, a more systematic approach is needed for comprehensive modeling of VBEs. For this purpose, and considering the complexity of the general VBE environments, the development of a "reference framework" for VBEs, addressing the entire set of heterogeneous VBE characteristics is required. Some research in the last few years has focused on the definition of reference architectures for virtual enterprises (Tolle et al., 2003) (Zwegers et al, 2003), and to a much lesser degree also for the virtual organizations, nevertheless research on the reference modeling and a reference framework for their design and development is still at its early stages.

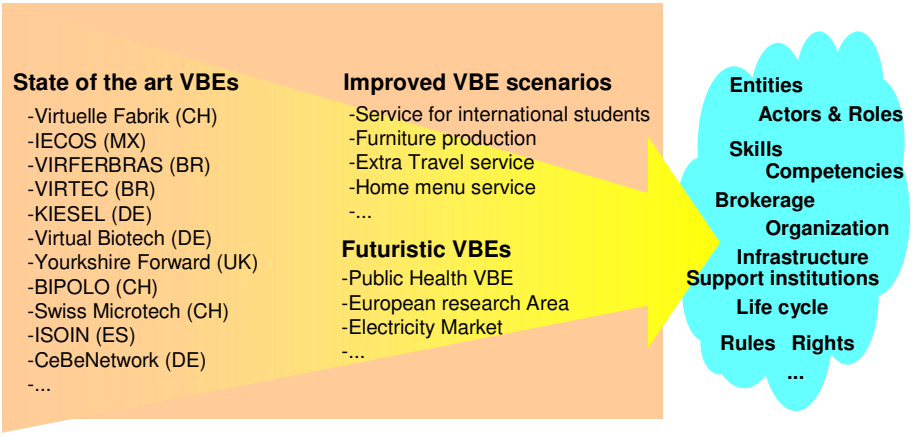


Figure 1 - Examples of studied VBEs

Generally, a *framework* is a conceptual structure used to approach and solve a complex issue. The *VBE reference framework* is therefore aimed to serve as a container of comprehensive concepts, entities, and functionalities needed both for establishing and managing VBEs. The VBE reference framework also provides guidelines for researchers and experts to model various aspects of VBEs, as a step towards developing the VBE management systems. Thus, to support modelers, designers and developers, the VBE reference framework consists of reusable guidelines and possible generic models that can assist such users with both understating of the existing components and concepts in VBEs, as well as how they operate.

Defining a comprehensive and generic "VBE reference model" is challenging. Nevertheless, based on the large amount of literature in this area and the initial empirical knowledge gathered from a large number of existing cases, it is realistic to systematically define a **"reference framework for VBEs"**, addressing its variety of aspects from the VBE topology, to its behavior and structure among many others.

In this chapter a VBE reference framework is presented, addressing the 2nd generation VBEs. For this framework, we first in Section 2 address the identified environment characteristics of a VBE, e.g. its actors and their rights / responsibilities, its life cycle and the main VBE functionalities related to different stages of its life cycle, etc., resulted from literature and empirical studies. We then in Section 3 present four near-orthogonal sub-spaces for the VBE paradigm grouping the endogenous VBE elements. Furthermore, in Section 4 we introduce an ontological representation of the various VBE knowledge concepts. Finally, in Section 5 we present a VBE semi-typology that is developed through the identification of a set of distinguishing characteristics for different kinds of VBEs.

2. VBE ENVIRONMENT CHARACTERIZATION

This section addresses the general VBE characterization. It first presents the motivation for the VBE creation as well as the advantages provided by the VBEs. It then defines the VBE actors and their roles in the VBE. Finally it addresses the VBE life cycle and main functionalities related to every stage of the life cycle.

2.1. Base VBE concepts

Some earlier research have assumed that partners for a new VO could be easily identified and simply selected from the wide *open universe* of available enterprises / organizations, and merged into a collaborative network. This assumption however overlooks a number of important obstacles in this process among which the following can be mentioned:

> *How to know about the mere existence of potential partners in the open universe and deal with incompatible sources of information? How to acquire basic profile information about organizations, when there is no common template or standard format? How to quickly establish an inter-operable collaboration infrastructure, given the heterogeneity of organizations at multi-levels, and the diversity of their interaction systems? How to build trust among organizations, which is the base for any collaboration? How to develop and agree on the common principles of sharing and working together? How to quickly define the agreements on the roles and responsibilities of each partner, to reflect sharing of tasks, the rights on the produced results? Etc.*

In order to support rapid formation of collaborative networks, e.g. a business consortium, as a basic rule, it is necessary that potential partners are *ready and prepared to participate* in such collaboration. This readiness includes common

interoperable infrastructure, common operating rules, and common cooperation agreement, among others. Any collaboration also requires a base level of trust among the organizations. Therefore, the concept of breeding environment has emerged as the necessary context for the effective creation of dynamic virtual organizations. Figure 2 shows the vision of the next generation of VBEs and how the fluid creation of dynamic VOs can be enhanced through the pre-existence of VBEs.

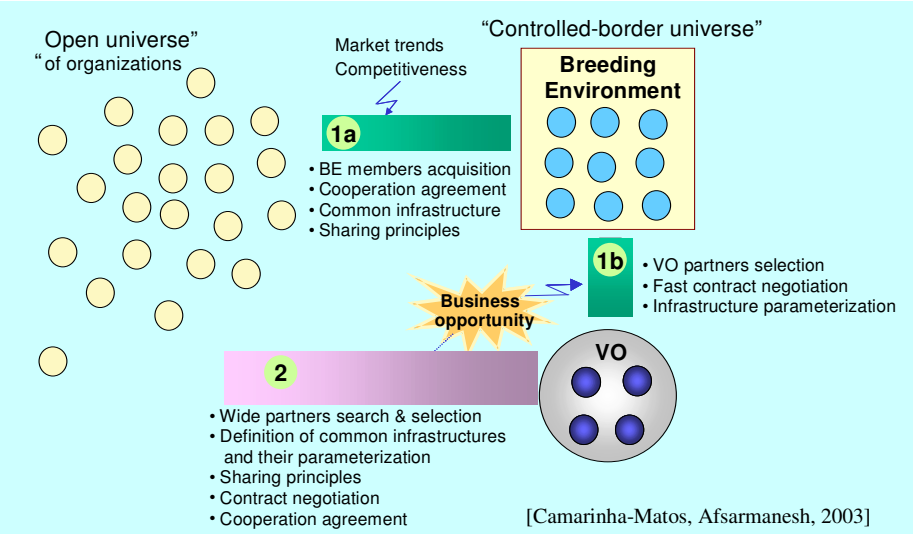


Figure 2 - Two approaches to the formation of virtual organizations

The concept of **breeding environment** (traditionally bound to a sector), has emerged as the necessary context for the effective creation of dynamic virtual organizations.

Cultural ties and particular human relationships are important motivating factors to start up and form such associations representing the VBE, as the support environment for dynamic formation of VOs.

Primarily VBEs constitute two categories of regional and global. While regional VBEs mainly involve organizations (of different sizes) from one geographical region, a global VBE incorporates the involvement of geographically distributed organizations. In this chapter, we address mainly global VBEs. Furthermore, both regional and global VBEs can be either single-sector, i.e. specializing in a single focus area, or multi-sector, i.e. covering a number of focus areas.

Generally VBEs aim at the transition from point-to-point connections among organizations, to a network structure, in order to increase the chances of their member organizations' involvement in opportunities for collaboration. Traditionally, breeding environments are established within one geographic region, in the tradition of industry districts, with the advantage of having common business culture and sense of community, as well as focusing on one specialty sector of the region. But, this restriction can today, in most cases, be overcome by VBEs.

The main purpose for the existence of the VBEs is the efficient creation of VOs. As such, the motivation for creation of VBEs primarily depends on identification / creation of opportunities for organizations' collaboration in certain sector(s). There are two kinds of opportunities pursued by a VBE, namely those that can be identified in the market / society, and those that can be created by the VBE for the purpose of innovation. The main actors in creation / identification of opportunities are either the VBE members who broker the VOs, or the VBE administrator who promotes the initiation of some VOs that seem to be beneficial for the market / society.

Establishment of VBEs provides the **advantages** listed and exemplified below (Afsarmanesh, Camarinha-Matos 2005), that are further addressed and described in this chapter:

- *Agility in opportunity-based VO creation*: supporting reduction of needed efforts and complexity, flexibility for VO re-configurability, and cost effectiveness.
- *Acquiring a(n apparent) larger size and negotiation power*, which contributes to better access to markets / opportunities and better (joint) purchasing conditions.
- *Provision of base effective IC technology infrastructures for VBE members*: the common grounds for interoperability / inheritability / collaboration.
- *The VBE bag of assets, providing properties of interest for its members*: general sharable information / knowledge (e.g. standardized product definitions and processes), software tools, lessons learned.
- *Provision of mechanisms, guidelines, and assisting services to both motivate and facilitate configuration and establishment of VOs*: creating system of incentives, mechanisms to create positive reputation, and services for partners search, contract negotiation, etc.
- *Proactive management of competencies and resources available in VBE*: assuring coverage of the needed competency / resources within the VBE.
- *Provision of related consulting / life maintenance support for VBE members through its support institutions*: supporting insurance, branding, training, etc.
- *Introduction of approaches / mechanisms to build trust among VBE members*: by recording the performance history, and definition of criteria for organizations' trust worthiness.
- *Provision of general guidelines for collaboration*: constituting rules of conducts, working and sharing principles, value systems, collaboration ethics and culture, IPR protection, etc.
- *Increasing the chances of VO involvement for VBE members, even from remote geographic regions*: through provision of members' profile in the VBE catalog, including their competencies, resources, products, services, etc.
- *Improving the potential / capacity of risk taking by the VO planners*: due to the reduction of the VO setup efforts / time, availability of both a wide variety of competency / resources as well as indicators of the level of trust worthiness and past performance of the VBE members.

Nevertheless for VBEs to function properly and generate all these advantages there is a set of requirements that need to be met as some are addressed in (Afsarmanesh, Camarinha-Matos, 2005). The main requirements consist of the following:

- The VBE establishment itself needs to be supported by a strong ICT-based VBE management system, providing a set of tools to both support the administration of the VBE as well as the configuration and creation of new VOs.
- Active involvement from the VBE member organizations, including provision of up-to-date information about their capabilities, resources, capacities, costs, and conspicuities for the provided information.
- Proper establishment of a viable business model for the VBE establishment, covering the issues of VBE finances and how to survive in the market / society.
- Proper establishment of the management strategies, government rules and bylaws, addressing the working and sharing principles as well as contracting, rewarding and sanctioning.

