

A VIRTUAL BREEDING ENVIRONMENT REFERENCE MODEL AND ITS INSTANTIATION METHODOLOGY

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Virtual Breeding Environments (VBEs) are long-term strategic alliances of organisations aimed at offering the conditions to support the rapid and fluid configuration of Virtual Organisations (VOs). VBE reference models play a guiding role to conceptualise a set of business processes to enhance the responsiveness and flexibility of networks to react to a collaboration opportunity through a collection of collaborative drivers and enablers. VBE reference models serve as a reference guide for the implementation of breeding environments in different domains and application environments. This paper presents an instantiation methodology as a controlled process, addressing systematically a set of steps, supported by different mechanisms and methodologies needed to establish and characterize the management functionalities and running of a VBE that also addresses activities during its entire lifecycle based-on a VBE reference model proposed.

1. INTRODUCTION

Virtual Breeding Environments (VBEs) also known as source networks or clusters, are long-term strategic alliances of organisations aimed at offering the necessary conditions (e.g. human, financial, social, infrastructural and organisational) to support the rapid and fluid configuration of Virtual Organisations. VBEs mainly focus on creating an adequate environment for the establishment of cooperation agreements, common operation principles, common interoperable infrastructures, common ontologies, and mutual trust among others, with the objective of preparing their members (organisations and support institutions) to be ready to collaborate in potential VOs that will be established when a collaboration (business) opportunity arises. *Virtual Organisations (VOs)* are short-term and dynamic coalitions of organisations that may be tailored within a VBE to respond to a single collaboration opportunity, through integrating the core-competencies and resources required to meet or exceed the quality, time and cost frames expected by the customer, and that dissolve once their mission/goal has been accomplished, and whose cooperation is supported through computer networks (Camarinha-Matos & Afsarmanesh, 2007b).

This paper presents an instantiation methodology as a controlled process, addressing systematically a set of steps, supported by different mechanism and methodologies needed to establish and characterize the management functionalities

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and running of a VBE that also addresses activities during its entire lifecycle based-on a VBE reference model proposed.

2. BASIC CONCEPTS ON INSTANTIATION

Enterprise instantiation process has been conceptualised as a supporting process for specific description/modelling of a particular organisation, or network, based-on a specific reference model or architecture. A *reference model* or *architecture* serves as a reference guide in the creation and maintenance process of an entity to obtain and maintain a consistent list of requirements to define, prototype, design, implement, and execute business processes according to certain requirements. Instantiation concept is traditionally associated with enterprise modelling, mainly with enterprise reference models and architectures like CIMOSA (CIM Open System Architecture) and GERAM (General Enterprise Reference Architecture and Methodology).

An *instantiation process* serves as a controlled approach to guide an organisation, or network, in the derivation process of a reference model or architecture through three modelling levels (general, partial and particular) allowing the detailing of business requirements in each level: from *general* business requirements (requirements definition), through the optimisation and specification of *partial* requirements (design specification), to their *particular* implementation in a specific domain (implementation description). Each modelling level analysed from different modelling points of view: function, information, resources, and organisation.

For the purpose of this paper a *VBE instantiation process* can be referred as a controlled process characterizing a new breeding environment based-on a *VBE reference model* and the *VBE domain specificities*. The *VBE instantiation process* addresses systematically a set of steps, which are supported by mechanisms and methodologies, for the specification and/or generation of a customized VBE model, describing its components to characterize a specific VBE typology, and these components together represent an instance of the VBE reference model.

3. VBE REFERENCE MODEL

VBE reference model aims to synthesise and formalize the base concepts, principles and practices for long-term collaborative networks. The VBE reference model proposed in this paper intends to provide a common framework for traditional breeding environments (production/service oriented) such as: industrial clusters, industry districts & business ecosystems, and new emerging ones like: disaster rescue networks & virtual laboratory networks (Camarinha-Matos & Afsarmanesh, 2006).

The *VBE reference model* focuses on providing a comprehensive overview of the key elements/components of a breeding environment and the main requirements to create and manage one during its entire lifecycle. Table 1 presents a model-based VBE reference model derived from the ARCON* modelling framework (Camarinha-Matos & Afsarmanesh, 2007a) defining two sub-spaces, each one with four modelling views, providing an abstract representation of a VBE from its inside (endogenous elements) and its outside (exogenous interactions).

