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A Collaborative Platform for an Ambient Assisted Living Ecosystem

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Abstract

The population ageing is a global trend that affects almost all countries in the world. The global share of people with 60 years or over is expected to reach 21.6% by 2050.

The social and economic impact of this tendency is huge, creating new challenges to healthcare and social support services. Furthermore, population ageing is linked to an increased number of people with physical limitations together with the isolation of persons.

The Ambient Assisted Living paradigm seeks to answer to some of this challenges through the integration of innovative technologies, products, systems and services.

Aiming the development of an ecosystem of products and services for Ambient Assisted Living, the AAL4ALL project was created joining more than thirty research, academic and industry partners. During the AAL4ALL project a 3-layered model of services ecosystem was adopted for the conceptual architecture. This work presents a collaborative platform as a contribution to the top layer of the conceptual architecture - AAL Ecosystem.

Key words: Collaborative Networks; ICT; Ambient Assisted Living and Ageing

Resumo

O envelhecimento da população é uma tendência global que afeta quase todos os países no mundo. A nível mundial, a percentagem de pessoas com mais de 60 anos deve atingir os 21,6% até 2050.

Os impactos sociais e económicos desta tendência são enormes, criando novos desafios aos serviços de saúde e de assistência social. Além disso, o envelhecimento populacional significa um aumento do número de pessoas com limitações físicas bem como o seu isolamento.

O paradigma de Ambient Assisted Living procura responder a alguns destes desafios através da integração de tecnologias, produtos, sistemas e serviços inovadores.

Com o objetivo de desenvolver um ecossistema de produtos e serviços de Ambient Assisted Living, o projeto AAL4ALL foi criado reunindo mais de trinta parceiros das áreas académica, de investigação e indústria. Durante o projeto AAL4ALL, um modelo de ecossistema de serviços de 3 camadas foi adotado para a arquitetura conceptual. Este trabalho apresenta uma plataforma colaborativa como contributo para a camada superior da arquitetura conceptual – Ecossistema AAL.

Palavras-chave: Redes Colaborativas; TIC; Ambient Assisted Living e Envelhecimento

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Acronyms

AAL – Ambient Assisted Living

AAL4ALL – Ambient Assisted Living for All

CfT – Call for Tenders

CN – Collaborative Network

CO – Collaboration Opportunity

COC – Collaboration Opportunity Characterization

coFinder – Collaboration Opportunity Finder

ICT – Information and Communications Technology

IT – Information Technology

PCMS – Profile and Competencies Management System

SME – Small and Medium Enterprise

VBE – Virtual organization Breeding Environment

VE – Virtual Enterprise

VMS – VBE Management System

VO – Virtual Organization

XML – eXtensible Markup Language

1. Introduction

1.1.   Preamble

Almost all countries in the world are facing population ageing. This global trend has few decades and results from the decrease of mortality, and, most importantly, the decline of fertility (United Nations, 2013).

Between 1990 and 2015 the global share of people with 60 years or over increased from 9.2% to 12.3% and is expected to reach 21.6% by 2050 (United Nations, 2013) (United Nations, 2015). This means passing from 901 million people (aged 60 years or over) in 2015 to more than 2.1 billion in 2050. The older population is itself ageing. Globally, the share of people with 80 years or over (the "oldest old") within the older population is 13.9% in 2015 and is expected to reach 20.7% by 2050. This will mean 434 million people worldwide with 80 years or over by 2050.

In Europe, 24% of the population is already aged 60 years or over and that share is expected to reach 34% by 2050 (United Nations, 2015). The population with 80 years or over represents 19.8% of the older population and that proportion is expected to reach 28.9% by 2050. If this projection is realized, in 2050, there will be 240 million persons aged 60 years or over of which 70 million aged 80 years or over.

The social and economic consequences of population ageing are huge, raising new challenges to traditional systems of health care and pension funds, and leading to an increase of retirement age (Ambient Assisted Living for All, 2011). Consequently, people will need to remain active and productive for a longer time. Population ageing will be also followed by an increase of people with physical limitations together with the isolation of persons.

In this context there is an urgent need to find solutions to (Ambient Assisted Living Joint Programme, 2015):

- Extend people's lifetime in their favorite environment by increasing their autonomy, self-confidence and mobility;
- Support in maintaining the health and functional capability of the elderly;
- Promote a better and healthier lifestyle for individuals at risk;
- Enhance the security, to prevent social isolation and to support maintaining the multifunctional network around the individual;
- Support caretakers, families and care organizations;

- Increase the efficiency and productivity of used resources in the ageing societies.

The use of Information and Communication Technologies (ICT) such as high-speed broadband connectivity, web-based technologies, cloud-computing, Internet of Things (IoT) and ubiquitous computing bring new opportunities to provide care and assistance, along with new ways of working, social interaction facilitation, and decrease limitations imposed by time and location (Camarinha-Matos, et al., 2012). However, many past research and developments in elderly care services failed because the approaches have been focused on the development of isolated services, each one typically provided by a single organization, and excessively techno-centric. Recent approaches are moving from fragmented services to gradually more integrated care services which are usually provided by several stakeholders using well-elaborated collaboration mechanisms. Another trend that arises from past failures is that developments shouldn't be focused only on ICT (e.g. sensors), but also take into account the design and launching of adequate policy actions to support the success of such development as well as training actions, not only for elderly, but also for all the other stakeholders.

The development of innovative concepts or the integration of innovative technologies, products, systems, or services that contribute to support a better and safer life are the so-called Ambient Assisted Living (AAL) (Garcia and Rodrigues, 2015).

The Ambient Assisted Living (AAL) paradigm faces some obstacles such as (Ambient Assisted Living for All, 2011):

- AAL is a fuzzy target as it requires heavily interdisciplinary solutions and has many national and regional aspects;
- Health and social care systems of today typically do not focus on prevention and support;
- "Well-being" is not part of the benefits of health insurances;
- The first commercial offers are monolithic, incompatible, expensive (very important for the elderly) and potentially unsustainable;
- A clear definition of basic AAL services of general interest has not taken place yet;
- Technologies for AAL are available and often already in use for different purposes, but the existing business cases and market segments are not attractive and the investment risks are high.

The work addressed in this dissertation was conducted within the AAL4ALL project (QREN 13852). The name "AAL4ALL" stands for "Ambient Assisted Living For All". The AAL4ALL project (October 2011 – February 2015) aimed to develop an ecosystem of products and services for Ambient Assisted Living (AAL) associated to a business model and validated through large scale trial (Ambient Assisted Living for All, 2011). The project joined more than thirty research, academic and industry partners and was co-financed by the European Community Fund through "COMPETE - Programa Operacional Factores de Competitividade" representing an 8.3 million euros total investment.

1.2.   Problem and Objectives

The AAL4ALL project adopted a holistic perspective of ambient assisted living focusing on four important life settings (Camarinha-Matos, et al., 2012):

- Independent living - how technology can assist in normal daily life activities e.g. tasks at home, mobility, safety, agenda management (memory help), etc.
- Health and care in life - how technology can assist in health monitoring, disease prevention, and compensation for disabilities.
- Occupation in life - how technology can support the continuation of professional activities along the ageing process.
- Recreation in life - how technology can facilitate socialization and participation in leisure activities.