2.2. VBE members

Structurally, a VBE is a regulated open, but *controlled-border* association of its members. It aims at improving the preparedness of its member organizations for joining potential future VOs, hence providing a cradle for dynamic and agile establishment of opportunity-driven collaborative networks. As represented in Figure 2, since a part of the needed tasks are already performed within the VBE for all VBE members prior to the establishment of any VOs, for creation of a new VO it is far less costly and much more effective to quickly build a VO in a breeding environment context (branch-1b) than through a generalized partners' search (branch-2). In other words, VBEs substantially contribute to the increase of the level of preparedness of their members for participation in potential collaborative processes.

A VBE does not need to be a closed organization; new members can join and adhere to the association but they must comply with the general operating principles of the association. For instance, a *loosely associated member* of the VBE may need to adhere to nothing more than a minimum level of organization "preparedness" that is necessary for getting involved in a VO, and to making some minimum information available to the VBE administration, e.g. about their activities related to the VO. At the same time, typically a *fully active member* of the VBE contributes to its promotion, growth, and the enrichment of its bag of assets, and can take an active role from brokerage and planning of VOs in a niche market, to being involved in the expansion of the VBE into new sectors, and initiating VOs towards innovation.

Therefore there may be different levels of membership defined and supported in a VBE, each complying with a different set of rights and responsibilities. In principle, these different levels may constitute a range, with a loose-membership on one end and a tight-membership on the other end of the range. Within this VBE structure, for the formation of a VO, while preference will be given to the VBE members (at different levels), in some cases for example related to the lack or insufficiency of the required skills of capacities within the VBE, it might become necessary to find an external partner. The identified external partner will then

naturally have to adhere at least to the loosest level of VBE membership, e.g. including the common infrastructure and the VBE's cooperation principles. In this case, the external enterprise will be invited and/or coached to establish this loose membership with the VBE. This invitation and coaching will be either through the VBE administrator or the planners of the new VOs.

Further to the main VBE organizations, who aim at joining potential VOs, a VBE might include other kinds of organizations (such as research institutes, sector-associations, governmental support organizations, etc.) and even free-lancer individual workers e.g. consultants that represent a one-person small organization. The main purpose of including these other kinds of organizations in the VBE is to provide different services supporting the regular VBE members, and therefore they are referred to as support-institutions. Typical services / expertise required in VBEs may include legal services, marketing expertise, insurance, training, etc.

Therefore, three kinds of *organizations* can be identified as registered within the VBEs, including:

- *Business entities* providing products and services to the market that get involved in the VOs to gain quantitative profit, e.g. enterprises.
- *Non-profit institutions* that get involved in the VOs to gain qualitative profit, e.g. academic and research institutions.
- *VO Support institutions*, for example: legal and contractual service providers, companies supporting life maintenance to individuals (e.g. insurance and training companies), ministries, sector associations, chamber of commerce, environmental organizations, etc.

Within VBEs, organizations establish common ties with each other, as addressed before. VBE members shall comply with the general VBE rules and policies, e.g. adapting the common ICT infrastructure. At the same time, once joined the VBE, member organizations might benefit from the following available elements among others: common tools and technologies; common market and distribution channels; common resource and labor pool; common VBE cultural ties; facilities to share the cost of new experiences, e.g. to test new IT tool; facilities to share lessons learned.

A large variety of possibilities are offered to the VBE member organizations, some of which are mentioned below. For example, participants in a VBE can play the role of a broker, to establish a new virtual organization, for instance in response to a market opportunity or a new mission in the society, etc. Member organizations can be invited to join in new VOs due to their competencies and/or past performance records, or even to fulfill a skill gap in the running VOs. Every member can access a variety of necessary general information and knowledge available through the VBE, as well as sharing the costs for market research, advertisement, etc. Through the VBE, its members can have access and benefit from available necessary support services (e.g. legal, insurance, training, etc.) that are provided by the VBE support institutions, among many others. They can access the shared resources (software tools, information files, etc.) contributed to the VBE's bag of assets, which are either provided by the VBE administration or constitute contributions by other VBE members for common use. VBE members can also benefit from the experiences and lessons learned that are shared by other members in the common on-line space provided in the VBEs. Member organizations also receive a wider visibility and will have access to broader possibilities and markets.

Considering that the main goal of the VBE is the promotion and facilitation of effective VO formation, special support is provided in the VBEs for those member organizations that will act as the VO brokers. As such, the *Broker* of a new VO is a member of the VBE that starts the process of creating the VO, as a response to a new opportunity (e.g. for business or otherwise). Further to the above mentioned possibilities, the Broker within the 2nd generation VBE, can for instance benefit from a variety of VBE support services, for example the following:

- Access to the catalog of available variety of competencies provided by all VBE member organizations, and the costs associated with them;
- Access to the catalog of available variety of resources and their free capacities within the VBE;
- Support for finding suitable collaboration opportunities that can relate to the competencies in the VBE;
- Support for efficient search and selection of suitable partners for the VO;
- Possibility of evaluation / comparison of potential partners, in terms of their performance-based (rational) trust level;
- Support for planning the VO and task distribution among potential partners
- Access to an agreement/negotiation forum;
- Contracting assistance (using the provided templates and tools).

A variety of *roles* can be assumed by a large number of actors in the VBE (Mejia, Molina, 2002) (Molina, Flores, 2000), where a VBE actor represents either a VBE member organization, or an individual representing a VBE member organization. The following main roles are considered for the 2nd generation VBEs (as also represented in Figure 3):

- *VBE member*: this is the basic role played by those organizations that are registered at the VBE and are ready to participate in the VBE activities.
- *VO partner*: this is a basic role played by a VBE member in a VO.
- *VBE administrator*: the role performed by the organization responsible for the

VBE operation and evolution, promotion of cooperation among the VBE members, filling the skill/competency gaps in the VBE by searching and recruiting / inviting new organizations into the VBE, daily management of the VBE general processes, e.g. the assignment / re-assignment of rights to different actors in the VBE based in their responsibilities, the daily conflict resolution, the preparation of VBE's bag of assets, and the making of common VBE policies, among others.

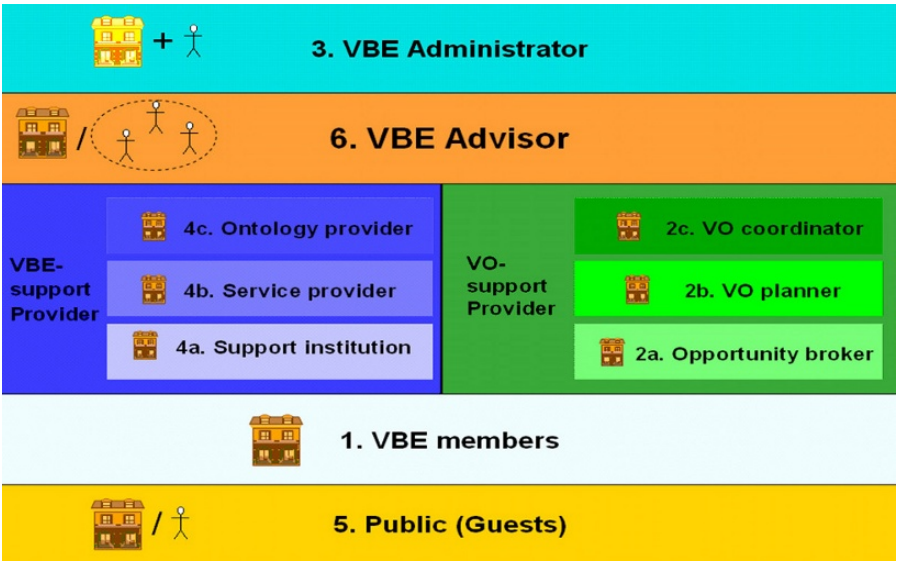


Figure 3 - The main roles in a VBE

• *Opportunity Broker* or simply *Broker*: a role performed by a VBE actor that identifies and acquires new collaboration opportunities (business opportunities or others), by marketing VBE competencies and assets and negotiating with (potential) customers. There is also the possibility of this opportunity brokerage role being played by an outside entity, as a service to the VBE.

• *VO Planner* or *business integrator*: a role performed by a VBE actor that in face of a new collaboration opportunity (designed by an opportunity broker), identifies the necessary competencies and capacities, selects an appropriate set of partners (VBE members and even outsiders in case there is not enough competencies and/or capacities inside the VBE), and structures the new VO. In many cases the roles of opportunity Broker and VO planner are performed by the same actor.

• *VO coordinator*: a role performed by a VBE actor that will coordinate a VO during its life cycle in order to fulfill the goals set for the collaboration opportunity that triggered the VO.

Furthermore, the wide variety of services and support tools and mechanisms that will be provided within the VBE, including both the base necessary services as well as the advanced assisting tools, will be provided by different actors, e.g. those providing the common VBE services (here called common service providers), or those providing the common VBE ontology (here called common ontology providers) within the VBE, that again each require assigning proper rights / responsibilities to these actors. Therefore, a number of other roles are also useful to be considered in a VBE, including: the *VBE advisor* (or an advisory board), the *VBE Services provider*, the *VBE Ontology provider*, the service provider through a support institution involved in the VBE, and the last but not least is the role of a VBE guest played by an organization outside the VBE that is interested in finding general promotion information about the VBE, either interested to become a VBE

member or interested in contacting the VBE for a business opportunity, etc. Figure 3 represents these different kinds of roles to be considered in the VBE.

Due to the dynamic nature of both the VBE's environment and its member organizations, the defined roles and therefore the responsibilities / rights of VBE member organizations cannot be static. Following items represent the main characteristics of the VBE roles, rights, and responsibilities:

- Different roles can be assumed by a VBE member organization at different times, or even simultaneously. For instance, a VBE member can act as a VO broker for one VO, while either at the same time or at another time, it may act at the coordinator of another VO.
- Every role taken by a VBE member organization represents a set of responsibilities, a set of required rights / authorization, and further requires a set of assisting tools for the actor in this role. For instance, a VBE member, acting in the role of a VO broker, has accepted the responsibility to configure and negotiate a VO, for which it requires a set of access / visibility rights to the information on competency / past-performance of other member organizations in the VBE, and requires an assisting tool to search for best fit organizations for the required skills.
- Considering the responsibilities and rights that need to be associated with every role of an actor in VBE, it is necessary that VBE members inform the VBE administrator about every new role they plan to assume within the VBE (starting with becoming a VBE member organization) and to request that proper rights for the role are associated to them.

