

# COMPETENCY AND PROFILING MANAGEMENT IN VIRTUAL ORGANIZATION BREEDING ENVIRONMENTS

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*A main characteristic of a Virtual organization Breeding Environment (VBE) is the set of competencies that it can offer to the market and society. The VBE competencies are defined in this paper through the competencies of three main VBE information components, such as the VBE member, the Virtual Organization (VO) formed in the VBE, and the VBE itself. Typically competencies appear as a part of the VBE members' profiles. VO's competencies need to be obtained through the VOs' profiles, during the operating stage of the VBE. The competencies of the VBE itself need to be carefully defined at each VBE and are contained in the VBE profile. These three kinds of profiles are addressed in this paper. The management of profiles and competencies within a VBE shall be supported by a special subsystem of the VBE Management System (VMS) – Profiling and Competency Management System (PCMS) specified in this paper.*

## 1. INTRODUCTION

An effective creation of dynamic Virtual Organizations (VOs) requires pre-existence of a suitable Breeding Environment (VBE). VBE is currently defined as “an association of organizations (members) and their related supporting institutions, adhering to a base long term cooperation agreement, and adoption of Common operating principles and infrastructures, with the main goal of increasing their preparedness towards collaboration in potential Virtual Organizations” (Afsarmanesh, Camarinha-Matos, 2005).

The competencies in VBE need to be defined through the competencies of its three main components, including the VBE member, the VO, and the VBE as a whole. Therefore, competencies in VBEs can be classified as follows:

- VBE's (self) competencies address the abilities of the VBE to manage networks of organization towards VO formation;
- VBE member's competencies constitute capabilities and capacities of a VBE member which it can offer to the VBE in order to form a VO;
- VO's competencies are the result of clustering VBE members in a VO.

The competencies of VBE members and VOs in a VBE can be arranged into the VBE competency catalogue.

Originally competencies are a part of the profiles. In general, an organizational *profile* can be defined as a set of structured information about the organization. VBE has three types of profiles including *VBE member's profile*, *VO's profile*, and *VBE's (self) profile*.

This paper specifies *common models for competencies and profiles*, and addresses a *Profiling and Competency Management System (PCMS)* which constitutes an important part of the VBE Management System (VMS).

Chapter 2 of this paper addresses the studied *state of the art* including, *first* the literature study on competency models, *second* the study of existing systems for organization profiling, *third* the study of profiling and competency management in existing VBEs, and *fourth* the experts' requirements to the PCMS.

Chapter 3 addresses the *specification of the PCMS's components and functions*.

This work on this paper was supported in part by the FP6 IP project, called ECOLEAD, funded by the European Commission.

## 2. STATE OF THE ART

In order to define the elements of the competencies and profiles of the VBE (self), the VBE member, and the VO, as well as to model the PCMS for VBEs, the state-of-the-art related to profiling and competency of organizations is studied.

In this chapter, a summary of some of the state of art work in this area as well as the results of some case studies that we have performed to identify the main requirements for the PCMS, as expressed by the field experts and academic experts, are presented.

### 2.1 Literature study of competency models

In the literature, different authors propose different definitions for competencies of organizations (companies), with some commonality (Galeano, Ermilova et al, 2006). Two of these definitions closer to our definition of competency are addressed below.

*Javidan* (Javidan, 1998) defines the competency hierarchy as depicted in Figure 1. According to Javidan, *resources* are the inputs into the organization's value chain. Javidan categorizes resources into three groups of *physical* resources (e.g. equipment, location and assets), *human* resources (e.g. manpower, management team, training and experience) and *organizational* resources (e.g. culture and reputation). *Capabilities* refer to the organization's ability to exploit its resources; they consist of a series of *business processes* that manage the interaction among its resources. Capabilities (e.g. marketing capabilities, production capabilities, distribution capabilities and logistics capabilities) are functionally based. *Competencies* represent a cross-functional integration and coordination of capabilities. In a multi-business corporation, competencies are a set of skills and know-how housed in a SBU (Strategic Business Unit). *Core competencies* are skills and areas of knowledge that are shared across business units and result from integration and harmonization of SBUs' competencies.