*ARCON (A Reference Model for COLlaborative Networks)

Table 1 – VBE Reference Model based-on ARCON Modelling Framework

VBE Endogenous Elements							
Structural	Componential	Functional	Behavioural	Market			
<p>Actors:</p> <ul style="list-style-type: none"> Private Organisations Public Organisations NGOs <p>Roles:</p> <ul style="list-style-type: none"> VBE Member(s) VO Support Provider Opportunity Broker VO Planner VO Coordinator VBE Administrator VBE Support Provider Ontology Provider Service Provider Support Institution Public (Guests) VBE Advisor(s) <p>Relationships:</p> <ul style="list-style-type: none"> Networking Coordination Cooperation Collaboration <p>Network:</p> <ul style="list-style-type: none"> Virtual Breeding Environment (VBE) Size Topology Location --- 	<p>Physical Resources:</p> <ul style="list-style-type: none"> Machinery <p>ICT Resources:</p> <ul style="list-style-type: none"> Hardware ICT-Infrastructure Software <p>Human Resources:</p> <ul style="list-style-type: none"> VBE Management System VBE Staff <p>Info./Knowledge Resources:</p> <ul style="list-style-type: none"> VBE-Itself, VOs, & VBE Members Profile & Competency Information VBE Governance Information VBE Value System Information <p>VBE Support Institutions Information</p> <ul style="list-style-type: none"> VOs, Information VBE Bag of Assets VBE & VO Inheritance Information <p>Ontology Resources:</p> <ul style="list-style-type: none"> VBE Ontology (Top, Core & Domain Levels) 	<p>Fundamental Processes:</p> <ul style="list-style-type: none"> Membership & Structure Management Profiling & Competency Management Trust Management Performance Management Decision Support Management VO Creation Management CO Identification CO Characterization & Rough Planning Partners Search & Selection Agreements/Contracts Negotiation Wizard VO Information Management VO Registration Management VO Inheritance Information Management <p>Background Processes:</p> <ul style="list-style-type: none"> Strategic Management Marketing Management Financial Management Accounting Management Resources Management Governance Management Value System Info. Management Ontology Management ICT Management Support Institutions Management <p>Procedures</p> <p>Methodologies</p>	<p>Prescriptive Behaviour:</p> <ul style="list-style-type: none"> Cultural Principles: Regional Traditions Business & NGO Culture VBE Culture Governance Principles: Performance Orientation Responsibility & Accountability Commitment to VBE Membership Eligibility Leadership Role Contract Enforcement Policy Brokering Principles Decision-Making Principles <p>Obligatory Behaviour:</p> <ul style="list-style-type: none"> Bylaws: Rights & Duties/Policies Membership Policies Security Issues Conflict Resolution Policy Amendments to Bylaws IPR Policies Internal Regulations: ICT User Guidelines <p>Constraints & Conditions:</p> <ul style="list-style-type: none"> Adhesion Agreement Agreement Amendments Confidentiality Constraints Legal Constraints (Contracts) Internal Normative Constraints <p>Incentives & Sanctions:</p> <ul style="list-style-type: none"> Incentives & Sanctions Policies 	<p>Network Identity Statement:</p> <ul style="list-style-type: none"> VBE Mission VBE Vision VBE Strategy VBE Goals <p>References/Testimonials</p> <p>Network Profile:</p> <ul style="list-style-type: none"> Who are we? How to contact us? <p>Market & Branding Strategy:</p> <ul style="list-style-type: none"> Marketing/Advertisement Strategy Broadcast & Direct Branding Strategy <p>Market Interactions:</p> <ul style="list-style-type: none"> VBE & VO Customers: Strategic Customers Potential Customers Competitors: Direct Competitors Indirect Competitors (Potential) Suppliers Substitutors Complementors <p>Interactions/Transactions:</p> <ul style="list-style-type: none"> Bidding Handling Inquiries Contracting 	<p>Network Social Nature:</p> <ul style="list-style-type: none"> Profit/Not-For-Profit Governmental NGO <p>Support Entities:</p> <ul style="list-style-type: none"> Certification Entities Insurance Entities Logistics Entities Standard Registries: Cleaning Centers Financial Entities: Banks Investors & Sponsors Coaching Entities: Advisers & Experts Training Entities: Professional Associations Research Entities: Universities Research Institutes <p>Service Acquisition:</p> <ul style="list-style-type: none"> Financial Relation Technological Service Training Action Coaching Action Guarantee Action Knowledge Transfer <p>Agreement Establishment</p>	<p>Network Legal Identity:</p> <ul style="list-style-type: none"> Legal Status Legal Entity Informal Entity Values & Principles <p>Impacts:</p> <ul style="list-style-type: none"> Advertising VBE Insurance Competency Domain VO Creation <p>Legal Issues:</p> <ul style="list-style-type: none"> Conflict Resolutions Intellectual Property Rights <p>Public Interactions:</p> <ul style="list-style-type: none"> Governmental Organisations: Social Security City Hall Civil Defence Associations Interest Groups Supporters Opponents Regulatory Boundaries Other Entities <p>Public Relations:</p> <ul style="list-style-type: none"> Political Relations Seeking Support Information Transfer Broadcast & Direct Social Relations Cultural & Patronage Building Reputation Building Success Cases 	<p>Constituency</p> <p>Attracting Factors:</p> <ul style="list-style-type: none"> VBE Reason for Existence Attracting & Recruiting Strategy Advertising Industrial Fairs Motivating Community Participation Incentives <p>Rules of Adhesion:</p> <ul style="list-style-type: none"> Charter of Foundation Rewards mechanism for Enrolment Notice of Termination of Business <p>Potential Members:</p> <ul style="list-style-type: none"> Business Organisations Private Institutions Individual Experts Public Institutions <p>Sustainability Factors:</p> <ul style="list-style-type: none"> Members Searching: Invitation Solicitation Rewarding