Considering this variety of roles for VBE actors and their associated responsibilities and rights, at a first step the classification of these roles became necessary. This includes the identification of what elements (information) they mainly need to access as well as the base assisting services (software tools) that they need to use to perform their responsibilities. At a second step, the scope of access / visibility / use rights (to the information and available service) associated with each role, as well as the propagation of these rights are classified. The results of these two steps are described below in more details.

Step 1: VBE roles identification

The Table 1 below represents the first classification of roles in the VBE into ten classes, and their example "main" requirements to access information and the need to use assisting tools / services.

Step 2: VBE rights propagation

Earlier it was addressed that with every role in the VBE, there are some associated responsibilities, for which the actors require sufficient access / authorization rights, e.g. for information visibility and/or for use of certain assisting tools / services to help them with performing their tasks. It was also described that the actors in the VBE shall request the VBE administrator to acquire a higher role (with more responsibilities) in the VBE. Once the request for a higher role is accepted, the associated access / authorization rights will be granted to the requesting actor.

Table 1 - Specification of VBE roles

1. VBE Member	– all needs of public (guests) – needs to access the VBE's internal assisting info / news, as well as the internal shared services / tools – requires tools to register and submit its competency info and to apply for potential broker position
2. VO support providers:	
2.1. Opportunity broker	– all needs of VBE members – need to access information about VBE capabilities – needs to access VBE members information and competencies – requires tools to publish new opportunities, search for competency/resource/product/services that can be made available in the VBE, and potentially to apply for the VO planner position
2.2. VO planner (Integrator)	– all needs of VBE members – needs to access the past performance of the VBE Members – needs to access information about new opportunities – requires tools to search for best fit VBE members to the VO requirements, and to create/negotiate VOs, and potentially to apply for VO coordination position
2.3. VO coordinator	– all needs of VBE members – needs to access the VO related information – requires tools to measure & submit VO (partners') performance
3. VBE Administrator (Manager/Coach)	– all needs of advisors – requires tools to register (from the provided info) VBE members / opportunity brokers / VO planer / VO coordinator, and all other kinds of roles in the VBE and tools to assign roles/rights to all members, and to run several software (Monitor usage / Evaluate system / Extract knowledge, etc.) and store the results in the VBE database
4. VBE support providers:	
4.1. Support institution assistance provider	– all needs of VBE members – needs the VBE Member info – requires tools to submit new information about available services
4.2. Common tools/services provider	– all needs of VBE members – needs system-evaluation results and usage monitoring results – requires tools to submit new services/tools
4.3. Common Ontology provider	– all needs of VBE members – needs the knowledge extraction/discovery results – requires tool to submit new model/meta-data definitions
5. Public (guest)	– needs access to the VBE's public information and services – requires tools to apply for VBE membership
6. VBE advisor (board)	– all needs of providers and organizers – requires tools to submit recommendations to the administrator
6. VBE Administration	– all needs of advisors – requires tools to register VBE members / opportunity brokers / VO planer / VO coordinator (from their provided info.), and all other kinds of roles in the VBE and tools to assign roles/rights to all members, and to run several software (Monitor usage / Evaluate system / Extract knowledge, etc.) and store the results in the VBE database

In this step, the classes of VBE roles were arranged in a semi-hierarchical diagram that defines the incremental propagation of access / authorization rights among different VBE roles. The incremental propagation of rights coincides with the increase in the VBE member's responsibility, associated with each role. The propagation of rights, as shown in Figure 4, also represents different degrees of sensitivity of each VBE role in comparison to the others, and the fact that clearly higher level decision making in VBE requires higher access / authorization to the

existing more sensitive assets (proprietary information, models, etc.) and supporting tools in the VBE.

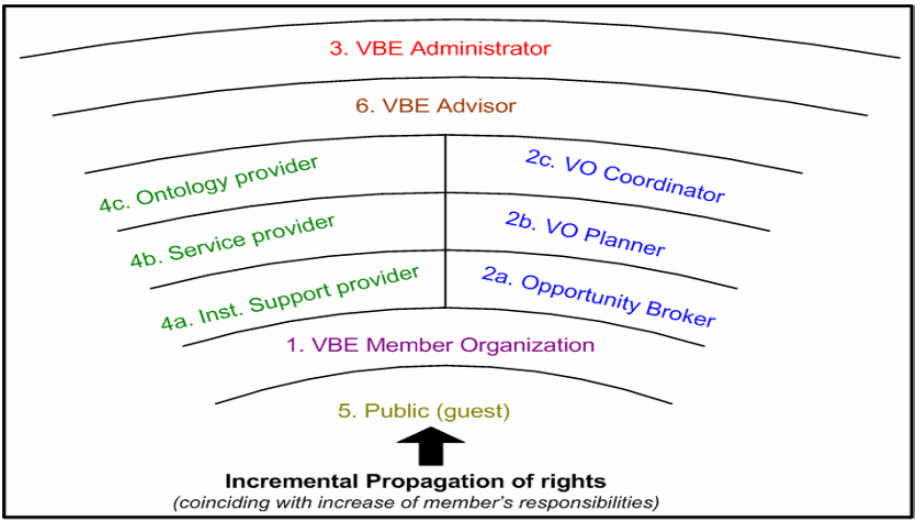
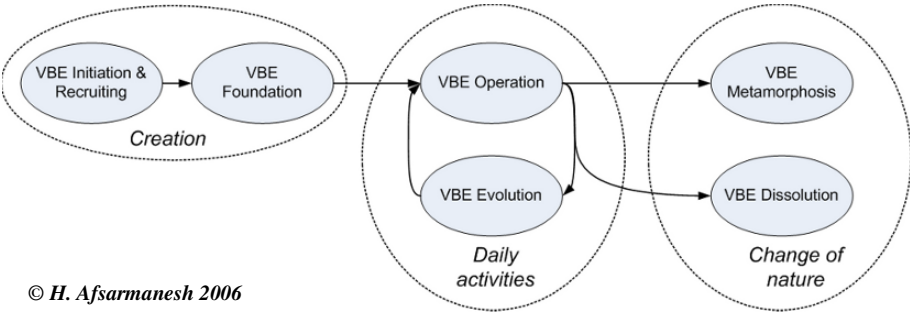


Figure 4 - Incremental propagation of rights for different roles in VBE

2.3. VBE life cycle and life cycle functionalities

The *life cycle of the VBE* (Figure 5) represents all stages that a VBE may go through during its life, from its creation stage, to its operation, and possible dissolution.



- VBE Initiation & Recruiting – *planning and incubation*
- VBE Foundation – *constitution and start up*
- VBE Operation – *the "normal" phase of the VBE existence*
- VBE Evolution – *small changes in membership, daily operating principles*
- VBE Metamorphosis – *major changes in objectives, principles, membership and/or mergers, leading to a new form and purpose*
- VBE Dissolution – *when the collaborative entity ceases to exist, to preserve its valuable gained knowledge, typically this stage of VBE is replaced by the metamorphosis stage*

Figure 5 - VBE life cycle stages

In fact for a VBE, being a long-term alliance, the role that it plays in the market / society, and considering its valuable bag of assets that is gradually built up, its

dissolution is a very unusual situation. Instead, it is much more probable that the VBE goes through another stage, our so called metamorphosis stage, where it can evolve and change its form and purpose, as it is also described later below. On the other hand, it is the case that only during the operation stage of a traditional VBE (e.g. an industry cluster), the VOs can be created. However, considering the overwhelmingly increasing variety of VOs, and the fact that usually VBEs serve specific sectors / domain and have specific aims, in the coming time there will be large numbers of different sector / domain-dependent VBEs, needed to be established. Therefore, it is very important to cover and support all stages of the VBE's life cycle in the reference framework, and not only focus on its operation stage.

Management of the VBE during all stages of its life cycle is at the heart of the 2nd generation VBE research and development area. But as mentioned before so far, there is still a lack of a common "reference models" for the VBEs that addresses its different aspects, including their behavior, structure, physical topology, cultural / legal framework, etc., as well as to support sensitive issues such as the value systems, IPR, trust, sanctions and rewards etc., so far there are no clear definitions of what exact activities are associated with the VBEs that need to be supported by their management system. However, several examples of VBEs can already be found in practice that are used as a source of inspiration for our work, e.g. the cases represented by Virtuelle Fabric (Switzerland), IECOS (Mexico), SMT (Switzerland), CeBeNetwork (Germany), and HELICE (Spain), and the potential next generation VBEs that we can learn from their practice and standards. Nevertheless, for research and development work related to the management of the VBE during its life cycle, we did not start from scratch. For instance, during our earlier studies in some other European initiatives, e.g. THINKcreative and VOmap (Camarinha-Matos, Afsarmanesh, 2004b), VOSTER (Camarinha-Matos et al, 2005), and PRODNET (Camarinha-Matos, Afsarmanesh, 1999), the main requirements for the VO environments are identified. Although, these results on VOs cannot be directly applied to the VBEs, they served as the base and a starting point in ECOLEAD. The remaining of this section presents the main identified *required functionality for the 2nd generation VBEs*, in relation to different stages of the VBE life cycle. For this purpose, we have applied three groups of life cycle stages, as defined in Figure 5, to group different VBE life cycle stages. As such the first group refers to *VBE's Creation* or the "Initiation and Foundation", the second group refers to *VBE's Daily activities* or the "Operation and Evolution", and the third group refers to *VBE's Change of nature* or the "Metamorphosis and Dissolution".

Figure 6 represents the base required functionality for VBEs, as divided into these three groups of its life cycle stages:

- *Base functionality supporting the VBE creation* – This phase includes two main steps: (1) initiation / recruiting, which requires the establishment and setup of a common base infrastructure, recruiting potential organizations to join the VBE, and establish some base ontology / thesaurus of the domain, to establish the vision and strategic objectives of the VBE are defined; (2) VBE foundation, requiring support for parameterization of the used systems, setting up the necessary links, creation of the necessary databases (with initial meta-data / ontology), and populating these

information structures.