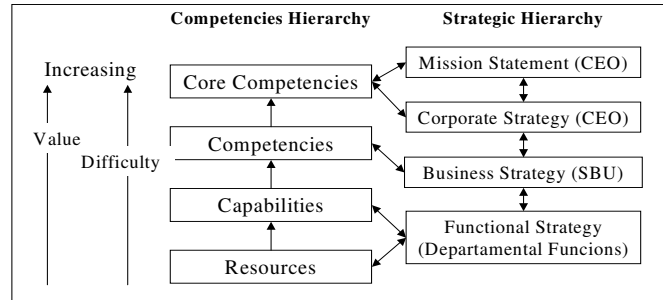


Figure 1 – Competency hierarchy and strategic hierarchy by Javidan

Molina et al (Molina et al, 1997) defines competences as the match between fulfilling the tasks defined by the VO broker with the constituent skills provided by the cluster. In their scenario there is a representation of competency which is describing the capability to make products, perform process or use technologies (humans, practices, resources). Following this argument, competencies can be described using the information entities as illustrated in Figure 2.

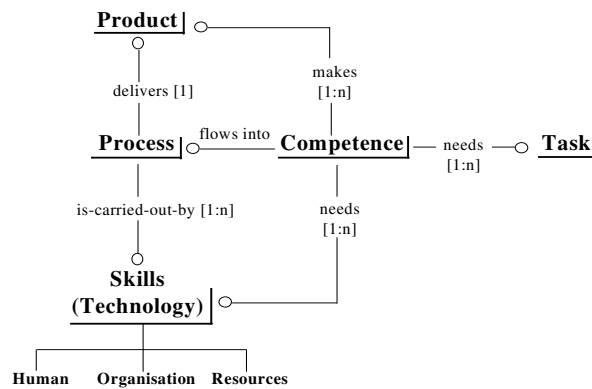


Figure 2 - Representation of competences by Molina et al

Products addressed in Figure 2 are the products of the organization or the VBE, which are attractive from the perspective of the customer, and which make a substantial contribution to organization's or VBE's success. (Business) processes are all the processes of the organization, e.g. product development, order generation and fulfillment, integrated logistics, etc. Skills (Technology) are theoretical and practical knowledge, human skills and abilities that can be used to develop products and services. According to Molina et al, a representation of competence, which satisfies its definition, can be achieved by combining the information entities of products, business processes and technologies.

Several elements introduced in the above two models are used as the base for specification of the common competency model of the VBEs.

## 2.2 Study of existing organizational profiling systems

In our study, two de-facto standard profiling information systems, one Dutch and one European, which organize regional centralized profiling, are considered. These systems, addressed below, specify and classify a wide variety of information about organizations.

*The Dutch Chamber of Commerce (DCC\_URL)* has a trade register consisting of a large number of companies' profiles. Each company/organization is presented with the following data: contact information, information on the roles and functions, organization's legal form, date of establishment, number of employees, actual activities, the size of the company, summary of figures, annual accounts, etc. This register provides a very good example of categorizing organization's information for profiles in VBEs.

An example of arranging profiles of non-commercial organizations is the *EU register of organizations involved in proposal submission (ProposalForms\_URL)*. Organizations' information includes the following categories: organization legal name, short name, department, postal address, legal national registration number (e.g. the Chambers of Commerce register), activity type, legal status, NACE (NACE\_URL) business area, annual turnover, annual balance sheet total, number of employees, independence, owners, affiliation, etc.

*The profile elements introduced by the two above systems are further used to specify the common profile model for VBEs in ECOLEAD.*

## 2.3 Study of profiling and competency management in existing VBEs

The main aim of analyzing the existing profiling and competency management in running networks of SMEs is to design a more advanced and generic PCMS which can fit most VBE domains and applications.