The *VBE endogenous elements* aim at identifying a set of characteristic properties that can together capture the VBE constituting elements. Modelling views proposed by ARCON modelling framework for this sub-space are: (1) *Structural* - addressing the VBE network structure in terms of its constituent elements such as actors, roles and their relationships, as well as the network topology; (2) *Componential* - focusing on the VBE resources composition such as human, technological, information, knowledge, and ontologies; (3) *Functional* - attending the VBE processes, procedures and methodologies as the base functions/operations related to the different VBE lifecycle stages; and (4) *Behavioural* - covering the VBE principles, policies and governance rules that drive and constrain the VBE and its members behaviour.

The *VBE exogenous interactions* aim to reveal the VBE interactions with its surrounding environment. Modelling views proposed by ARCON modelling framework for this sub-space are: (1) *Market* - addressing the interactions with customers and competitors; (2) *Support* - attending the support services provided by third party institutions; (3) *Societal* - capturing the interactions between the VBE and the society in general; and (4) *Constituency* - focusing on the interaction with the potential VBE members.

4. VBE MANAGEMENT FRAMEWORK

Making a zoom-in the *VBE reference model functional modelling view*, a set of fundamental and background processes can be defined as important catalysts for ensuring the success of all VBE management activities. Table 2 and 3 intent to provide a widespread overview of the key business processes (management functionalities) required to support and facilitate the VBE management activities needed to be performed during the VBE lifecycle, under a three division classification: VBE actors, VO creation and VBE general management.

VBE fundamental processes, also known as main processes, are those business processes that fundamentally affect the VBE performance and influence how well other processes are executed to increase the VBE competitiveness.