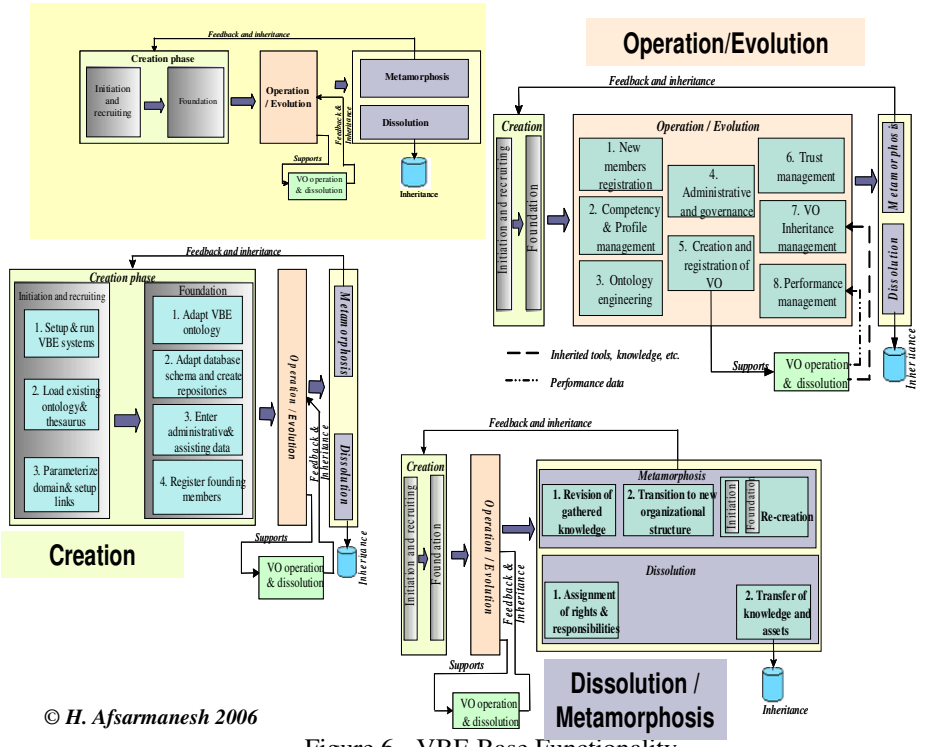


Figure 6 - VBE Base Functionality

- *Base functionality supporting the VBE operation and evolution* – This phase requires support for: (i) Management of competencies and assets, (ii) Registration of new members (including profiling, characterization of competencies, products, services, etc.), (iii) Assisting VO creation, (iv) Incremental generation / evolution of meta-data / ontologies for the domain / sector, (v) Keeping records of past performance and collaboration processes, (vi) Assessment and assistance tools, (vii) Collaboration support (e.g. newsgroups, discussion forum, common information repositories, etc.), (viii) Management and evolution of working and sharing principles and rules, (ix) Acquisition and management of common knowledge and assets.
- *Base functionality supporting the VBE metamorphosis and dissolution* – This phase will require assistance for the design of the aimed new organizational structure, selection and reorganization of the information and knowledge collected during the VBE operation and that might be transferred to the new organization, analysis and adjustment to the new context, etc. In the case of VBE dissolution there is a need to plan the transfer of its collected knowledge, information, bag of assets to its members or another organization based on defined agreements.

Considering the life cycle stages of the VBEs, by nature VBEs represent self organizing environments and thus can be defined through the Chaordic graphs from the Chaordic system theory (van Eijnatten, 2003). Figure 7 represents the main

stages of the VBE life cycles in a chaordic graph. As illustrated in this Chaordic graph, the normal operation phase of a VBE involves a number of small evolutions, where each small evolution in the VBE has itself a similar, though shorter life cycle. Furthermore, the combination of these smaller evolutions constitutes the operating stage of the dynamic VBEs.

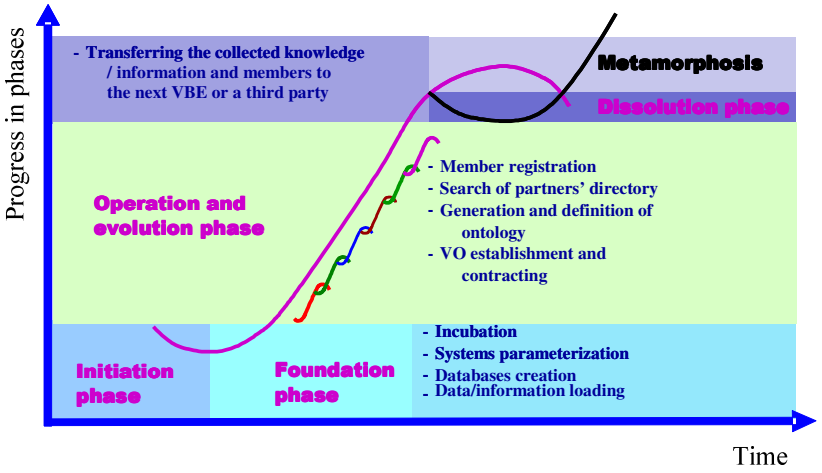


Figure 7 - Chaordic graph representation of VBE life cycle stages

3. NEAR-ORTHOGONAL VBE SUB-SPACES

Considering the complexity of VBEs, any attempt to formally define this paradigm and description of its supporting infrastructure, must carefully cover the *multiple perspectives and dimensions* of this system. With this aim in mind, identification of the multi-dimensions of this paradigm and its supporting system is of high importance.

These dimensions must together comprehensively, or at least as much as possible totally, cover all the *known features and aspects of the VBEs*, no matter how simple or how compound these features are. Different features and aspects of the VBEs that all need to be modeled and formally defined, are of completely different nature, ranging from the hardware resources at the level of one organization, or the generic working and sharing as well as conflict resolution policies, to the functionalities related to the configuration of a newly instantiated VBE or different goal-oriented activities related to different phases of the VBE's life cycle, and even the semi-automatic decision making processes for knowledge discovery, etc. These aspects among others shall all be covered by these dimensions.

As a first trial reference framework for VBEs, with its roots in an early work in the Data Base community (Afsarmanesh et al, 1985), we have identified four complementary near-orthogonal (*elements within different dimensions are bound to each other)* dimensions / perspectives for VBEs that can together represent the complexity of the variety of entities, concepts, and functionalities, and model different aspects of the VBE environments and needed support systems. The applicability and benefits of the introduction of these dimensions for the purpose of

systematic classification and better modeling of multiple perspectives of the VBEs are further investigated. The ARCON reference model for collaborative networks, also developed within the ECOLEAD project, have adopted these four dimensions for modeling the *endogenous elements* of collaborative networks. A short description of these dimensions is presented in this section. Also Figure 8 represents these dimensions as *overlays* above the VBE.

1. ***VBE Structural dimension***: Conceptual structure of roles and functions of VBE actors. For instance: Roles, rights, responsibilities, duties etc. associated with each member organization, e.g. the VO broker's role, rights, and responsibility, etc.
2. ***VBE Physical dimension***: entities, materials, and all physical resources in the VBE, being the organizations themselves, or belonging to the VBE management system. For instance: HW (e.g. machinery and networking) / SW (e.g. assisting shared tools), personnel (human capital), and the stored information / knowledge, etc. belonging to the VBE or to an organization, as well as the organization entities themselves in the VBE.
3. ***VBE Activity Sequence dimension***: Activities / procedures / processes related to the entire VBE life cycle management and coordination. For instance: the Conflict resolution procedure, the performance management procedure, the member registration procedure, etc.

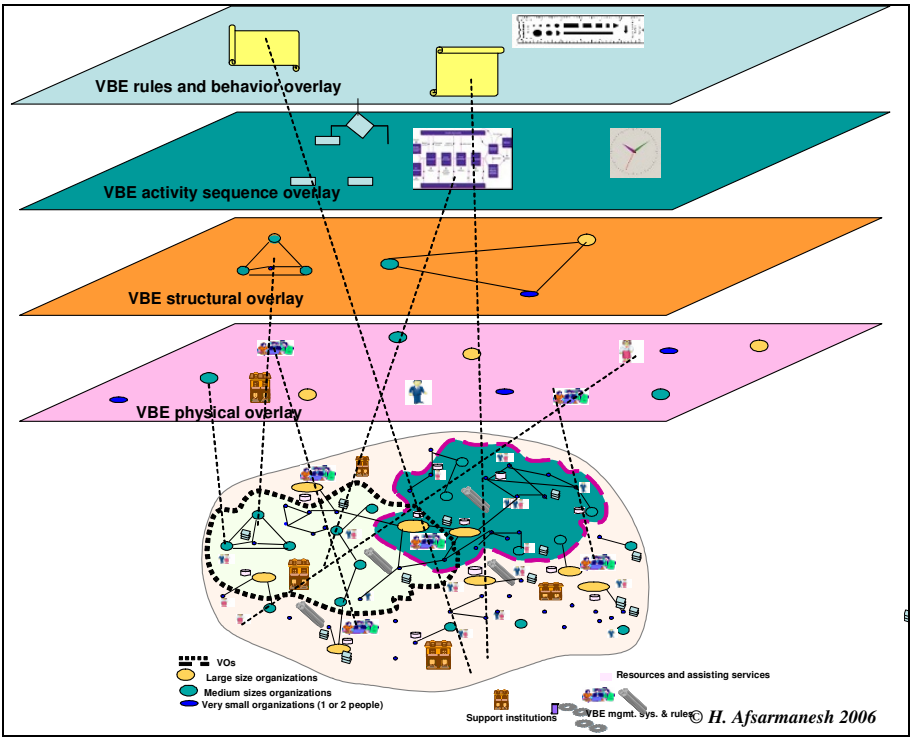


Figure 8 - The layered VBE Reference Modeling framework

VBE rules of Behavior dimension: Policies and governance rules. For instance: the Interoperability principles, Policies for code of conduct, Conflict resolution policy,

Contract enforcement policy, etc.

Every dimension represents a specific aspect / perspective of the complex VBE environment and its needed support system. These specific four dimensions are chosen for the reason of their near-orthogonality, in the sense that elements in each dimension mostly belong together and are mainly inter-related with each other, and may only be weakly related to elements in the other dimensions. Namely, if elements in different dimensions are bound to each other, then changes in one dimension affect the elements of the other dimensions, weakly across some region of relevance. For example, there may be some relationships among elements of the physical and structural dimensions of the VBE.

Some example bindings between different dimensions follow:

- between the physical components (different organization) and the structural components (different roles and functions to be assumed by VBE member) there can be a relationship identifying the role of each organization;
- between the behavioral components (policies) and the life cycle related sequence of activities (procedure for measuring the performance of VBE members during the operation phase in a VO) there be a relationship that identifies the policy applied to every procedure.

Figure 8 addresses these dimensions and how they can be linked through the bindings. This defined reference framework is applied and validated for comprehensive modeling of all endogenous aspects of VBEs.

4. VBE ONTOLOGY

This section addresses an ontological representation of the VBE paradigm. Besides the contribution to the VBE reference framework, the VBE ontology - developed in the ECOLEAD project - aims to support the following challenging tasks related to the VBE instantiation and management:

1. Establishment of a common semantic subspace for VBEs.
2. Instantiation of VBE knowledge repositories for VBEs from different domains / business areas.
3. Automated processing VBE knowledge by software tools in dynamic VBEs.
4. Enabling inter-organizational learning & co-working.
5. Integrability of VBE knowledge with existing standards.