The underlying assumption in this project is that the development of effective support environments for the ageing citizens requires the participation and coordination of multiple stakeholders, from varied sectors and different backgrounds (Camarinha-Matos, et al., 2012). Thus, before adopt specific (technical) implementation approaches and technologies, it is essential to consolidate concepts in order to mobilize and align all the required stakeholders. Therefore, a conceptual architecture was designed, aiming structuring the developments for AAL by defining a unified terminology, and describing the functionality and roles of components, in order to facilitate the creation of synergies among stakeholders.

Following a socio-technical approach, a 3-layered model of services ecosystem (Figure 1) was adopted for the conceptual architecture, intending to have an environment that facilitates rapid composition of (eventually multi-stakeholder) services, forming integrated care and assistance

services (analogous to consortia formation). This requires that services and their providers are ready to collaborate with each other. Like a Virtual organizations Breeding Environment (VBE), we can consider in this environment the existence of supporting entities that take care of issues such as quality of service, billing, etc. Each layer is focused on specific features of the planned ambient assisted living environment, and a logical hierarchical structure is established among these layers.
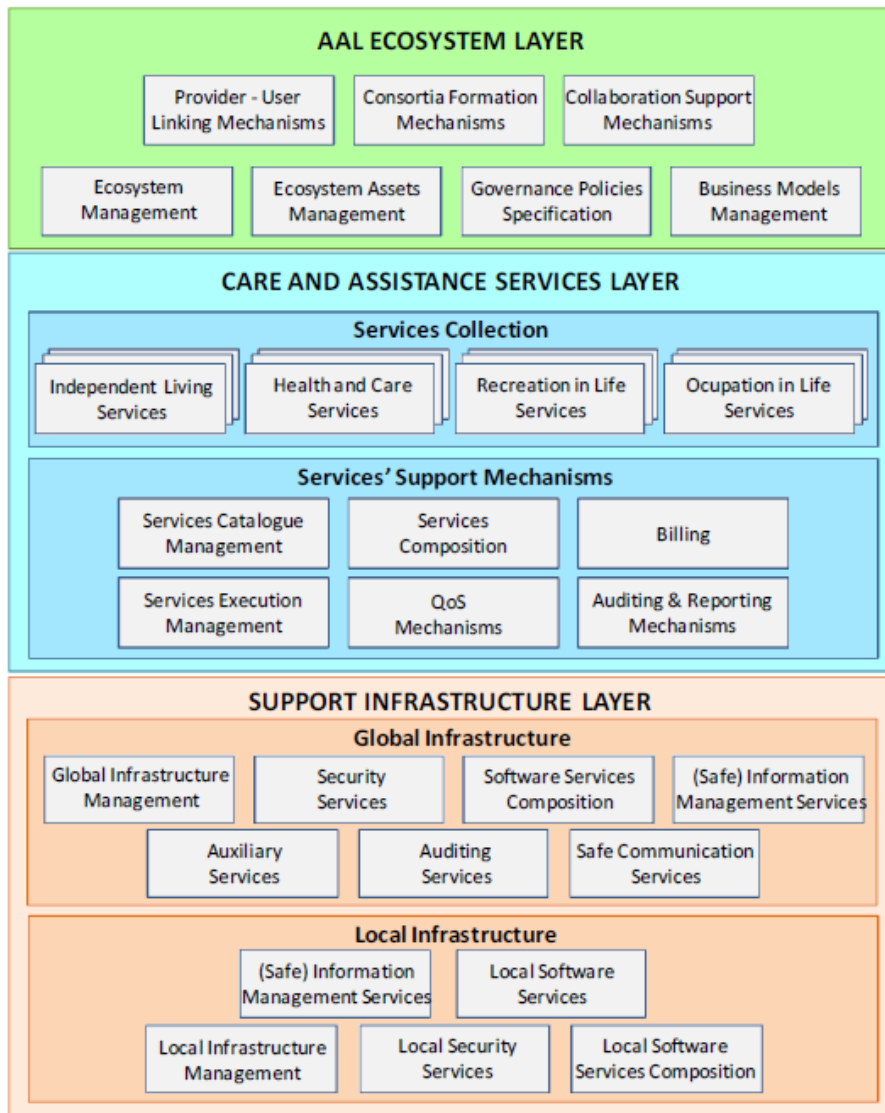
Figure 1 - AAL4ALL conceptual architecture (Camarinha-Matos, et al., 2012)

The focus of this work is given to the top layer of the architecture - AAL Ecosystem. The AAL Ecosystem layer provides organization, governance, and collaboration support for the AAL multi-stakeholders from a socio-technical perspective (Camarinha-Matos, et al., 2012). It can comprise, besides the senior citizens, a combination of formal care and informal care networks.

To achieve the AAL Ecosystem purposes, adequate functionalities for modeling and management have to be provided. Such functionalities should then give support to:

- Organize and structure dynamic organizations;
- Define and enforce governance policies;
- Define profiles, roles and business models;
- Launch collaborative processes;
- Support links between providers and clients/users.

In order to respond to some of the aforementioned needs, a collaborative platform prototype was thought, being the main objective of this work to design and develop it by applying the principles and models of collaboration that best fit the AAL4ALL project. Consequently, the problem was formulated the following way:

Problem statement: *What platform can boost collaboration among members of AAL4ALL towards the creation of new Ambient Assisted Living products and services?*

1.3.   Methodological Approach

In order to achieve the objectives proposed the chosen approach was the Design Science Research comprising three phases.

This project has begun with a state-of-art research in order to deepen knowledge on the subject and study of the theories that serve as the basis to solve the problem.

The second phase encompassed the design and development of a collaborative platform prototype for the AAL4ALL project according with the identified needs and following the best practices. This phase included, also, the provision of the platform to AAL4ALL community to be tested.

Finally, the third phase, consisted in the evaluation of results through a questionnaire among AAL4ALL partners. The questionnaire consisted of closed-ended questions to assess both the platform's utility and the features the respondents value the most. A statistical analysis treatment was then performed using the questionnaire results.

1.4.   Dissertation Structure

This dissertation is structured as follows:

In the first chapter, an overview of the research background is presented, stating the problem, the research objectives, the motivation for the work, and explaining the methodological approach.

The second chapter is dedicated to the literature review of the main themes related with the developed project.

The third chapter presents the planning and development of the AAL4ALL collaborative platform.

In the fourth chapter, an evaluation of the developed work is presented based on the results of questionnaires.

Finally, the fifth chapter presents the dissertation conclusions and outlines suggestions for future work.

2. Literature Review

2.1. Virtual Organizations Breeding Environment

In an increasingly connected world, the "network" concept is, these days, present in different fields such as computer science, communications, physics, social sciences, biology and ecosystems (Camarinha-Matos and Afsarmanesh, 2005). Among other types of network there is one, in computer science field, that has special relevance: collaborative networks.

A collaborative network (CN) is a network consisting of a variety of entities (e.g. organizations and people) that are largely autonomous, geographically distributed, and heterogeneous in terms of their operating environment, culture, social capital and goals, but that collaborate to better achieve common or compatible goals, and whose interactions are supported by computer network (Camarinha-Matos and Afsarmanesh, 2008).