Table 2 – VBE Fundamental Processes

	Functionality	Description
VBE Actors' management	Membership & Structure Management	Set of management activities and supporting tools allowing integration, accreditation, disintegration, rewarding, and categorization of members within the VBE. It is separated into mechanisms for members' registration, members' rewarding, and assignment of roles, rights and responsibilities to VBE members (Afsarmanesh & Camarinha-Matos, 2005; Sitek et al, 2007).
	Profiling & Competency Management	Set of management activities and supporting tools for creating and maintaining profiles for VBE members, for the VBE itself, and for the VOs registered within the VBE; as well as for the competency-based assessment of new VBE members and discovery of new competencies out of the collective competencies of all VBE members in the breeding environment (Ermilova & Afsarmanesh, 2006).
VO Creation Management	Collaboration Opportunity Identification	Set of management activities and supporting tools that will support the identification of new collaboration opportunities that will trigger the formation of new VOs. Collaboration opportunity detection will be according to the VBE competency domain. A collaboration opportunity might be external, originated by a (potential) customer or internal detected by a VBE member acting as a broker (Demšar et al, 2007; Camarinha-Matos et al, 2007).
	Collaboration Opportunity Characterization & VO Rough Planning	Set of management activities and supporting tools for identifying the required competencies, capabilities and capacities needed to respond to the collaboration opportunity identified, as well as for defining a rough structure for the potential VO, including its organisational form and the VO partners corresponding roles. At this stage it is important to define the VO partnership form which is typically regulated by contracts and cooperation agreements (Concha et al, 2008; Camarinha-Matos et al, 2007).

VO Creation Management	Partners Search & Selection	Set of management activities and supporting tools devoted to the identification of potential VO partners, their assessment and intelligent selection by matching their competencies with the competencies required to respond to the collaboration opportunity identified. Some elements for search and selection could be: technical, economical, reliability indicators, preferences, etc. (Baldo et al, 2007; Camarinha-Matos et al, 2007).
	Agreement/ Contract Negotiation Wizard	<i>Agreement Negotiation:</i> Set of management activities and supporting tools that will assist human actors (VO partners) during the negotiation processes (iterative process to reach agreements and align needs with offers) towards the VO constitution. Management activities include formulation and modelling of contracts and agreements, as well as the contracting process itself. Important issues to consider at this process include: determination of the objects of negotiation; negotiation protocols; decision-making process and corresponding parameters; representation of agreements (Camarinha-Matos & Oliveira, 2006; Camarinha-Matos et al, 2007). <i>Contracting:</i> As a set of management activities and supporting tools that will assist the contracting process through the formulation and modelling of contracts and agreements as well as the contracting process itself, before a VO can effectively be launched (Camarinha-Matos & Oliveira, 2006; Camarinha-Matos et al, 2007).
	Virtual Organisations Information Management	Set of managing activities and supporting tools to manage the information related to the VOs registered within the VBE. (1) <i>VO Registration:</i> This task comprises the process of registering a newly created VO in the VBE; and (2) <i>VO Inheritance Information:</i> This task comprises the management of inheritance information after VO dissolution; information feeds back into the VBE to create sustainable effects and to provide the VBE members with lessons learned from previous VOs (Loss et al, 2006; Karvonen et al, 2007).
VBE General Management	Trust Management	Set of management activities and supporting tools for basic trust assessment of VBE membership applicants, and subsequent dynamic trust appraisal and monitoring during their ongoing VBE membership (Msanjila & Afsarmanesh, 2006).
	Performance Management	Set of management activities and supporting tools based-on a systematic procedure of planning, monitoring, rating and rewarding VBE actors' performance based-on the definition of key performance indicators (Camarinha-Matos & Abreu, 2005).
	Decision Support Management	Set of management activities and supporting tools for monitoring key performance indicators in the VBE and issuance of notifications and warnings. It is separated into mechanisms for VBE competency gap analysis, lack of performance warning, and low trust level warning (Afsarmanesh & Ermilova, 2007).

VBE background processes, also known as supporting processes, are those business processes that run basic but relevant business processes in charge of supporting the VBE effective management during its lifecycle. The supporting processes are characterized for its necessity for maintaining, leverage and optimizing daily VBE business operations.

Table 3 – VBE Background Processes

	Functionality	Description
VBE General Management	Strategic & Marketing Management	Set of management activities and supporting tools that will support the strategic formulation process, including the marketing and branding activities, for promoting the VBE competencies among its potential VBE members and potential VO customers (Strum et al, 2004).
	Financial, Accounting & Resource Management	Set of management activities and supporting tools based-on accounting procedures to guarantee the VBE financial health and ensure the effective, efficient and equitable use of the VBE resources (Romero et al, 2006; 2007a).
	Governance Management	Set of management activities and supporting tools that refer to the VBE policy management, including internal operational rules and bylaws, for supporting the operation, regulation, and control of the VBE network structure: actors, positions, authorities, roles, rights, responsibilities and relationships between them (Romero et al, 2006; 2007b).
	VBE Bag of Assets Management	Set of management activities and supporting tools for handling the VBE assets, including: documents to share, software tools to share, lessons learned, VBE governance policies, etc. It is separated into mechanisms for enforcing proper access rights (public, restricted, private) for all VBE stakeholders, and announcement of news (dashboard) (Afsarmanesh & Ermilova, 2007).
	Value System Information Management	Set of management activities and supporting tools that will provide features for supporting and handling both, material and immaterial values, within the VBE (Romero et al, 2007a).