The main motivations for engineering the VBE ontology are to support the above tasks through providing the following:

– Adequate, formal and uniform representation of VBE knowledge / information.
– Unified and common semantic subspace for VBE knowledge / information.

4.1. Definition and scope of the VBE ontology

We define the VBE ontology as *a form of unified and formal conceptual representation for the heterogeneous knowledge within the VBE environments to be easily accessed by, and communicated between human and application systems, for analysis and evolution purposes (Afsarmanesh, Ermilova, 2007) (Ermilova, Afsarmanesh, 2008).*

As a first step for specification of the VBE ontology, the main conceptual groups of the heterogeneous VBE knowledge are identified mainly through focusing on and covering two of its characteristics, including:

- Variety of *owners/providers* of the VBE knowledge, such as: the VBE-self, VBE members / participants, and VO-self networks.
- Variety of *usage of VBE knowledge* in the VBE document repositories and in the sub-systems of the VBE Management, System (VMS) such as: VBE Bag of Assets repository, VBE Governance's document repository, Profile and Competency Management system, VBE Performance Measurement system, Trust Management system, and VBE Value system (Afsarmanesh et al, 2007).

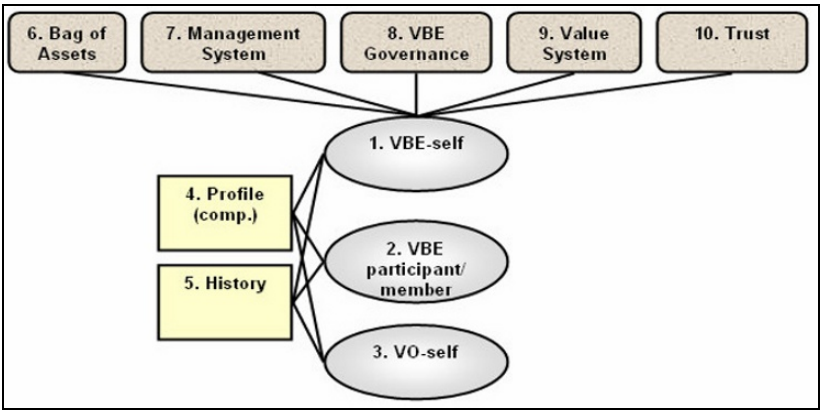


Figure 9 - Conceptual groups of the VBE knowledge

As a result, the following ten main disjoint, but inter-related **conceptual groups** of VBE knowledge were identified as illustrated in Figure 9:

(1) *VBE-self* knowledge that represents the general concepts about the VBE itself, e.g. the VBE life cycle stages concept.
(2) *VBE participant / member* knowledge that represents the main concepts related to the characteristics of VBE member organizations, e.g. the roles of VBE members.
(3) *VO-self* knowledge that represents the concepts about VOs that are configured within the VBE, e.g. the VO contract concept
(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, e.g. the concept of capacity of resources owned by a VBE member.
(5) *History* knowledge that represents concepts related to the history of performance, collaboration and cooperation of VBE members, e.g. the VO inheritance concept.
(6) *VBE Bag of Assets* knowledge that represents the concepts addressing the Assets structure in VBEs, e.g. the concept of Lessons Learned.
(7) *VBE Management System* knowledge that represents those concepts related to the functionalities and services supporting the VBE management, e.g. the generic VBE service definition.
(8) *VBE Governance* knowledge that represents the concepts related to the VBE rules, bylaws and culture, e.g. the classification of VBE principles.
(9) *Value System* knowledge that represents the concepts describing VBE capitals and measures, e.g. the concept of performance indicator.
(10) *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 trust level of

organizations, e.g. the concept of trust objective and criterion.

Additionally, the VBE knowledge categorized in each conceptual group is divided by their **levels of abstraction or usability / reusability** into:

(i) meta-knowledge, constituting the very small set of characteristics describing all other knowledge;
(ii) core knowledge, constituting the ten groups of knowledge addressed above, that are common to all VBEs, e.g. generic/unified model of the VBE competency;
(iii) domain knowledge, e.g. classification of general metalworking competencies;
(iv) application knowledge, e.g. concepts which are specific only to one VBE application from the above domain;
(v) real knowledge, e.g. the detailed competency description of a real VBE member.

4.2. VBE ontology structure and engineering approaches

The **structure** of the VBE ontology consists of four levels of abstraction and ten partitions constituting sub-ontologies of the VBE ontology, as also illustrated in Figure 10. The four levels of abstraction are introduced to reflect on reusability of the VBE ontology by the variety of VBE application environments. Namely, all VBE applications are supposed to share the ontology defined for the three above levels and differ only at the application level. The ten ontology partitions address the conceptual classifications of VBE knowledge as addressed in section 4.1 above. Please note that in Figure 10, the number / symbol inside parenthesis next to each ontology level represents the cardinality of instances of this VBE ontology level, namely there is only one VBE meta and one core ontology common to all VBEs, while N and M both represent "many", e.g. the fact that there are many different domains / business areas for VBEs and each VBE domain / business area may have many VBE applications.

Further, the decomposition of this ontology structure into levels and partitions supports the incremental development of the VBE ontology, while the developed parts of the ontology can be reused by different VBE management subsystems.

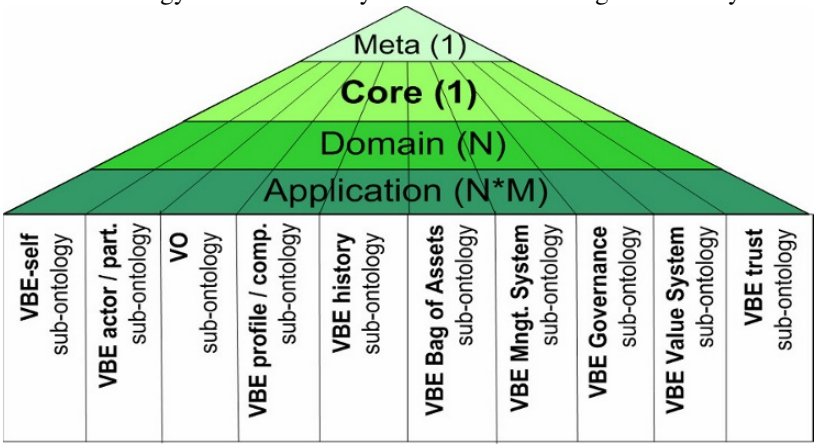


Figure 10 - VBE ontology structure

A description of the levels of the VBE ontology is addressed below, while an example of a constructed sub-ontology, namely the VBE profile / competency sub-ontology, is presented further in section 4.3.

1. *Meta level* represents the meta-concepts (such as "synonym" and "abbreviation") that are used to define other concepts of the VBE ontology.
2. *Core level* specifies the VBE concepts that are common to all VBEs, no matter to which domain it is applied (e.g. the specification of "VBE bag of Assets", "VO inheritance", "VBE member's competency", etc.), which will be then reused by different VBE applications. Therefore, the main objective of the core ontology is to present the common main types of information/knowledge that VBEs typically accumulate.
3. *Domain level* represents all VBE concepts related to different specific VBE domains (e.g. manufacturing, tourism, health care, etc.), that contains/extends the entire VBE core ontology. As such, it represents the customization and population of the VBE core ontology to the specific domain that it applies, for instance addressing specific competencies (e.g. "injection moulds fabrication"), or specific processes/activities (e.g. "welding", "milling", etc.) Therefore, the main objective of the domain ontology is to formally specify and organize the VBE domain knowledge.
4. *Application level* represents the VBE concepts that are common only for the members of the same VBE application, such as trust criteria or VBE value metrics, etc. for the specific food processing application of manufacturing canned food domain.

The **approaches for engineering** the VBE ontology for the meta and core levels differ from the domain and application levels as explained below. The main reason is that the domain and application level ontology of VBEs cannot be predefined and need to be created on demand during the operation stage of each specific VBE. Additionally, the domain and application levels evolve continuously during the VBE operation and evolution phases (e.g. when new VBE members bring new knowledge to the VBE). Below a summary of approaches for engineering different levels of VBE ontology are presented:

I. *For the meta and core levels:* the meta-concepts and meta-properties (e.g. semantic information such as "synonyms" and "abbreviations") for the unified VBE ontology as well as the core concepts for the unified VBE ontology shall be pre-defined by VBE experts together with ontology experts. The information / knowledge resources that can be reused for construction of the VBE ontology at the core level include the database schemas / data models from existing VBEs, as well as some VBE concepts presented in the literature, e.g. in (Afsarmanesh, Camarinha-Matos, 2005).

II. *For the domain and application levels:* the specific concepts to the VBE business area / domain as well as the specific concepts to the VBE application need to be defined on demand for each of the N domains and M applications in each domain. The main approaches that can be considered and applied for building up the domain and application ontology levels include: (1) Integration of all existing domain ontologies into a unified ontology (Pinto et al, 1999), (2) Semi-automated discovery of ontology concepts from text documents (Grobelnik, Mladenić, 2005) (Anjewierden at al, 2003).

4.3. Detailed overview of the VBE profile and competency sub-ontology

Engineering of the VBE profile and competency sub-ontology is fundamental for modeling, collection and processing of the information about VBE profiles and VBE competencies within the VBE, and namely within its **Profile and Competency Management System (PCMS)**, as also addressed in chapter 2.4 of this book.

First of all, in order to achieve the VBE's main goal, i.e. to prepare its member organizations for participation in VOs, it is necessary to collect and analyze the knowledge about all member organizations at the VBE level. We define a concept of the *VBE member organization's profile* to represent the knowledge about each organization in the VBE.

Additionally, in order to represent the qualifications of VBE members for collaboration in VOs, we define the *VBE member organizations' competencies*, as a fundamental element of their profiles. The initial purpose of introducing the "profile" and "competency" concepts is to present the knowledge about the VBE member organizations. We have introduced the *"VBE entity"* concept to represent all acting entities in the VBE context. For example, the VBE entities may include: VBE member organizations, VBE support-providing organizations, VBE customers, VO-self networks (for VOs formed in VBE), and the VBE-self network. The "VBE profiles" and "VBE competencies" represent the knowledge about all types of VBE entities. The VBE profiles and VBE competencies are defined as follows:

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

VBE competency *is the main element of the VBE profile that provides up-to-date information about capabilities and capacities of each VBE entity, as well as conspicuous information about their validity, qualifying it for participation in some specific activities / operations within the VBE, and mostly oriented towards the VO creation.*

The **generic VBE profile and competency model** (Ermilova, Afsarmanesh, 2007) represents the set of classes of VBE knowledge/information, as well as the relationships among these classes that needs to be collected and managed in the VBE. A high-level abstraction of the main elements of unified / generic model of the VBE profiles and VBE competencies is illustrated in Figure 11.