A questionnaire called Q1, is prepared for collecting information from the running VBEs. We have purposely chosen VBEs from different countries for this study. Five VBEs in Europe and Latina America, including IECOS (Mexico), Virtuelle Fabrik (Switzerland), Toolmaker Cluster of Slovenia (Slovenia), GIZ ACS (Slovenia), and VIRFEBRAS (Brazil).

From the analysis of the answers to Q1, the following conclusions have drawn among others.

- Only four of the VBEs collect profiles of their member organizations. Two of the VBEs address VBE (self) profiles. One VBE collects VO profiles. Three of the VBEs collect competencies of their member organization.
- *Competencies in the VBEs* are in most cases replaced by the combination of member's products/services, business processes and resources.
- *Some elements of profiles common among these VBEs* include information on products/services, customers/suppliers, business processes, performance indicators/benchmark, competencies, strategy and goals of a company, and ICT/human/physical resources.
- *Some functionality of the VBEs in relation to profiling* includes profile creation, search for members to form a VO, assessment of members performance, analysis of the VBE, defining new VO's resources, competencies, etc.

The model designed for the PCMS supports and further extends the above competency and profile structures and the required system functionality.

## 2.4 Requirements to the PCMS from academic and industry experts

The main aim for analyzing the requirements from experts was to specify the components and functionality of an advanced “future” PCMS for VBEs. In order to identify the requirements for the PCMS, we decided to study by collecting these requirements from the experts both in academia and industry. Therefore two questionnaires were developed, a questionnaire for academic experts, called Q2, and a similar questionnaire for industry experts called Q3.

The study with **academic experts** included more than twenty experts involved in ECOLEAD consortium. Some conclusions from the analysis of Q2 follow.

- *Competency* is defined by most researchers as an ability to perform tasks, business processes, job, core business, activities, practices applying human/physical/ ICT resources (e.g. personnel knowledge, skills, attitude, as well as organization machinery) aimed at offering products and/or services in the market.
- *The common elements of profiles* for VBEs should include contact information, business process, human / physical / ICT resources, products / services, best practices, partner organization (e.g., customer, supplier, as well as filial and corporation).
- *VBE member’ profile* should also provide availability of member’s competency or free capacity with a high level of detail.
- *VO’s profile* should include the VO type, a list of organizations involved, and the information on VBE member components that constitute the VO partners.
- *The arrangement of the profiles catalogue* should be formed as a tree or a network, which may be arranged in several different ways depending on different criteria, and it should have a user-friendly interface and be flexible.
- *PCMS functionality* needs to support indicating what VBE provide in order to promote itself towards new members and customers. The PCMS functions shall support profile creation, profile modification, profile construction, analysis of VBE’s evolution, analysis of profile catalogue changes, assessment of VBE members and search for members’ competencies to form a VO. The features necessary for the search for VO partners include: classification of organization profile information regarding different criteria (e.g. city, competency, product, etc.), including combination of criteria, several levels of approximation to the result as well as some optimization of the results. Obtaining member’s profile information can be either directly performed through structured questionnaires, or indirectly through text-mining of member’s documents (e.g. web-sites, brochures).

The above requirements are applied to the further modeling of the PCMS.

A group of **business experts**, involved in our study, responded to Q3 questionnaire. These consisted experts from seven different companies involved in the IECOS network. In summary, the following suggestions were proposed by the contacted organizations to improve PCMS functionality.

- *Customers' letters of recommendation* should appear in VBEs as well as the contact information about the person signed this letter (information of the customer).
- The PCMS could also have information of the VBE members' *network of suppliers*. This will help to find other companies recommended by the VBE members, e.g. to invite them into the VBE to both increase the competency of the VBE, and to be involved in VOs.
- *Letters of confidentiality* should appear in the VBE to make sure that the people that are going to use the PCMS tool will not use the information out of the necessary context.
- A very strict *system of members' data evaluation* is required.

The above requirements are considered for modeling the profile component. Namely, Associated partner, as well as Evidence of validity of profile information are introduced

### 3. SPECIFICATION OF PCMS

Based on the state of the art addressed in chapter 2, the model of the PCMS is specified. The PCMS mainly consists of: **profiles** of VBE member, VO, and VBE itself as the main information components; **ontology** for profiles and competency; and **functionalities** to access and analyze information.