The last years have seen the appearance of a large variety of collaborative networks (Figure 2) due to the challenges faced by the business, social, and scientific worlds and enabled by the fast progress in the information and communication technologies (Camarinha-Matos and Afsarmanesh, 2008).
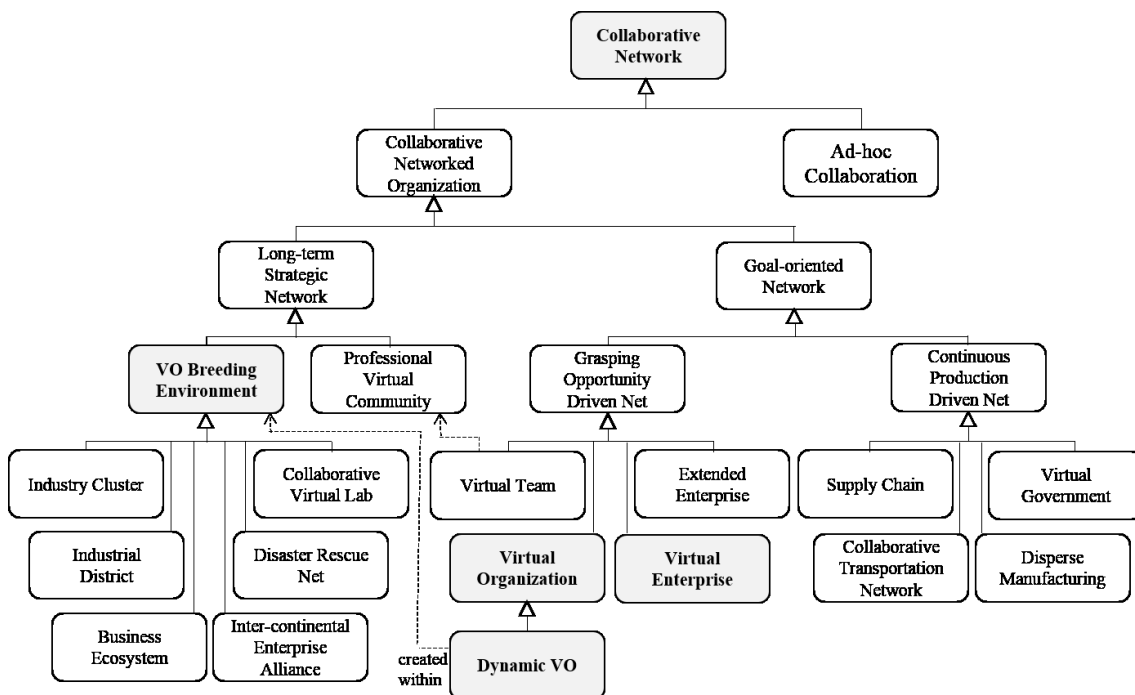
Figure 2 - Examples of Collaborative Networks (Camarinha-Matos and Afsarmanesh, 2008)

In a market/society increasingly competitive, organizations, especially small and medium enterprises (SMEs), have on collaboration with others and in forming Virtual Organizations (VOs) a way to increase access to market opportunities, share risks, reduce costs, achieve business goals not achievable by a single organization, etc. (Camarinha-Matos, et al., 2005a). An approach to the creation of VOs is the establishment of long term alliances, the so-called Virtual organizations Breeding Environments (VBEs).

In this dissertation, the following definitions for Virtual organizations Breeding Environments (VBEs), Virtual Enterprises (VEs), Virtual Organizations (VOs) and Dynamic Virtual Organizations (Dynamic VOs) are considered.

Virtual organizations Breeding Environment (VBE) are associations of organizations and a number of 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 rapid configuration of temporary alliances for collaboration in potential Virtual Organizations. Namely, when a business opportunity is identified by one member (acting as a broker), a subset of VBE organizations can be selected to form a Virtual Enterprise/Virtual Organization (Camarinha-Matos and Afsarmanesh, 2008).

Virtual Enterprise represent a temporary alliance of enterprises that come together to share skills or core competencies and resources in order to better respond to business opportunities, and whose cooperation is supported by computer networks (Camarinha-Matos and Afsarmanesh, 2008).

Virtual Organization represent a concept similar to a virtual enterprise, comprising a set of (legally) independent organizations that share resources and skills to achieve its mission/goal, but that is not limited to an alliance of profit enterprises. A virtual enterprise is therefore, a particular case of virtual organization (Camarinha-Matos and Afsarmanesh, 2008).

Virtual Organizations that are established in a short time to respond to a competitive market opportunity, and have a short life cycle, dissolving when the short-term purpose of the VO is accomplished are called Dynamic Virtual Organizations (Camarinha-Matos and Afsarmanesh, 2008).

Traditionally, earlier forms of VBEs are established within a geographic region with the advantage of having common business culture and sense of community, as well as focusing on one or a few specialty sectors of the region. Nowadays, the goal is to remove those restrictions and find solutions to extend and boost these organizations' associations using 2nd generation VBEs. This new generation of VBEs aims 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, through the use of effective information and communication infrastructures, tools and services (Afsarmanesh, et al., 2008).

2.2. VBE Reference Framework

A framework is typically a conceptual structure used to approach and solve a complex issue (Afsarmanesh, et al., 2008). The VBE reference framework aims therefore to enclose the comprehensive concepts, entities, and functionalities needed both for establishing and managing VBEs, providing guidelines to model various aspects of VBEs towards the development of VBE Management Systems. The use of reusable guidelines and possible generic models can assist modelers, designers and developers in understanding the existing components and concepts in VBEs, as well as how they operate.

2.3. VBE Environment Characterization

2.3.1. Base VBE Concepts

Past research have assumed that partners for a new VO could be easily identified and selected from the wide open universe of available enterprises/organizations, and merged into a collaborative network (Afsarmanesh, et al., 2008). This assumption misses, however, a relevant number of obstacles such as:

- 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 interoperable 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?