The core level of the VBE profile and competency sub-ontology, as well as an example of its domain level, was constructed in OWL (OWL, 2007).

The **core level of the VBE profile and competency sub-ontology** is a form of representation of the core / generic VBE profile and competency model. One example screen-shot from this core sub-ontology, constructed in the Hozo editor (Sunagawa at al, 2004), is partially illustrated in Figure 12. In this Figure, the ontology concepts, e.g. "VBE Profile", "Competency", "Resource", representing the elements in the core/generic profile and competency model, are illustrated as boxes. There are also three types of relationships among the concepts, including the "p/o"

meaning "part of", the "a/o" meaning "attribute of", and the "is-a" meaning "is a kind of".

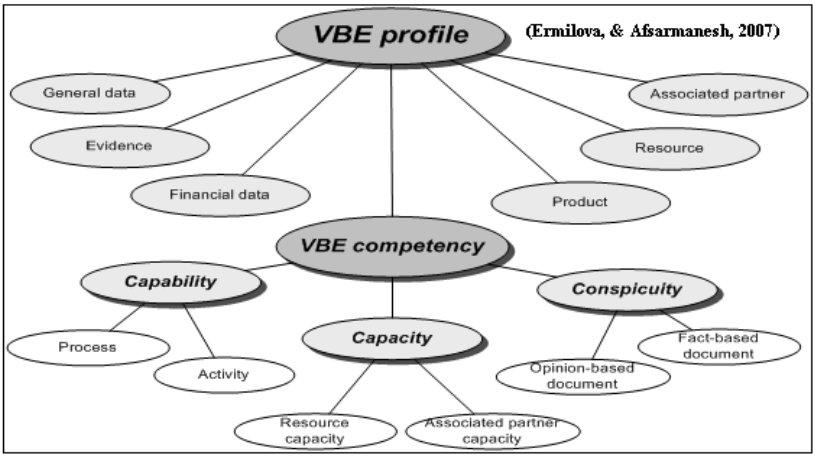


Figure 11 - A high-level abstraction of the model of VBE profiles and competencies

The *main purposes and usage* of the sub-ontology of the core VBE profile / competency in the VBE includes the following:

(1) Support of the R&D in the VBE field through providing means for the evolution of the VBE profile and competency models by being an extensive, uniform and sharable representation of these models.
(2) Support for the common understanding of the structure of the VBE profiles and competencies through providing the extensive definitions of the related concepts.
(3) Support for semi-automated design and development of the PCMS's database, or example using a methodology provided in (Guevara-Masis et al, 2004).

Support for structuring of the VBE profile and competency knowledge in the PCMS's GUI.

The **domain level of the VBE profile and competency sub-ontology** is a form of representation of the domain classes of profile and competency information/knowledge and their generalization hierarchies. The domain VBE profile / competency sub-ontology can be further partitioned into several specific "sub-sub-ontologies" depending on: a specific core concept (e.g. only for domain capabilities), or a specific domain / business area (e.g. only for metalworking domain). One example partial screen-shot from the sub-sub-ontology of practices and processes in the metalworking domain that is constructed in Protégé (Protégé, 2007) is illustrated in Figure 13 specifically depicting a part of domain-dependent classifications of practices and processes within an existing VBE from Mexico, called IECOS.

The *usage* of the domain VBE profile and competency sub-ontology in the VBE includes the following:

(i) Support of the representatives of the VBE entities with the definition of their domain-specific profile and competency related data (e.g. identification of

classes of the domain-specific business processes performed within a VBE entity).

(ii) Support for representation of the "standard names" and the "standard relationships" for the domain-dependent profile and competency knowledge/information that can be further facilitate the software-based matching/processing of the knowledge.

(iii) Support for structuring of the domain-dependent VBE profile and competency knowledge in the PCMS's GUI.

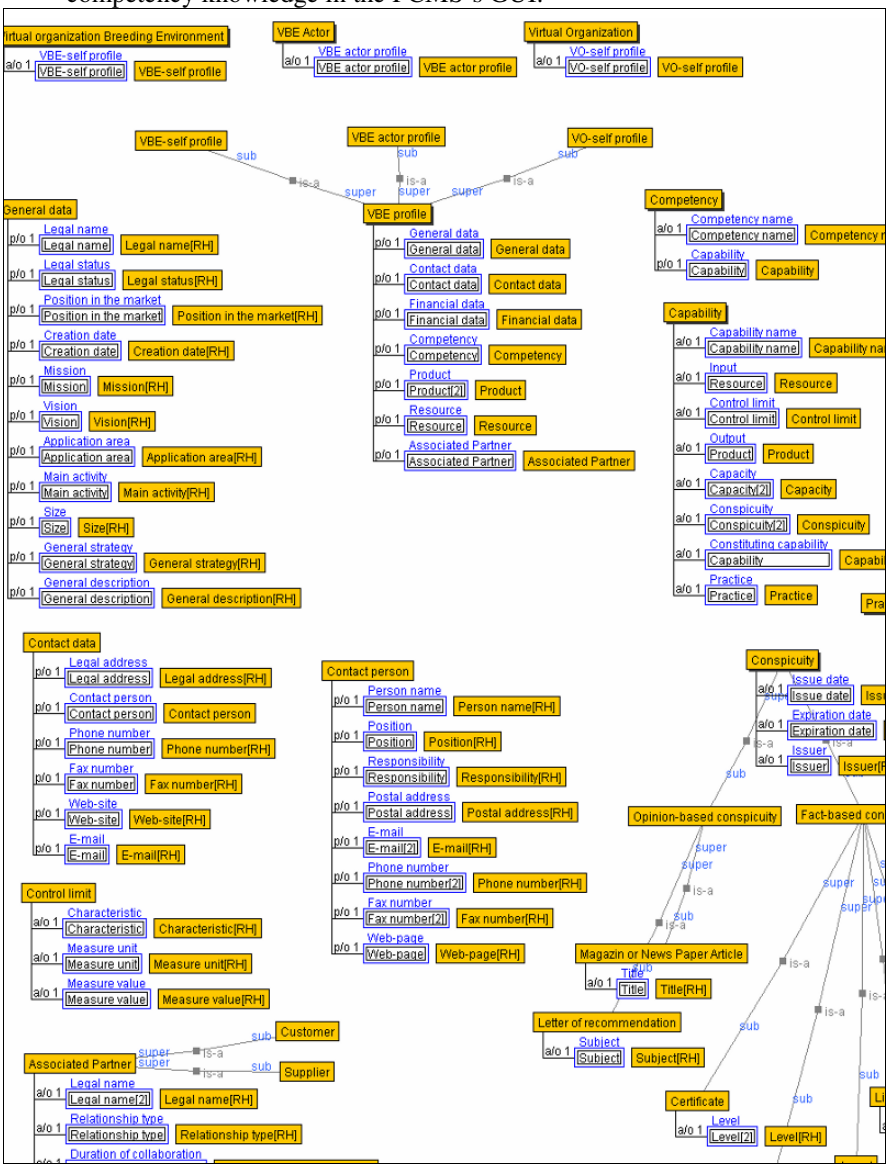


Figure 12 – Example Partial screen-shot from core profile/competency sub-ontology (in Hozo)

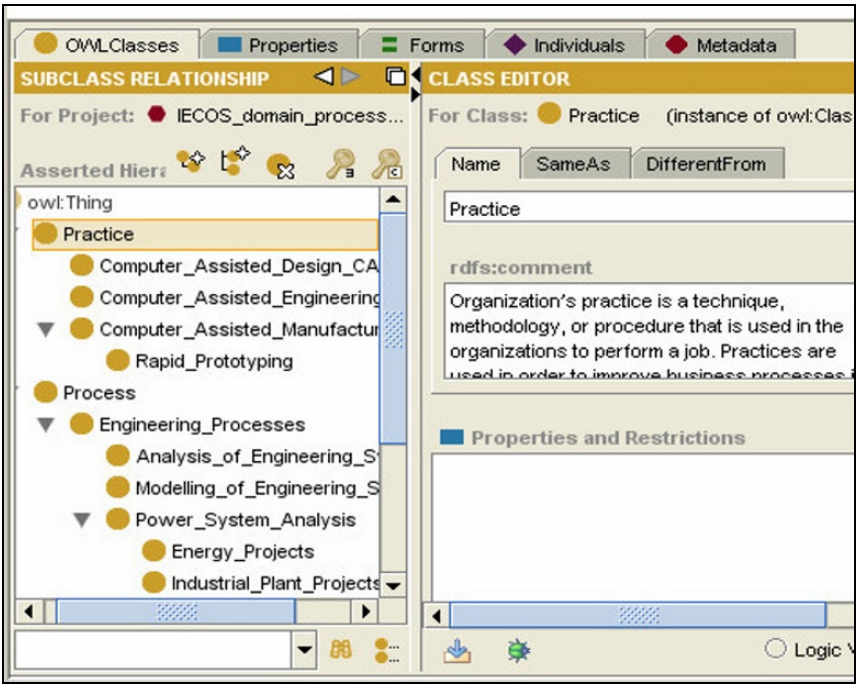


Figure 13 – Example partial screen-shot from domain VBE profile and competency sub-ontology (in Protégé)

5. VBE SEMI-TYPOLOGY

A systematic study of the wide variety of existing and emerging VBEs can facilitate both the modeling of their structural, componential, functional, and behavioral aspects, as well as the creation of a base for their reference modeling. In this section we aim to classify the VBEs and to identify their main "types", thus establishing the base for future research on each type of VBE. Namely, 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. In addition 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, we define a systematic approach for the specification of the VBE semi-typology (Afsarmanesh, Camarinha-Matos, 2007).

5.1. Investigated networks

Prior to addressing the systematic approach for the definition of the VBE typology,

below this sub-section summarizes our investigation results related to each of the six networks of SMEs. Please note, that in order to preserve the anonymity of these SME networks we refer to them as VBE-A, -B, -C, -D, -E, and -F.