This chapter provides the common models for profile and competency in VBEs. It introduces the ontology for profiles and competency as a supporting component. It also provides the minimal necessary set of functionalities for the PCMS.

#### 3.1 Common models for profile and competency in VBEs

*Profile of an organization (e.g. VBE member, VO, and VBE itself) is defined as a set of structured information that describes the organization.* Since the focus of this paper is on competency as the most significant element of profile, the organization's profile information is divided into two main groups – the general organization's information, and is competency-related information, as described below.

- *General information* of an organization contains the basic information about the organization (see section 2.2) including the organization's name, its general description, coordinates, industry sector, legal status, strategy, total sales, financial information, etc.
- *Competency-related information* (see sections 2.3 and 2.4) includes description of: competencies themselves, (business) processes, products/services, resources, practices and associated partners (e.g. customers) available for the organization. These six types of the organization's elements are defined further below as six classes. We have also identified a number of attributes for these classes, which are validated by representatives of the IECOS, a running network of manufacturing organizations (IECOS\_URL). The model of the competency-related profile information is presented in Figure 3. In the text below we further define these six classes.

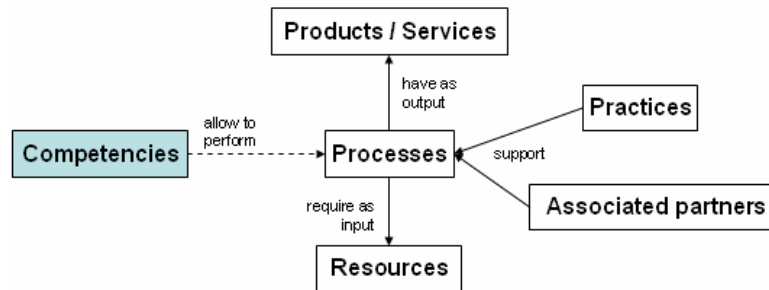


Figure 3 – Competency-related organization information

*Process* of an organization is a structured and measured, managed and controlled set of interrelated and interacting activities that uses resources to transform inputs into specified outputs (Davenport, 1993), (ISO9004:2000, 2000). The attributes of the process class include Name, Description, and Type.

*Product/service* of an organization is an output of a process which can be offered to the market/society and which consists of a bundle of tangible or intangible benefits that satisfy customer needs. Product/service class attributes include Name, Description, Strategy, Contribution to sales, and Type.

*Resource* represents an element applied to a process that performs a number of operations which can transform some tangible/intangible inputs into some outputs. Organization can have three types of resources, including human resources, ICT resources (e.g. software) and physical resources (e.g. buildings, machines, equipment, transport, and knowledge assets). The resource class attributes include, for human resource: Job function, Educational level, Professional field, Degree obtained, Years of experience, and Number of employees; for ICT resource: Name, Description, and Type (e.g. software); for physical resource: Name, Type (e.g. buildings), Description, Number, and Functionality.

*Practices* are the techniques, methodologies, and procedures that are used in the organizations to perform a job. Practices are used in order to improve business processes in the organization (Stuhlman\_URL). Practice class attributes include Name, Description, Implementation time, Introduction date, and Reason for introduction.

*Associated partner* is an organization which has some (business) relations with the organization. This class appears through the answers for questionnaire Q3. The supposed minimal set of the attributes for this class includes: Name, Type (e.g. suppliers, customers, filial, or corporation), General textual description, and Contact information.

We define **competency** as the organization's capability to perform (business) processes (in collaboration with partners such as suppliers), having the necessary resources (human, technological, physical) available, and applying certain practices, with the final aim to offer certain products and/or services to the customers.