	Ontology Management	Set of management activities and supporting tools for VBE ontology adaptation into a specific VBE domain sector. VBE ontology evolution during the VBE lifecycle, as well as for VBE ontology learning process (e.g. in the form of a dictionary of the VBE related concepts) (Afsarmanesh & Ermilova, 2007; Plisson, 2007).
VBE General Management	ICT Management	Set of management activities and supporting tools for managing a low cost, easy-to-access and operational ICT-infrastructure that will allow VBE actors with different distributed/heterogeneous applications to communicate with each other transparently and seamlessly, in order to support collaboration (businesses) between them over the Internet (Rabelo et al. 2006).
	Support Institutions Information Management	Set of management activities and supporting tools for identifying and integrating Support Institutions into the VBE. Support Institutions information will be entered through registration mechanism, like the one applied to the VBE members' registration process (Romero et al. 2006).

5. VBE INSTANTIATION METHODOLOGY

The *VBE instantiation process* happens only once for every specific breeding environment - a priori to its creation. As such, different VBE characteristics are needed to be identified at this time, independently of the VBE lifecycle stages during which they may be activated or applied.

The *VBE instantiation methodology* aims to identify the necessary components and functionalities required during all the VBE lifecycle stages to support its actors (stakeholders) towards the successful creation of a breeding environment and its effective and efficiently management (operation) towards the achievement of the VBE strategic goals. Figure 1 presents an overview of the main steps to be followed to create and manage a VBE during its lifecycle, based-on UML notation.

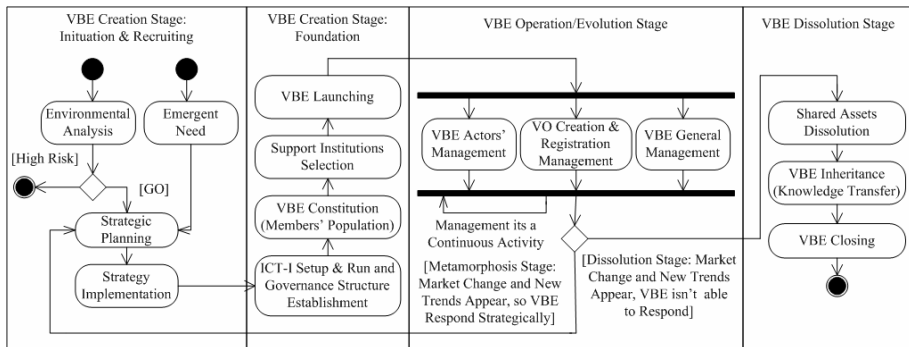


Figure 1. VBE Instantiation Methodology based-on the VBE Lifecycle

As depicted in Figures 2 and 3, the *VBE creation stage* is divided in two sub-stages: (1) *VBE initiation and recruiting* - referring to the processes of planning the creation of a new breeding environment by following a number of preparation steps to facilitate the execution of all operational activities; and (2) *VBE foundation* - referring to the processes of set-up and running an ICT-infrastructure to support the VBE operation, establishing the VBE governance structure, and populating the VBE by registering founding members and their related support institutions to allow the breeding environment initiate its operations.

During the VBE initiation and recruiting sub-stage, three processes should be performed: (1) *Environmental analysis* - focusing in the VBE creation drivers and the identification of the attractors (reasons) for organisations to join the VBE. The expected results from this process are the identification of the critical success factors for the VBE business model in a specific domain sector; (2) *Strategic planning* -

addressing the VBE goal setting, strategy analysis and strategy formulation towards the VBE business model definition. Expected results: VBE identity statements (e.g. mission, vision, goals) and first draft of the business plan including marketing, operational, organisational, financial and legal aspects; and (3) *Strategy implementation* - covering the VBE strategy implementation plan at business processes, ICT-infrastructure and governance levels. Expected results: Business processes required to enable a successful VBE management framework, an interoperable ICT-infrastructure for supporting the information systems and repositories related to the VBE business processes, and a VBE governance structure.