In order to support rapid formation of collaborative networks (e.g. a business consortium) it is necessary that potential partners are ready and prepared to collaborate. This readiness includes common interoperable infrastructure, common operating rules, common cooperation agreement, and also a base level of trust among the organizations. Thus, the breeding environment concept has emerged as the needed context for the effective creation of dynamic virtual organizations. Figure 3 shows how the creation of dynamic VOs can be improved through the pre-existence of VBEs.
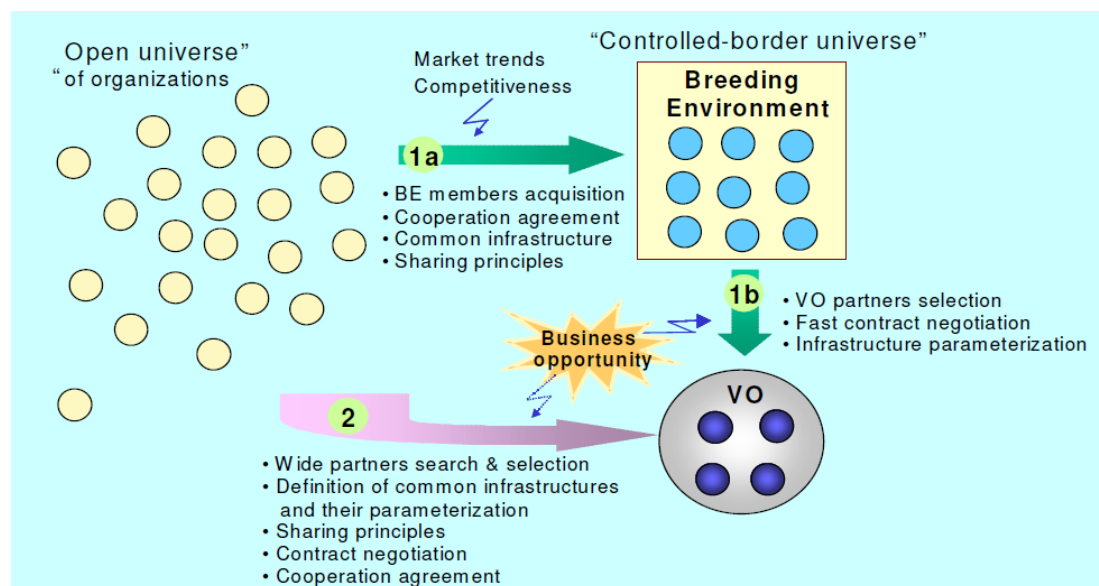
Figure 3 - Two approaches to the formation of virtual organizations (Afsarmanesh, et al., 2008)

VBEs set up offers the following advantages:

- VO creation agility by supporting the reduction of needed efforts and complexity and offering flexibility for VO re-configurability and cost effectiveness;

- Achieve an apparent larger size and negotiation power, contributing to better access to markets/opportunities and purchasing conditions;

- Provision of base ICT infrastructures for VBE members as a common ground for interoperability/inheritability/collaboration;

- The VBE bag of assets, providing assets of interest to its members like sharable information/knowledge (e.g. standardized product definitions and processes), software tools, and lessons learned;

- Provision of mechanisms, guidelines, and assisting services to motivate and facilitate the configuration and establishment of VOs like systems of incentives and positive reputation, and services for partners search, contract negotiation, etc.;

- Proactive management of the competencies and resources available in VBE assuring the coverage of the necessary competency/resources within the VBE;

- Provision of consultancy and support to VBE members through support institutions (e.g. supporting insurance, branding, training, etc.);

- Introduction of approaches and mechanisms to build trust among VBE members like recording the performance history, and defining criteria for organizations' trustworthiness;

- Provision of general guidelines for collaboration like conduct rules, working and sharing principles, value systems, collaboration ethics and culture, IPR protection, etc.;

- Increase the VO involvement chances of VBE members, even from remote geographic regions through the provision of members' profile in the VBE catalog, including their competencies, resources, products, services, etc.;

- Improve 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 trustworthiness and past performance of the VBE members.

However, to function properly and generate all these advantages, a VBE needs to met a set of requirements, such as:

- The establishment of a VBE must be supported by a strong ICT-based VBE management system, comprising a set of tools to support both the VBE administration as well as the configuration and creation of new VOs;

- Active involvement of the VBE member organizations, including the provision of up-to-date information about their capabilities, resources, capacities, costs, and conspicuities for the provided information;

- Establishment of a viable business model for the VBE, covering issues like VBE finances and how to survive in the market/society;

- Establishment of management strategies, government rules and bylaws, addressing the working and sharing principles as well as contracting, rewarding and sanctioning.

2.3.2. VBE Members

Structurally, a VBE is a regulated open, but controlled-border association of its member organizations (Afsarmanesh, et al., 2008). It aims at enhance the preparedness of its members towards joining potential future VOs, by providing the basis for dynamic and agile establishment of opportunity-driven collaborative networks. As exemplified in Figure 3, the pre-existence of a VBE reduces the cost of creating a new VO (branch 1b) when compared to a generalized partners' search (branch 2) since a part of the necessary tasks are already performed within the VBE for all VBE members prior to the establishment of any VOs (branch 1a). By other words, VBEs considerably contribute to enhance the preparedness of its members for participation in potential collaborative processes.

A VBE doesn't have to be a closed boarder. At any time new members can join and adhere to the association but they must comply with its general operating principles. However, different levels of membership can be defined and supported in a VBE, each one complying with a different set of rights and responsibilities. These different levels may constitute a range, with a loose-membership on one end and a tight-membership on the other end. For instance, a *loosely associated member* of the VBE may need to adhere just to a minimum level of organization "preparedness" that is necessary for getting involved in a VO, and to make available some minimum information to the VBE administration (e.g. about their activities related to the VO). On the other hand, a *fully active member* of the VBE contributes to its promotion, growth, and the enrichment of its bag of assets, taking an active role from brokerage and planning of VOs in a niche market, being involved in the expansion of the VBE into new sectors, and initiating VOs towards innovation.

When a VO formation takes place inside the VBE, preference is given first to the VBE members (at different levels). However, if a lack of skills or capacity inside the VBE is identified, organizations outside the VBE can be selected to join a VO. The identified external partner have then 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 organization will be invited and/or coached to establish this loose membership with the VBE. This invitation/coaching is typically made by the VBE administrator or the new VO planners.

Besides the main VBE organizations, who aim at joining potential VOs, a VBE can include other types of organizations such as research institutes, sector associations, governmental support organizations, and even free-lancer individual workers (e.g. consultants that represent a one-person small organization).

The inclusion of these other types of organizations in the VBE aims to offer 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.

We can distinguish three types of organizations registered inside the VBEs:

- *Business entities* which provide products and services to the market and 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.

Inside VBEs, organizations establish common ties with each other and shall comply with the general VBE rules and policies (e.g. adapting the common ICT infrastructure). After joining the VBE, member organizations can benefit from several available elements such as: common tools and technologies; common market and distribution channels; common resource and labor pool; common VBE cultural ties; share the cost of new experiences (e.g. to test new IT tool); share lessons learned.

VBE member organizations have many possibilities offered. For instance, participants in a VBE can act as a broker and establish a new VO in order to respond to a business/market opportunity or a new mission in the society, etc. Member organizations can be invited to join new VOs according with their competencies and/or past performance records, or even to fulfill a skill gap in the running VOs. Each member can access a diversity of needed general information and knowledge available in the VBE, and also share 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.) provided by the VBE support institutions, among others. Members can access the shared resources (software tools, information files, etc.)

which are either provided by the VBE administration or constitute contributions by other VBE members for common use, as well as benefit from the experiences and lessons learned shared by other members in the common on-line space provided in the VBEs. Member organizations also gain more visibility and have access to broader possibilities and markets.

The main goal of a VBE is to promote and facilitate the effective VO formation in order to respond to a new opportunity (e.g. for business or otherwise). Therefore, member organizations that act as VO brokers have special support provided within VBEs. Brokers within the 2nd generation VBE can benefit from a variety of VBE support services such as:

- Access to the catalog of available variety of competencies and their costs within the VBE;
- Access to the catalog of available variety of resources and respective free capacities in the VBE;
- Support for collaboration opportunities identification based on the competencies inside the VBE;
- Support for VO partners search and selection;
- Evaluate/compare potential partners based on their trust level;
- VO planning support and task assignment among potential partners;
- Support for agreement/negotiation through a forum;
- Support for creation of contracts (through provided templates and tools).