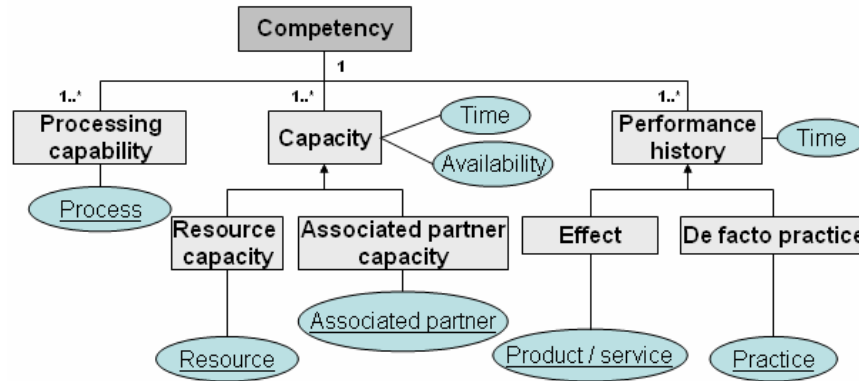


Figure 3 – Competency model

The earlier definition of organization's competency as "capability + capacity" (Afsarmanesh, Camarinha-Matos, 2005) addresses (*processing*) *capability* as a potential ability to perform a *process*, and the *capacity* as the *availability* of *resources or associated partners*.

As represented in Figure 3, this definition is further extended by including another important descriptor for competency – the *performance history*, that itself includes *effects*, including products/services (Enterprise project\_URL) and *practices* of an organization. The ECOLEAD model of an organization competency is illustrated in Figure 3.

### 3.2 Main information components of the PCMS

Based on the ECOLEAD common models of profile and competency, we define below the VBE member's profile, VO's profile and VBE's (self) profile as components of the PCMS.

The **member's profile** is completely based on the common profile model.

The **VO's profile**, in addition to the common profile elements, includes: a List of VO partners, Type of partnership, Collaborative opportunity description and other general VO-related information. *Competencies of a VO* can be of two types, including, first the VO partners' competencies, and second the new emerging competencies, which are the result of VO partners' collaboration.

The **VBE's (self) profile**, in addition to the common profile elements, includes: a List of members, List of actors, List of roles, List of rules and other general VBE-related information. The examples of VBE's *processes* include network management, VO formation, VO creation, marketing/branding of products/services (to be sold through the VBE), innovation promotion, etc. The examples of *VBE's competencies* include its ability related to VBE management, VO formation and creation, innovation promotion, etc.

Two important catalogues are necessary to be presented and managed inside the VBE, one catalogue for VBE members' profiles, another for VO's profiles catalogue. The **VBE members' profiles catalogue** can be accessed as a collection of members' profiles sorted by different types of organization information. In this



catalogue all the competencies, resources, product/services, etc., available in a VBE through its members, as well as the *new emerged competencies* appearing as the result of a possible assembly of VBE members' competencies, can be presented. **VO's profiles catalogue** can be accessed as a collection of VOs' profiles sorted by different types of VOs' information. These two catalogues are combined in a single VBE profiles catalogue system.

### 3.3 Main functionalities of PCMS

The summary of the PCMS functionalities can be found in Table 1. Please notice that inside the table some details are provided about these functionalities and how they will be achieved, e.g. manually, semi-automatically, etc.

The proposed set of PCMS functionalities is divided into five groups, including **creation, updating, structuring, search & retrieval**, and **analysis**. Each group is addressed by the three PCMS's profile components for VBE member, VO and VBE (itself), as well as by the *catalogue of the VBE members' profiles and VOs' profiles*.