1. VBE-A (Italy). This VBE is made up of 200 member companies that mostly constitute the information and communication sector in their respective district. This VBE is fully financially supported by the government. In its operation, the VBE administrator helps the member companies in finding business opportunities. Further to configuring VOs, this VBE in some cases also generates and configures new specialized VBEs, focused on certain regional specialties, and constituting organizations that know and trust each other. But also, sometimes, this VBE helps these generated sub-VBEs to merge into a larger VBE. The VBE administration does not get involved in VO coordination. Only partial overlap of competencies is allowed among organizations, and the VBE tries to avoid any competition.

2. VBE-B (Finland). This VBE consists of 12 member companies mostly in paper and automation industry ranging in size from big to small, and coming from close by regions. This VBE does not receive any financial support from the government. It is privately supported, by collecting a token fee of 100 Euros, charged to each member company. VBE management also does the brokerage of VOs, and in most cases making decisions about new business opportunities are also handled by the VBE management. However, once the VO is initiated, the VBE management does not provide any more support for the VO operation, which will be led by the VO coordinator. For this VBE, it was stated that a few software services may be helpful to assist with the VBE management tasks, but for the moment all activities are supported manually. This VBE avoids any possible competition between member companies (no overlap of expertise is allowed) in the network, believing that it is not good for trust establishment. Furthermore, in this VBE, there is an "oral" set of rules, and a number of "boards" of people in charge of different network activities, but there are no written rewards/sanctions rules to handle conflicts. Only some ethical rules in written form but even those they are not compulsory.

3. VBE-C (Germany). This VBE has 28 member companies from the aircraft industry, and it has been growing both in size and in making profit continuously. It has a single customer that is a major aeronautics company in Europe, which constantly gives them many opportunities for which they can configure VOs. In fact the motivation to create this network came from the fact that the aeronautics company decided to reduce the number of suppliers and therefore these companies had to join efforts in order to qualify as a supplier. Financially, the VBE administration depends on the actual profits made from opportunities/projects (it charges about 5% of the profit) made by the VOs that are configured in the VBE. In this VBE, the management does the marketing and brokerage, but other partners can also bring in opportunities. Member companies in this VBE trust each other and work together very well, not competing but some overlaps are allowed in case it is required to fulfill customer's orders. This VBE believes that more and more companies join in the network because the amount of the product/services demanded is high and no company alone can provide the products and the needed capacity in the required time. Furthermore, VOs can still be configured including non-member

companies, but only when the capacity cannot be achieved within the VBE or the required expertise is not available within the VBE. Usually losses in a VO are taken by the VO partners, but this VBE also has a loss insurance contract for the sake of the VBE as whole.

4. VBE-D (Finland). This VBE is a one year old regional engineering and automation network consisting of 16 engineering companies as its members. Financially, it depends on small membership fees. In addition to brokerage of business opportunities, the VBE initiates the VO, and also supports the VO management. For easier searching of suitable partners and also management of the VBE at large, the VBE management believes that it needs to maintain and manage a competency/expertise matrix, and share knowledge and experience, promote cooperation, raise the image of companies, support collaboration in marketing activities, and making bigger and more international contacts.

5. VBE-E *(*Italy). The region around this VBE in Italy represents a very old collection of more than 10,000 manufacturing companies, from a wide variety of areas that includes from sport clothing to furniture, etc. but all focused on innovation and new products. The government supports establishment of self organizing clusters, a kind of VBE, in the area. Each cluster must have a minimum of 80 SMEs in order to qualify for funding. There are already about 40 clusters formed in this region. Organizations in the region represent a strong mix of competition. The tradition in the area governs the cooperation, and defines the rules. The aspects of time and fashion are the most important criteria for successful cases and projects. As it is, this VBE does not run any VBE management system.

6. VBE -F (Spain). This VBE has a strong consulting company associated with it. It has 23 member companies and 20 other associated supporting SMEs, mostly in the aeronautics industry. The consulting company is working as a supporting institution for the VBE, and mostly providing legal assistance. This VBE is supported financially both by the government and also through the token membership fees from its members that use some tools provided in the VBE for their VO internal operations. When a business opportunity is identified, it is presented to the VBE members, where several VBE members may plan some VOs and submit a proposal to the VBE administration. Depending on the case, the evaluation of these proposals is either done by the VBE administration to suggest to customer and/or together with customer itself to choose the best VO and start it. VBE management only configures and initiates VOs and does not coordinate it. Currently, the VBE management of the VBE has perceived the need for the following aspects in order to improve the VBE management functionalities: trust management measures and ensuring confidentiality issues; storage of the past history/performance of organizations, to ensure trustability / trustworthiness evaluation; better legal framework for non conformance and for conflict situations; competencies management.

5.2. A systematic approach to development of the VBE semi-typology

Due to the lack of a defined scientific approach for typology identification in formal

sciences, and aiming to identify the main types of VBEs, we have partially followed a systematic stepwise approach, mimicking the case by case investigation (collection and observation) approach practiced in Beta-sciences (e.g. bio-diversity). In our study, both for the VBEs reported in the literature and the six clusters mentioned above, we followed a 3-step approach: The *first step* was to characterize different VBEs, in order to reach a *common set of characteristics for the VBE paradigm.* The *second step* was to use the common characteristics to classify different VBEs, and thus to reach the *main categorization of the VBEs*. The more challenging *third step* was to investigate if based on the main VBE classification results reached in second step we can *identify and generate a typology for the existing and emerging VBEs,* such that the attributes defining every type in the typology are true for all its members.

Table 2 - VBE Domain Categories

	Criteria	Potential network categories				Criteria impact
1.	**Finances**	Public support		Own support (Members' fee or % of turnover)		Level of VBE's autonomy
2.	**Orientation / Value system**	Profit		Non profit		Pressure from market or society
3.	**Localization**	Regional		Non regional		Legal and tax issues
4.	**Customer**	One or few		Many		Strong or weak customer's dependence
5.	**Product / service**	One or few		Large diversity of products/services		Product/service dependency
6.	**Sector / domain**	Single sector		Multi sector		Sector dependency
7.	**Collaboration aim**	Cost reduction		Innovation		Goal dependence
8.	**Dynamism level**	More Static		More dynamic		Stability
9.	**Member Competences**	Based on competence complementarities		Based on complementarities and competition		Trust issues
10.	**Integrating new members**	Loose alliance - limited term / condition alliance		Tight alliance - permanent full members		Role of actors, Membership level
11.	**Origin**	VBE with strong historical roots		New VBE		Strong impact on ICT tools
12.	**Focus**	Product / service oriented		Market / society oriented		Volatility
13.	**Stage of VBE Life cycle**	Creation	Operation	Evolution	Meta-morphosis	Needs in term of guidelines, methodologies, and ICT tools
14.	**VBE size**	Small: <20	Medium: <100	Large: <1000	Very large: above	Role of the administration and needed ICT tools
15.	**VBE role in VO operation**	None		domination		Coordination and conflict resolution
16.	**Current use of technology and ICT tools**	Low	Medium	High		Level of ICT tools dependency
17.	**Members types**	Business companies only		Business companies + non-business organizations		More potential, less coherency
18.	**Broker**	Internal		External		Access rights and member roles

19.	**VO**	Recurrent		Formed with new members each time	Needs for VO creation tools
20.	**Profiles (management)**	Informal	Limited (Excel)	Database	Potential to be processed by ICT tools, trust, and access rights
21.	**Competencies (management)**	Informal	Limited (Excel)	Database	Potential to be processed by ICT tools, trust, and access rights

Below we address these three steps in details:

- ***Step 1: Common set of characteristics for VBEs***

Based on our network analysis experience, the following set of questions represents the main criteria for investigating these networks: *How many sectors are involved in the VBE? How and which sources support the VBE financially? How does the VBE find VO opportunities? What is the frequency of VO configuration, namely the VBE members' involvement in VOs? How the VBE is managed, and are there formal governance regulations? What are the functions performed by the VBE administration? How is the VBE configured in terms of roles of its actors, permitted competition, location of VBE members, etc.? What kind of organizations can be included or are invited to join the VBE and how large is the VBE? Are VOs always configured of the VBE members, or also consisting some organizations from outside? And if so, under what conditions SMEs from outside can be involved in such VOs? What is the relationship between the VO customers and the VBE?*

In this step of our study and as a response to the above questions, we encountered a large number of distinguishing characteristics for VBEs that can in one way or another be further used as the purpose/criteria for VBE classification. The *main identified "distinguishing characteristics",* which constitutes a subset of the identified common set of VBE characteristics, include: (1) Multiplicity of sectors/domains, (2) Variety of collaboration drivers, (3) Orientation (value system), (4) Level of dynamism, (5) Financial support mechanism, (6) Localization, (7) Size, (7) Nature of output results, (8) Mission categories, and (9) Application of ICT tools.

- ***Step 2: Main classes/categories of the VBEs***

At this step, we used the set of VBE common characteristics as the means to reach some classification of different VBEs. Therefore, for each characteristic, we identified a number of potential classes. For example, two classes were identified for the Multiplicity of sectors/domains that included the single-sector and the multi-sector. For some other characteristics, a number of classes could be identified, e.g. for the size characteristic for example, as suggested by some of the network's representatives, we could identify Small (under 20), Medium (under 100), Large (under 1000), Very-Large (above 1000) number of members, etc. The following list shows some of the identified classes in our study for each of main VBE characteristics addressed above:

– Multiplicity of sectors/domains: Single sector, Multi-sector
– Variety of collaboration drivers: Customer induced, Capacity achievement, etc.
– Orientation (value system): Business orientation, social welfare orientation, etc.
– Level of dynamism: Dynamic pace (evolving), Static pace, etc.
– Financial support mechanism: Publicly supported, Privately supported, etc.

– Localization: Regional, Non-regional
– Size: Small (under 20), Medium (under 100), Large (under 1000), Very-Large (above 1000) number of members, etc.
– Nature of output results: Tangible output, Intangible output, etc.
– Mission categories: Profit-based, Non-profit-based, etc.
– Application of ICT tools: Base management services, advanced services, etc.

In order to summarize our findings, Table 2 is developed to represent: (1) the main criteria/characteristics for characterization and comparison of different VBEs, (2) for each characteristic, it provides the two main potential categories for the networks, and (3) a clue to the main impact of each characteristic/criteria on the network.

- ***Step 3: A semi-typology for existing and emerging VBEs***

Our third and more challenging aim was to investigate if based on the main VBE classification results we can *identify a typology for all existing and emerging VBEs,* such that the attributes that characterize every type in the typology are true for all of its members. As described / argued below, reaching this aim was quite challenging and we could finally achieve not one, but a number of *semi-typologies* for VBEs.