2.3.3. Roles

Within the VBE, a variety of roles can be assumed by VBE actors. A VBE actor can represent a VBE member organization or and individual on behalf of a VBE member organization (Afsarmanesh, et al., 2008). The main roles of the 2nd generation VBEs are:

- *VBE Member* – basic role assumed by the organizations registered in the VBE and that are prepared to take part in the VBE activities.
- *VO Partner* – basic role performed by a VBE member within a VO.
- *VBE Administrator* – role played by the organization responsible for the VBE operation and evolution, promotion of cooperation among the VBE members, filling the skill/competency gaps within the VBE through searching and inviting/recruiting new organizations to join the VBE, daily management of the VBE general processes (e.g.

assignment/re-assignment of rights to different actors inside the VBE based on their responsibilities, resolution of daily conflicts, preparation of VBE's bag of assets, making of common VBE policies).

- *Opportunity Broker* or simply *Broker* – role assumed by a VBE actor that is responsible for identifying and acquiring new collaboration opportunities (business or others), by promoting VBE competencies and assets, and negotiating with (potential) customers. The opportunity brokerage role can be performed also by an outside entity, as a service to the VBE.

- *VO Planner* or *Business Integrator* – role played by a VBE actor that, as a result of a new collaboration opportunity (designed by the opportunity broker), identifies the necessary competencies and capacities, selects a suitable set of partners (among VBE members and even outsiders in case of lack of competencies and/or capacities within the VBE), and structures the new VO. The roles of opportunity broker and VO planner are, very often, played by the same actor.

- *VO Coordinator* – role played by a VBE actor that is responsible for the coordination of a VO during its life cycle, in order to meet the goals set for the collaboration opportunity that triggered the VO.

Due to the variety of services and support tools and mechanisms provided within a VBE which require the assignment of rights/responsibilities to their providers, other roles might be considered. Some examples are VBE Advisor or advisory board, VBE Services Provider, VBE Ontology Provider and the last but not least, the VBE Guest which represent 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.

Nevertheless, the roles of VBE member organizations and corresponding responsibilities/rights cannot be static due to the dynamic nature of VBE's and its members. The main characteristics of the VBE roles, rights, and responsibilities are:

- A VBE member organization can assume different roles at different times, or even simultaneously (e.g. a VBE member can be a broker of one VO, and at the same time be a coordinator of another VO);

- Each role played by a VBE member organization represents a set of responsibilities, a set of required rights/authorization, and a set of assisting tools required to play the role.

(e.g. a VBE member acting as a VO broker accepted the responsibility to configure and negotiate a VO, which will require a set of access/visibility rights to the information on competency/past-performance of other VBE member organizations as well as an assisting tool to search for the best fit organizations for the required skills);

- VBE members must 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.

2.3.4. VBE Life Cycle

During its life, a VBE can go through several different stages/phases, from its creation to possible dissolution (Afsarmanesh, et al., 2008). The VBE life cycle is divided in three stages each one comprising two different phases.

The first stage of the life cycle is the *VBE's Creation* or the "Initiation and Foundation" and encompasses:

- *VBE Initiation & Recruiting* – is the first phase a VBE goes through and includes the strategic planning and initial incubation of the VBE. It requires the establishment and setup of a common base infrastructure, the recruitment of potential organizations, the establishment of a base ontology/thesaurus of the domain, and the definition of the vision and strategic objectives of the VBE.

- *VBE Foundation* – this phase is related with the constitution and start up of the VBE requiring support for the parametrization of the used systems, setting up the necessary links, creation of the needed databases (with initial ontology), and populating these information structures.

The second stage is the *VBE's Daily activities* or the "Operation and Evolution" and includes:

- *VBE Operation* – the "normal" phase of the VBE existence.
- *VBE Evolution* – phase that deals with small changes in membership and daily operating principles.

Both operation and evolution phases require assistance for management of competencies, new members registration (including profiling, characterization of competencies, products, services, etc.), assisting in VO creation, generation/evolution of metadata/ontologies for the domain/sector, keeping records of past performance and collaboration processes, assessment

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and assistance tools, collaboration support (e.g. newsgroups, discussion forum, common information repositories, etc.), management and evolution of working and sharing principles and rules, acquisition and management of common knowledge and assets.

Finally, the third stage is the *VBE's Change of nature* or the "Metamorphosis and Dissolution" comprising:

- *VBE Metamorphosis* – phase characterized by major changes in objectives, principles, membership and/or mergers, leading to a new form and purpose of the VBE. It requires support for the design of the new organizational structure, selection and reorganization of the information and knowledge collected during the VBE operation, analysis and adjustment to the new context, etc.

- *VBE Dissolution* – when the collaborative entity ceases to exist. Although a VBE can come to an end, it's an unusual situation, being more likely to go through a metamorphosis stage in order to keep its valuable gained knowledge. In this case a plan for transferring the collected knowledge, information and bag of assets to its members or another organization is needed according with the defined agreements.

2.4.   VO Creation

The main goal of a VBE is the possibility of rapidly respond to a business/collaboration opportunity through the formation of a VO (Camarinha-Matos, et al., 2005b).

The motivations for the creation of a VO differ from the ones of a VBE and so do creation processes. VBE members are recruited from the "open universe" of organizations according to the criteria defined by VBE creators/administrators while VO members are primarily selected from the VBE members. If a lack of skills or capacity inside the VBE is identified, organizations outside the VBE can be selected to join a VO. When choosing partners outside the VBE a preference is given first to organizations that have or had some activities with VBE members. Only as a last resource an organization without any linkage to the VBE and its members will be chosen because of difficulties of preparedness, trust, etc.