Going through the VBE foundation sub-stage, four processes should be carried out: (1) *VBE ICT-infrastructure set-up & run + governance structure establishment* - attending the implementation of the ICT-infrastructure, including the parameterization of all information systems and repositories, and the creation of the VBE steering committee and the publication of the VBE governance principles, rules and bylaws. Expected results: Running ICT-infrastructure and VBE actors acknowledge of the breeding environment regulations and authority; (2) *VBE constitution* - addressing the population of the VBE by following a members' registration process. Expected results: A catalogue with a complete profile of the founding VBE members' competencies and their roles, rights and responsibilities assigned; (3) *Support institutions selection* - covering the recruitment of supporting entities and service acquisition from third party institutions to support different VBE requirements. Expected results: A catalogue of the support institutions associated to the VBE; and (4) *VBE launching* - focusing on starting the VBE operation. Expected results: Public announcement to the media that the VBE is beginning its operation.

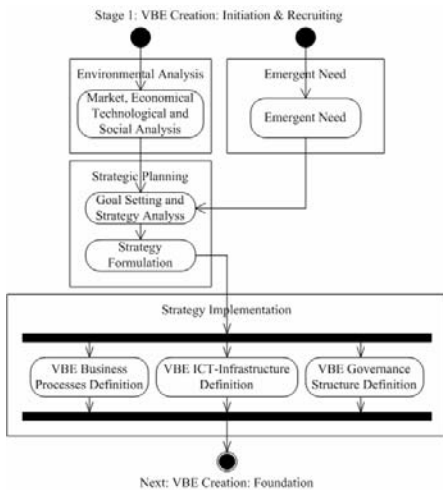


Figure 2. VBE Initiation & Recruiting

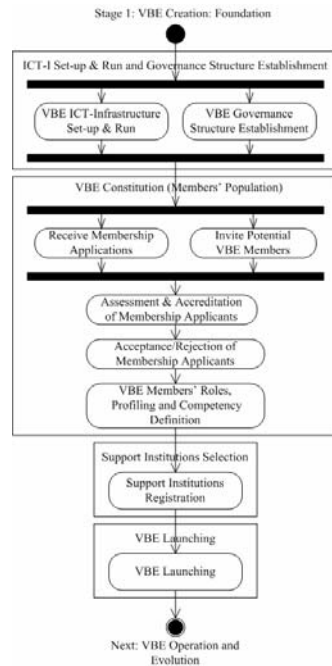


Figure 3. VBE Foundation

VBE operation stage (see Figure 4) comprises the processes of running,

executing and adapting the VBE management activities to support the breeding environment reaching its objectives. A detail description of these business processes is presented in Tables 2 and 3. *VBE actors' management* activities will focus on creating a full profile of the VBE actors and managing their competencies towards VO creation process; *VO creation management* will support all activities related to VO creation process in order to respond to the collaboration opportunities identified, and *VBE general management* will assist common network management activities.

Moreover, *VBE evolution stage* (see Figure 4) comprises a set of feedback activities carried out through the VBE performance management process to develop improvement proposal which could include: (1) design, operation and control of new management approaches, (2) recruitment, assessment and selection of new VBE members and support institutions, (3) re-definition and assessment of VBE actors' roles, etc.