	Member's profile	VO's profile	VBE's profile	VBE members and VOs' profiles catalogue
<b>Creation</b>	Manual / Semi-automatic: <ul style="list-style-type: none"> <li>– Obtaining the profile data</li> <li>– Creation of the profile</li> <li>– Updating the ontology</li> </ul>			
<b>Updating</b>	Manual / Semi-automatic: <ul style="list-style-type: none"> <li>– Obtaining the profile data</li> <li>– Updating the profile</li> <li>– Updating the ontology</li> </ul>			
<b>Structuring</b>	Automatic ontology-based structuring of the profile (e.g. structuring competencies in the profile according to the competency classification)			Automatic ontology-based sorting of the catalogue: <ul style="list-style-type: none"> <li>– by individual (e.g. city) or combined (e.g. city + competency) elements of the profile</li> <li>– by ratings (e.g. financial rating)</li> </ul>
<b>Search &amp; Retrieval</b>				<ul style="list-style-type: none"> <li>– Specification of values for any set of the profile elements</li> <li>– Value of each element field can be given in different ways and using different types of restrictions, including restrictions on object relations or object attributes</li> <li>– Representation of the search results as a profiles catalogue, as well as graphical visualization</li> <li>– Several levels of approximation to the search results (i.e. search can have several iterations)</li> </ul>
<b>Analysis</b>	<ul style="list-style-type: none"> <li>– Evaluation of a member by different criteria</li> <li>– Suggestion of new competency directions</li> </ul>			<ul style="list-style-type: none"> <li>– Ontology based Gaps identification</li> <li>– Supporting retreat or adding new VBE members for gap elimination</li> <li>– Ontology based “building” of new competencies in VBE, out of the existing ones</li> </ul>

Table 1 – Main functionalities of PCMS

### 3.4 Ontology for profiles and competencies

The ontology for profiles and competencies is a support component for the PCMS that aims at the following: (1) providing the *common understanding* of the concepts related to profiles and competencies in VBEs, (2) *classification of knowledge* (e.g. competencies) and support of interoperability of knowledge inside the VBE and among the VBEs, and (3) *supporting the PCMS functionalities* (see Table 1).

The current PCMS ontology is constructed *top-down* and *manually*, based on both the definitions of the competency-related classes of the generic organization's profile (see section 3.1) and the NACE classification system (NACE\_URL) that indirectly addresses the classification of competencies. One snapshot of PCMS ontology developed in Protégé is presented in Figure 4.

The use of ontology for the PCMS functionalities is addressed in Table 1.

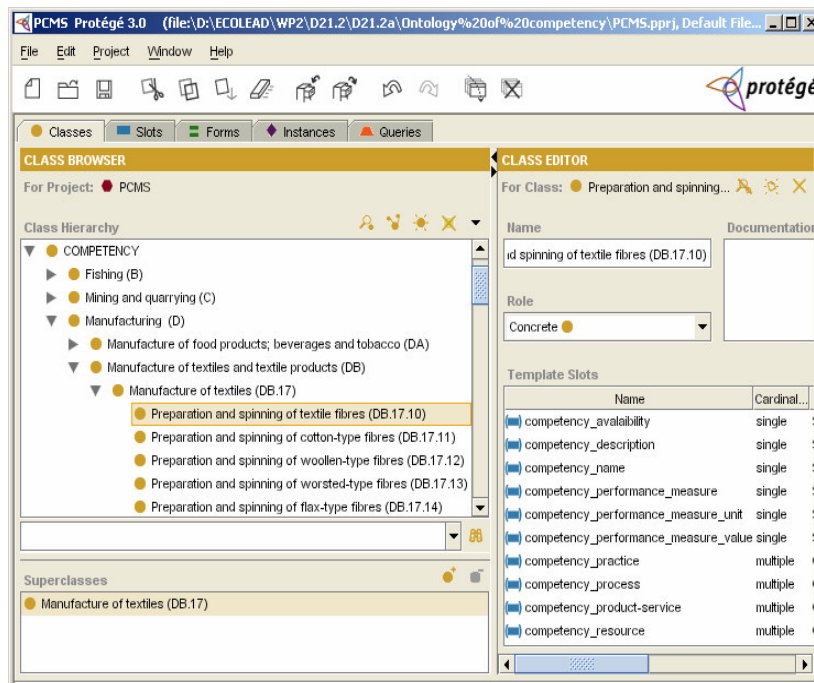


Figure 4 – Ontology for profiles and competencies

### 3.5 Adaptation/instantiation of the PCMS ontology

To adapt/instantiate the ontology for a specific VBE application (e.g. to add competencies of a specific VBE to the ontology), a *bottom-up* approach is required and suggested in ECOLEAD. The bottom-up approach aims at semi-automatic extraction of information / knowledge from VBE members and VOs for the

ontology using online text corpora. Semi-automatic adaptation of the ontology to the VBE application makes the PCMS *replicable*.