In this context, a VO creation process is needed aiming the identification and characterization of a collaborative opportunity, rough VO planning, partner search and selection, negotiation, detailed VO planning, contracting and VO launching (Figure 4).
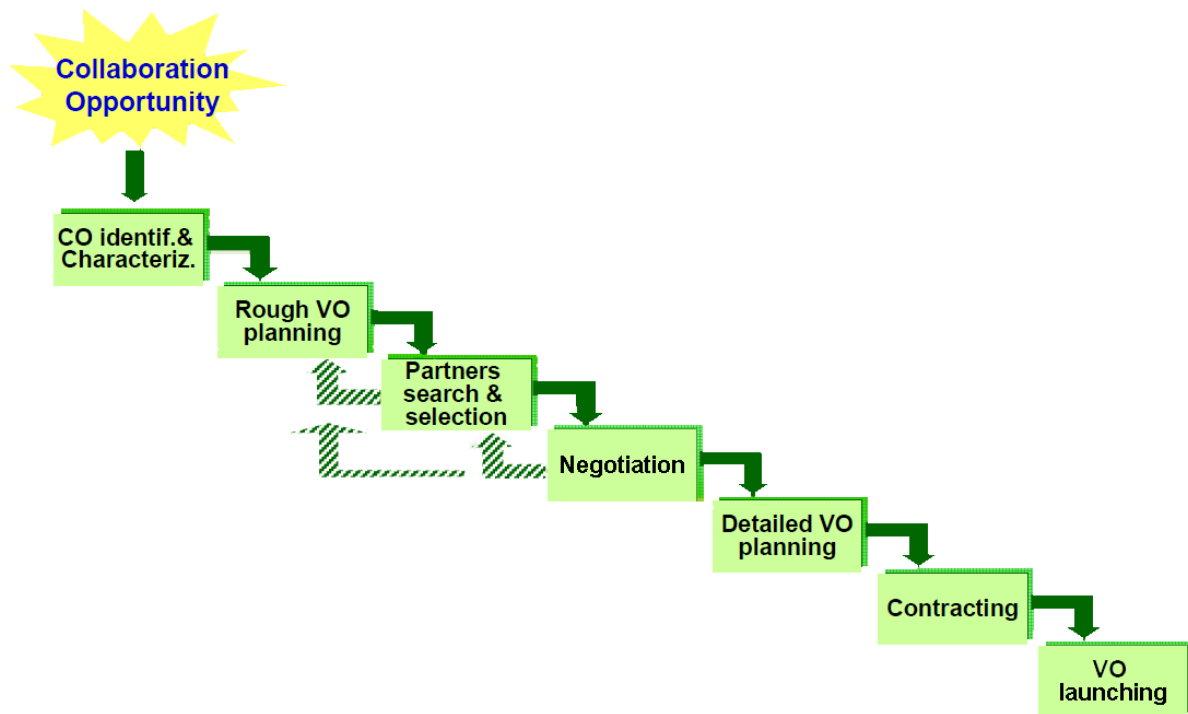
Figure 4 - VO Creation Process (Camarinha-Matos, et al., 2005b)

2.4.1. Collaboration Opportunity Identification and Characterization

Comprises the identification and characterization of a new Collaboration Opportunity (CO) that will trigger the formation of a new VO (Camarinha-Matos, et al., 2005b). The CO can be generated internally or externally depending if is a part of the development strategy of the VBE or if is originated by a (potential) customer and detected by a VBE member acting as a broker. There are four main collaboration modalities identified:

- **Collaborative Business Process** – set of heterogeneous activities normally distributed in cross-organizational sub-processes. These activities can be categorized as:
  - *Automatic Activities* - implemented by ICT services;
  - *Interactive Activities* - implemented by Collaborative Work plus ICT services;
  - *Cooperative Activities* - implemented by Co-Work;
  - *Manual Activities* - implemented by Humans;
  - *Decisional Activities* - followed by "or" branches, alternatives.
- **Collaborative Project** – support for multi-projects towards the definition of a work break down structure (WBS), composed by multi-projects, work packages, tasks and activities and the support for the human resource management where Human Resources

belongs to multi-organizations. VOs which adopt this model, need a set of supporting tools:

- o *Technical/Financial Control* - control primitives for progress, technical (percentage of completion) and financial (budget);
- o *Co-Work Integration* - integration with co-work services, collaboration measurement and rewarding;
- o *Knowledge Management Integration* - integration with document and multi-media material exchange/sharing;
- o *Project Management Facilities* - re-planning and re-scheduling facilities for project managers.

- **Collaborative Problem Solving** – establishment of a roadmap model defining the as-is situation and the to-be scenario, performing the gap analysis and identifying the working groups. In this case a VO will need:
    - o *Mediated Collaboration Model* - mediator identifies contributors, collects and evaluates contributions;
    - o *Collaboration Measurement & Reward* - identification of value metrics, rewarding of experts contributing decisively towards the roadmap's goal achievement;
    - o *Personal Time/Work Organizer* - possibility to integrate Project-Problem Solving Ad-Hoc collaboration sessions and/or off-line e-work;
    - o *Specific Tools for Problem Solving* - integration with specific Problem Solving tools, like Diagnosis Tools, Case-based Reasoning, Expert Systems and Continuous Improvement.

- **Ad-hoc Collaboration** - useful when big organizations, not used to tightly collaborate one with the other, are required to joint their efforts in order to rapidly give a quick response to an external request. In this model only few persons are required to take decisions and in this way addressing their organizations towards the common goal. Supporting to this model is given by:
    - o *Integration and Composition of Co-Work* - several Co-Work services to be combined and integrated as atomic services;
    - o *Co-Work Logging* - primitives for multi-media Co-Work logs recording (text, speech, image, video);

- o *Co-Work Analysis* - advanced services for Co-Work logs analysis (speech-to-text; MPEG analysis);
- o *Ubiquitous Access* - as far as possible to integrate the Co-Work services with PTO/PWO (personal time organizer/ personal work organizer) in an AAA (Anybody-Anywhere-Anytime) scenario.

The broker and the customer are the main contributors of this initial step for which the following main issues should be considered:

- Identification and categorization of the CO (external/explicit, internal/implicit);
- Collaboration modality;
- CO representation;
- CO feasibility analysis;
- Interaction with customer;
- Support (rapid) quotation/bidding.

2.4.2. Rough VO Planning

Comprises the determination of a rough structure of the potential VO, including the required competencies and capacities, as well as the organizational form of the VO and identification of corresponding roles (Camarinha-Matos, et al., 2005b). The partnership form, which is typically regulated by contracts and cooperation agreements, should be defined at this phase. Four typical organizational forms for collaborative consortia can be distinguished:

- **Explicit Consortium** - The collaboration is regulated by a joint contract with the customer and a consortium agreement. The Client cares about who is part of the consortium;
- **Internal Consortium** - There is a contract between one representative of the consortium and the Client. The Client doesn't necessarily know about the way the consortium is organized. The consortium is also formalized using an agreement and an internal contract. Only one partner (the one that signs the contract) is committed to the Client. The other partners are committed to the one that signs the contract;
- **Sub-contracting** - There is a contract between one partner and a client and subcontracts between this partner and the other service / product providers. The Client doesn't necessarily know about the way the contracted partner is organized;

- **Partnership** - The partnership creates an entity (new company) using a partnership agreement. The new company establishes a contract with the Client. Only the new company is committed to the Client. The partnership may continue after the end of the initial client contract.

The main contributors to this step are the broker and VO planner being the Explicit Consortium and the Internal Consortium the most typical situations for dynamic VOs. Other issues can be considered at this stage such as:

- Identification of needed competencies and capacities;
- Rough VO structure/topology/levels and associated roles;
- Macro governance rules;
- Representation of rough VO model;
- Top-down (planning) vs. bottom-up (emerging);
- Simulation (to assess different configurations).

2.4.3. Partners Search and Selection

Comprises the identification of potential partners and their assessment and selection (Camarinha-Matos, et al., 2005b). Several aspects must be considered, such as:

- Elements for search and selection (technical, economical, reliability indicators, preferences);
- Matching algorithms;
- (Multi-criteria) selection criteria;
- Optimization;
- Assessment (preparedness, etc.), consideration of collaboration history / record;
- External search (if the internal offer is insufficient).