Typology is a classification of all elements in the domain, based on the definition of particular types or categories in that domain, where the members of each type or category are identified by postulating their specified attributes. Typically, *types/categories in a typology are: (1) mutually exclusive,* and *(2) collectively exhaustive.* For example in the biodiversity area, the taxonomy defined for the "limited", though large, collection of animals on earth, although it took a few centuries to establish, has followed a straightforward procedure to create the typology classifying them, as well as to identify the few exceptions where the defined types are not mutually exclusive. Considering the above definition, in our study, it became clear that defining a typology for a new "paradigm" such as the VBE, is a big challenge if at all possible. This is simply due to the fact that first the VBE paradigm is not a limited environment, although it already has a large variety of manifestations. Second, every VBE has distinctly unique "intangible" specificities. And third, there is a wide diversity of purposes and perspectives that can be considered through which the existing and emerging VBEs can be classified.

Therefore, prior to our efforts towards identification of a VBE typology, we became aware of the fact that we will not identify a set of *mutually exclusive types* to classify the VBEs. Consequently, we chose to aim at the identification of a *VBE semi-typology* to tackle the challenge of identifying *a number of types that can collectively exhaust both the existing and the forthcoming VBEs*. Such a semi-typology defined for VBEs, even though does not provide clear cut categorization of VBEs, as for instance exemplified above for the Bio-diversity area, is still valuable, since it provides an insight into the characterization / understanding, and thus better modeling of the VBEs. Furthermore, if one of our identified semi-typology has an "intuitive" appeal for categorization of VBEs, and gets adopted by the research and practice community in this paradigm, we have reached a *common base* for understanding and co-working among the researchers in this area.

For this purpose, we have identified three main perspectives as more dominant and intuitive in representing and classifying the VBEs, which are also validated by the

networks involved in our study. Below, for every considered perspective, a list of references is also made to the rows in Table 2, which represent its related characteristics and classifications.

I. *Domain categories* (1, 3, 4, 5, 6, 7, 8, 9, 11, 12, 13, 14, 15, 16, 19, 20, 21)

II. *Main Collaboration Drivers* (1, 2, 3, 4, 5, 7, 9, 10, 11, 13, 14, 15, 16, 17, 20, 21)

III. *Orientation/Value Systems* (1, 2, 3, 5, 7, 11, 12, 13, 14, 15, 16, 17, 20, 21)

In the following text, applying each perspective, a few types (and their main characteristics) are identified. For every perspective, the identified types collectively exhaust the categorization of the so far reported as existing or emerging VBEs. Please notice that as explained above, the typology defined for VBEs under each perspective may not present mutually exclusive VBEs; namely while an existing VBE may primarily be a member of one type, it may at a secondary stage be also a member of a second type in that typology. Therefore, at best these three provide a semi-typology for VBEs. Below the VBE semi-typology is identified for each of the three perspectives:

I. Domain categories – Based on the investigated characteristics (both in literature and in the field) and with the perspective of categorizing the main domains, this VBE typology identifies the following four types of VBEs. For each type of VBE, the SME networks (among the six mentioned above) that best fit each type are also identified below (also see Table 3).

Type A1 - Stable products/services domain (e.g. VBE-C, VBE-B, VBE-D)
Type A2 - Stable one-of-a-kind domain
Type A3 - Emerging domain (e.g. VBE-F, VBE-A)
Type A4 - Innovation driven domain (e.g. VBE-E).

The Stable products/services domain VBE type is primarily characterized by substantiated sectors or domains, business or social oriented, traditionally regional but nowadays more with a mix of regions, and constituting VBEs of different sizes (from large to small), and using some IT related tools (e.g. VBEs to support traditional manufacturing and services industry). Some general principles for this type of VBEs are already established both in research and in practice. In several business oriented domains some body of knowledge as well as practiced regulations are already created and instantiated, that provide a strong base for the current study of this type of VBEs. These VBEs are operation-based, meaning that their daily activities are known and repetitive, and thus do not require new or innovative solutions for each product and service (Bremer et al, 1999) (Mejia, Molina, 2002) (Pluss, Huber, 2005). Nevertheless, this type of VBE still lacks proper mechanisms and semi-automatic tools for the management of its competency and profile, establishing trust, developing generic ontology, and enhancing the potential of the VBE in responding to the market/society demands.

The Stable one-of-a-kind domain VBE type – typically identified with substantiated sectors and domains focused on longer term VOs to develop one of a kind products/services - typically with a mix of business & possible social orientation, constituting medium size regional VBEs with a high trust level among the members from multi-sector and complementary organizations, using IT related tools (e.g. VBEs to support traditional construction industry, environmental cleansing of wastes). Similar to the stable products/services domain, also for the one-of-a-kind domain in some areas, e.g. construction industry, there is a rich body of knowledge and formal definitions of

some general principles that can be used as the base. Despite the fact that these VBEs are well established, their products are always unique, e.g. a bridge, an airport, etc. Thus, they have a project-based working style where some unique ideas are necessary for every new product. Once developing proper IT tools for trust establishment among VBE member organizations, this type of VBE can benefit from extending its boundaries to include new non-regional members that may increase its level of competency.

The emerging domain VBE type is primarily characterized by the merge of organizations from several substantiated domains in order to respond to some new market/society demands. The VBE for emerging domain will constitute organizations from different sizes with complementary capabilities, established knowledge, culture, and practice tradition. A number of challenges rise due to the merge of these heterogeneous domains, e.g. the integration/inter-linking of their substantiated and formalized knowledge, developing rules of cooperation and establishing trust and recognition among the involved organizations. Examples of this type of VBEs include the merge between the housing and ambient intelligence domains to address the house of the future, merge between the broadcasting, mobile devices, and the entertainment industry to address the entertainment of the future, or the merge between the public safety and environmental scientists/engineers to address the environmental cleansing of the future.

Table 3 - Brief summary of the VBE typology according to the Domain categories

	Collaboration driver	**Dynamism level**	**Degree of readiness**	**Customer**	**Finance**	**Typical VO's duration**
Type A1	Ecosystem, capacity achievement, Customer induced cost reduction	Some static/ dynamic	Medium	One/Many	Self support	Medium
Type A2	Customer induced Complement competence	Static	Medium	One	Self support	Long
Type A3	Market induced Cost reduction	Evolving	High	Many	Need public support	Medium
Type A4	Innovation	Evolving	Very high	One/many	Need public support	Short

The Innovation driven domain VBE type – this classification of VBE mostly identifies with the establishment of its short term VOs to deliver innovation for the market or society's benefit, constituting a number of organizations potentially from different sectors with complementary competencies. The degree of readiness of the organizations in this VBE must be very high and typically, due to the role that these VBEs play in a region and the risks involved in innovation-based VOs, there is usually public support available to these VBEs. The new line of products in clothing,

e.g. from Italy, and in computer hardware, e.g. from California, are examples of this type of VBEs.

Please notice that the following is considered for measuring the duration of the VOs: Short = some weeks to 6 months, Medium= between 6 months to 1 year, Long= longer than 1 year.

Table 4 - Brief summary of VBE typologies according to main collaboration drivers

	Membership	**Overlapping of competencies**	**Support institutions**	**Market accesss**
Type B1	Enterprises & others Highly selective	Possible	Limited	Extremely focused
Type B2	Organizations in same domain/sector	Mostly	Limited	Focused in one domain (general)
Type B3	May cover various sectors Basic adhesion rule	Possible, limited (regulated)	Limited	Generic (as much as possible)
Type B4	Specific sector (mostly) Regional basis	Possible	Strong	Generic with regional focus

II. Main Collaborative Drivers - If we put our perspective on the main collaboration drivers, a different VBE typology classification can be established including the following four classes (also see Table 4):

Type B1 - Customer induced VBE, when the alliance is formed to qualify as a supplier (e.g. VBE-C).

Type B2 - Capacity achievement driven VBE, formed to support high demands (e.g. VBE-F, VBE-D).

Type B3 - VBE oriented towards complementary competencies, formed to capture new markets, new products/services, or new dimension (e.g. VBE-B).

Type B4 - Regional ecosystem, formed to preserve local specificities, tradition, culture, benefiting from government incentives (e.g. VBE-E, VBE-A).

Table 5 - Brief summary of the VBE typologies according to the value system

	Main expected benefits	**Membership**	**Outputs**
Type C1	Economic (profit)	-Private organizations (enterprises)	-Products - Services
Type C2	-Social prestige -Coverage	-Public organizations -NGOs	- Services (mostly)
Type C3	-social prestige & -Economic sustainability	-Public & -Private organizations	-Services -Products (some)

III. Orientation/Value systems - With the perspective of the underlying value systems, another VBE typology classification may include the following three classes (also see Table 5):

Type C1 - Profit / market oriented – to produce economic profit (e.g.

manufacturing – VBE-C, VBE-B, VBE-D, VBE-F, VBE-A, VBE-E)
Type C2 - Social oriented – to support the society (e.g. environment support)
Type C3 - Hybrid market/social – (e.g. R&D on new source of energy).

6. CONCLUSIONS

The Virtual organization Breeding Environment (VBE) is an emerging challenging area of research. Most elements comprising VBEs are not yet properly defined, and so far there is a lack of suitable reference models and reference architectures addressing the constituting elements and behavior of the VBEs. The multi-disciplinarity of research on VBEs further adds to its complexity. Consequently, even discovery and identification of VBEs' requirements and proper definition of this problem area itself becomes challenging. Furthermore, to handle its wide variety of requirements, innovative approaches and mechanisms are required.

Nevertheless, in order to support the establishment of VBEs in the market / society, as well as the development of the supporting ICT-based VBE Management Systems, development of a comprehensive VBE "reference framework" is presented in this paper as a contribution to the VBE field of research, addressing the fundamental components so far identified for VBEs. Therefore, the chapter addresses the identification, definition, and classification of the VBE's main characteristics. Based on the case studies of several existing networks of organizations, and the related past research, we systematically approached and represented the VBE reference framework from different perspectives.

First, this chapter presents the VBE's basic characteristics, such as its actors and their roles, rights and responsibilities, its' life cycle and the life cycle functionalities, etc. Second, it approaches the VBE reference framework through the definition of four generic near-orthogonal sub-spaces to address different aspects of the VBEs. Third, it introduces an ontology-based framework for different types of VBE-related knowledge. Last, it approaches the VBE paradigm definition through the categorizations of its "distinguishing" characteristics for the purpose of identification / specification of a VBE typology.

Elements defined in the VBE reference framework further support the definition and development of components that are needed to support different stages of the VBE life cycle, and for proper management of the VBEs, as addressed in the other chapters of the Part 2 of this book. The next step in the research will extend/merge this framework with the VBE reference modeling research, which is the subject of another forthcoming book from ECOLEAD results.

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