Figure 5 illustrates the high level approach for semi-automatic adaptation/instantiation of the PCMS ontology to a specific VBE application. The approach consists of several stages involving a feedback from the organizations side, thus involving the VBE members themselves, the VOs representative organizations, as well as VBE actors such as the VBE administrator, the VBE competency expert and the VBE ontology provider. This approach is mostly based on the results of Metis project devoted to semi-automatic construction of domain and task ontologies (Anjewierden et al, 2003).

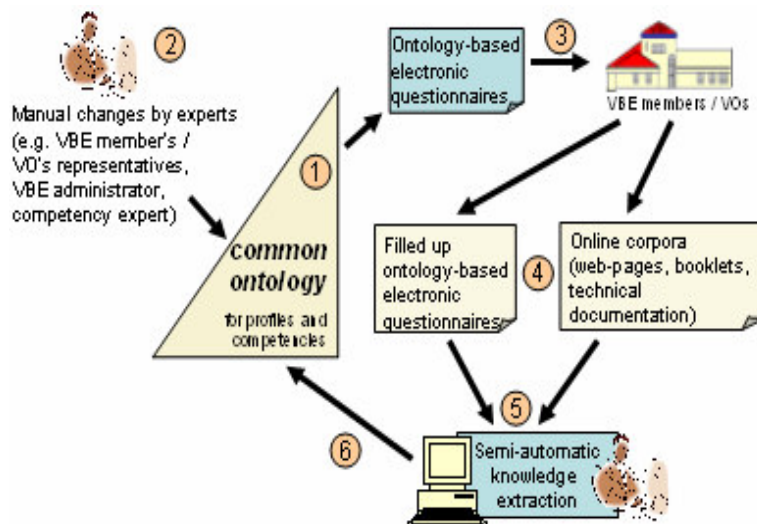


Figure 5– Adaptation of the PCMS ontology to a specific VBE application: (1) the top-down constructed ontology, (2) manual adaptation of the ontology by experts, (3) preparation of questionnaires for organizations, (4) receiving online information from organizations, (5) semi-automatic knowledge extraction through text mining, (6) semi-automatic bottom-up extension of the ontology

#### 4. CONCLUSIONS

The PCMS is a subsystem of the VBE management system, supporting the competency orientation of a VBE which is fundamental for its role of breeding and creation of VOs, and focused on the aim of replicability and coverage of the varied competencies in VBEs.

The specific *innovative contributions* of this research are three-fold. *First*, the specification / modeling of all VBE related profiles / competencies, consists of: (a) specification of the VO's profile and the VBE's profile in addition to proper modeling of the VBE member's profile, (b) extended modeling of organization competencies for VBEs. *Second*, a core common ontology for profiles and

competency in VBEs is provided. *Third*, a semi-automatic (bottom-up) approach is suggested for making the PCMS replicable.

The PCMS in ECOLEAD is specified in a generic replicable way, therefore it can fit diverse VBEs from all sectors. Namely, the PCMS can be applied to any industrial sector or other domains, and its generic model can be customized and adjusted to specific application needs according to the VBE type. This process, also called an instantiation, supports that general model is extended and converted into a specific model. This instantiation processes will be realized by following a methodology with necessary steps to adapt general information into specific information, and creating a catalogue of organization profiles and competencies to be supported by the VBE Management System of ECOLEAD.

At present, the work on the approach for semi-automatic adaptation of ontology for profiles and competencies to a specific VBE application is being further developed and will be the subject of the following paper.

### Acknowledgments

The author thanks the valuable contributions from their partners in the ECOLEAD consortium, especially the contribution of Nathalie Galeano from ITESM, Mexico.

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