For the search and selection, two approaches can be distinguished:

- **Top-down** – the VO planner designs the VO, determine the roles and select the partners that best fit his plan.
- **Bottom-up (competition)** – the VO planner or the broker announces the collaboration opportunity to the VBE and waits till some consortia spontaneously form (by the initiative of some members) and then analyzes their global bids.

The selection is important even after the creation phase. For example, during the operation phase a new partner might be needed to perform a task that no other VO partner can execute. The main contributors to this step are the VO planner, the VBE member, and in some cases the broker.

2.4.4. Negotiation

Iterative process that aims reaching agreements through the alignment of the needs with offers (Camarinha-Matos, et al., 2005b). This step is complementary to others and can run parallel with them. For instance, if a solution cannot be found with the current configuration of partners, go back to the previous step(s), such as partners' selection process, might be need. The negotiation process includes some important issues such as:

- Determination of the objects of negotiation;
- Negotiation protocols;
- Decision making process and corresponding parameters;
- Representation of agreements.

At this stage, the business process refinement and assignment to partners may also be considered if not in the detailed VO planning. The main contributors to this step are the VO planner and the VBE member.

2.4.5. Detailed VO Planning

Detailed VO planning addresses the refinement of the VO plan and its governance principles and begins after the partners' selection and the establishment of collaboration agreements (Camarinha-Matos, et al., 2005b). Detailed VO planning step involves:

- Business/collaboration process modeling depending on the type of collaboration;
- Final VO representation;
- Assignment of roles and responsibilities;
- Definition of sharing principles, access levels (assets/resources, IP, benefits, etc.), preliminary operating policies.

The main contributors to this step are the VO planner and the VBE member.

2.4.6. Contracting

Comprises the final formulation and modeling of contracts and agreements as well as the contract signing itself (Camarinha-Matos, et al., 2005b). A contract is an agreement between two or more parties that defines their duties, rights and obligations as well as remedy clauses and other clauses that are important to characterize the goal of the contract. An agreement is an arrangement between parties regarding a method of action, aiming the regulation of cooperation actions among partners, and being always associated to a contract. Besides the definition of the types of contracts and their representation, this step includes:

- Contracting process (manual, e-contracting);
- Contract enforcement mechanisms and institutions;
- Legal issues.

This step is performed in parallel with the Negotiation and Detailed VO Planning steps being the VO planner, the VBE member and VO coordinator the main contributors.

2.4.7. VO Launching

It is the last phase of the VO creation process and consists in putting the VO into operation (Camarinha-Matos, et al., 2005b). This step is responsible for tasks such as:

- Configuration of the ICT infrastructure;
- Instantiation and orchestration of the collaboration spaces;
- Assignment and set up of resources/activation of services;
- Notification of the involved members;
- Manifestation of the new VO in the VBE.

The main contributors to this step are the VO coordinator, the VBE member, and possible the VBE administrator.

2.4.8. Collaboration Opportunity Finder Tool

During the last years, numerous tools have been developed aiming to facilitate the VO creation process and its several steps. The Collaboration Opportunity Finder (coFinder) is a software tool that was designed and implemented aiming to facilitate the work of a VO broker (Demsar, et al., 2007). The tool uses the same approach a VO broker would use manually by comparing

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potential business/collaboration opportunities from public Calls for Tenders (CfT) with the competencies available inside the VBE. This competencies are typically stored in the Profile and Competencies Management System (PCMS) which is a part of the VBE Management System (VMS). To automatically detect similarities and consequently detect possible collaboration opportunities, the coFinder tool needs that the information present in both sides has a comparable structure. The matching is then based on the comparison of textual descriptions of tenders and VBE competencies. Like a broker would do, the coFinder browses public CfTs available on relevant web pages and extracts tenders' descriptions. Similarly, competencies can be obtain from web pages or manually entered in text format within the coFinder tool. Eventually, coFinder will interact with the PCMS in order to get the competencies. After getting tenders' descriptions and competencies, the coFinder is able to compute their similarity in order to estimate the interestingness of tenders and identify the most promising ones, and finally to propose them to the broker as potential collaboration opportunities. The outcome is stored as a list of potential collaboration opportunities in an XML document structured according with the directives imposed by an XML schema specified by the VMS.

2.4.9. Collaboration Opportunity Characterization Tool

The characterization of a collaboration opportunity is the process of identifying the main features to be developed and decompose them, from the most complex items (assemblies/activities) to the simplest ones (components/sub-activities) which can be then mapped into the competencies required in a VO partner for providing such item (Concha, et al., 2008).

In order to facilitate the work of a broker or business integrator (also known as VO planner) during the first step of VO Creation, a Collaboration Opportunity Characterization (COC) tool was designed aiming the characterization of a collaboration opportunity in terms of competencies required to further matching VO partners. The COC tool seeks a seamless interoperability with other VO creation support tools such as Collaboration Opportunity Identification (e.g. coFinder) and Partner Search and Suggestion (e.g. PSS tool) and covers three general functions: collaboration opportunity decomposition, item competency assignment and reporting or data exporting.

For each item identified to fulfil the collaboration opportunity, there is a set of competencies required to be a VO partner. These competencies have to be freely defined by the broker or the business integrator, but aligned with the classification of competencies dictated by the knowledge domain where the COC tool is used. The competency classification restrictions have to be somehow pulled from the knowledge domain (e.g. NACE Classification - Nomenclature of Economic Activities).

2.4.10.   Partner Search and Suggestion Tool

In the VO creation process, one of the most critical aspects is how to choose the right partners to respond to a specific CO (Baldo, et al., 2007). Until few years ago there was the idea that partners could be quickly and easily identified and recruited from the "open universe" of organizations. That vision changed due to problems such as:

- How to acquire organizations' information?
- How to quickly establish a collaboration infrastructure?
- How to build trust among organizations?

Furthermore, past approaches related to partners' suggestion focused only on costs, delivery dates and availability of resources as suggestion criteria. Nowadays, is a common sense that the use of these reduced set of generic information is not enough to ensure the quality of partners' suggestion, and that a well-defined set of criteria based on a common set of attributes known by every interested organization should be used. These common set of criteria can be based on the information used to measure performance either within or among organizations, e.g., SCOR Model, Balanced Scorecard, benchmarks, etc.

The Partners' Search and Suggestion (PSS) tool aims to assist the VO Planner in selection of the most suitable members for a VO by using the requirements received from the previous VO creation phases (CO identification and characterization, and rough VO planning) (Camarinha-Matos, et al., 2008). The tool comprises three functionalities:

- **Suggestion criteria identification** – identify the criteria that will be used to compare potential candidates;
- **Partners' search** – look for potential partners based on the required competences/processes and resources availability;

- **Generation and analysis of suggested VOs** – generate optimized arrangements of organizations based on potential partners previously identified.

Suggestion Criteria Identification

Aiming to help in the suggestion criteria identification, Baldo et al. (2007) proposes a strategy to filter the whole set of performance indicators (PIs) in order to identify the ones that can be used to compare and after to suggest organizations for new VOs, assuming that the suggestion criteria can be represented through organizations' PIs and that each VBE has a well-defined set of PIs used to measure performance among its members.