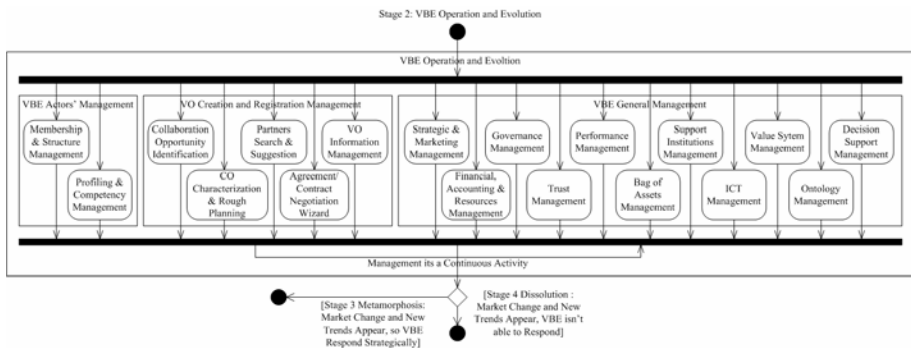


Figure 4. VBE Operation/Evolution

During *VBE operation stage*, two actions could take place as result of market changes and new trends appearances: *metamorphosis* or *dissolution*. VBE could go into a *metamorphosis stage* to respond to these environmental factors and survive by adapting its structure to these new competitive factors, or it could go into a *dissolution stage*, if the adaptation is not possible and a closure is necessary to completely re-structure the breeding environment.

VBE metamorphosis stage (see Figure 5) refers to the VBE nature adaptation by changing its strategy, business processes and structure to tactically respond to new market changes and trends, allowing VBE to remain competitive in its domain sector.

VBE dissolution stage (see Figure 6) refers to a closure stage where total activities in the VBE will cease. Dissolution happens when a VBE cannot achieve anymore its objectives, and even its metamorphosis cannot help the VBE to keep going with the new market changes and trends. VBE dissolution focuses mainly in planning the transfer of collected knowledge during the entire VBE lifecycle to other breeding environments. It is divided in three main processes: (1) *Shared assets dissolution* - aimed at returning the belongings on the VBE bag of assets to their owners. Expected results: VBE bag of assets dissolution; (2) *Knowledge transfer* - covering the capture and transfer of knowledge collected during the VBE lifecycle. Expected results: VBE knowledge base legacy; and (3) *VBE closing* - addressing the ending affairs and contracts with all VBE actors (including customers), shutting down ICT-infrastructure and announcing the VBE closing. Expected results: Contracts ended, information systems and repositories shutdown and public announcement to

the media that the VBE is closing its operation.

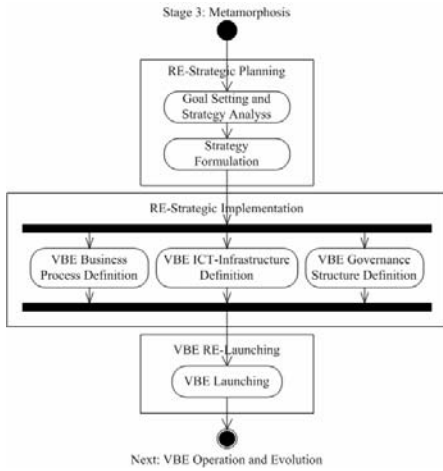


Figure 5. VBE Metamorphosis

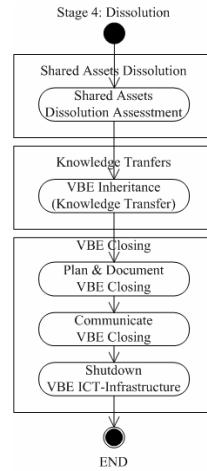


Figure 6. VBE Dissolution

6. CONCLUSIONS

The *VBE instantiation methodology* presented in this paper aims to serve as a systematic and standardized guideline for supporting the processes and activities involved in the creation and management of new breeding environments. As such, the *VBE reference model* proposed aims at understanding the requirements as well as provision of mechanisms and functionalities for VBEs through adequate organisational models, operating principles, as well as through provision of ICT tools to support the entire VBE lifecycle and its actors.

As the base, the proposed *instantiation methodology* uses the *VBE reference model* to provide a comprehensive overview of the key generic elements, components and features of VBEs and their main requirements that must be addressed while creating and managing VBEs throughout their entire lifecycle. A detailed description of each processes and its activities is available as part of ECOLEAD project results, this detail was not presented in this paper due to the limitation of space.

The presented *VBE reference model* and its *instantiation methodology* represent a fundamental step and an effort towards defining a set of standardized guidelines which will support the instantiation (principle of replicability) of the *VBE reference model* into different domains and application environments, and thus support covering all activities required to customize a specific VBE model.

7. ACKNOWLEDGMENT

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