The methodology proposed for assist the VO Planner to identify the most appropriated PIs for a given CO is divided in two phases:

- **Preparation phase** – only runs once and comprises the setup of the environment as well as the acquisition of the information related to the PIs (name, description, type, etc.) used to measure the organizations' processes and activities in a given VBE, and the application of a semantic annotation technique, combined with an ontology that describes PIs, to create annotations in the acquired PIs. These annotations are then indexed to improve the retrieval of information.

- **Execution phase** – runs whenever a new VO needs to be created to fulfill a certain CO and comprises the acquisition of the preferences and constraints' list that the CO needs to fulfill, the identification of the CO performance requirements based on the match between the preferences and constraints list and the CO ontology, the search for the proper PIs based on the keywords selected previously, and the analysis and evaluation (driven by the VO Planner) of the results in order to ensure whether the PIs are good enough to start the partners' search.

The methodology presented allows the VO Planner to perform the partners search and suggestion process using more accurate information to compare candidates and suggest the ones that best fit the performance expectation. In order to improve the results, this methodology can be combined with other developed works.

Partners' Search

The partners' search starts by selecting as potential partners all VBE members that have some competencies required for the new VO that is being created (Camarinha-Matos, et al., 2008). The selected potential partners are then classified in groups of similar competencies. According with the suggestion criteria defined in the previous functionality, the most suitable VBE members are chosen to be part of the new VO.

Generation and Analysis of Suggested VOs

This functionality finds and assesses feasible VO configurations through user-defined criteria (Camarinha-Matos, et al., 2008). The feasibility of a configuration can be defined through its ability to perform the requirements of the CO being these requirements described by tasks and linked to the specific competences required. Additionally, work-loads (e.g. person month) can be attached to the tasks, and the VO partner selection made as a work-allocation problem. In the end, the generated VO configurations are presented to the VO Planner for a further decision making and final VO composition. By comparing the expected performance of whole VO configurations instead of only individual partner candidates, the VO Planner have a better view on the overall performance of the VO enabling the incorporation of inter-organizational dependencies in partner selection such as collaboration history or geographical distance.

3. Proposed Solution

3.1. Introduction

This chapter comprises the design and development of a collaborative platform for the AAL4ALL project based on the findings of the previous chapter. As Napoleon Bonaparte allegedly said: "A good sketch is better than a long speech"[1]. Following this approach, the design of the platform was based on Rational Unified Process and using UML for modelling.

3.2. Business Modelling

During the AAL4ALL project, Camarinha-Matos et al. (2012) proposed a 3-layered model for the AAL4ALL conceptual architecture. This chapter starts by focusing on the top layer of the architecture (AAL4ALL Ecosystem) and modelling the business processes (Figure 5) related with organization, governance, and collaboration support, identified for the AAL multi-stakeholders from a socio-technical perspective (Camarinha-Matos, et al., 2012).

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[1] Quoted in L'Arche de Noé (1968) by Marie-Madeleine Fourcade, p. 48
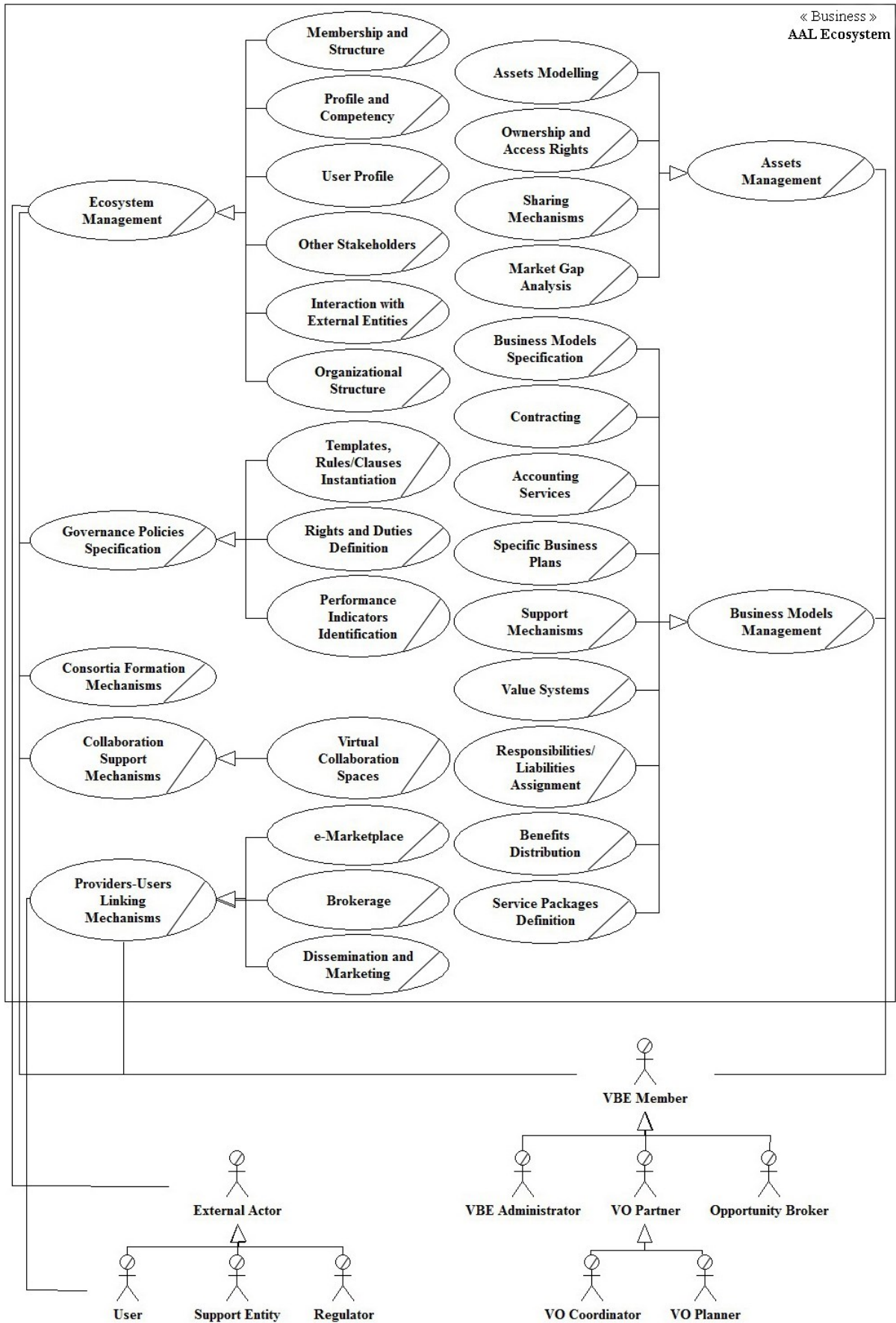
Figure 5 - Business Use Case Diagram

3.3.   Requirements

The collaborative platform prototype focused on some of the previous mentioned business processes namely, Membership and Structure Management, Profile and Competencies Management, Assets Management, Collaboration Support Mechanisms and Consortia Formation Mechanisms. The functionalities associated to the selected business processes are presented and detailed in the following system use case diagrams and tables.

3.3.1. Membership and Structure Subsystem
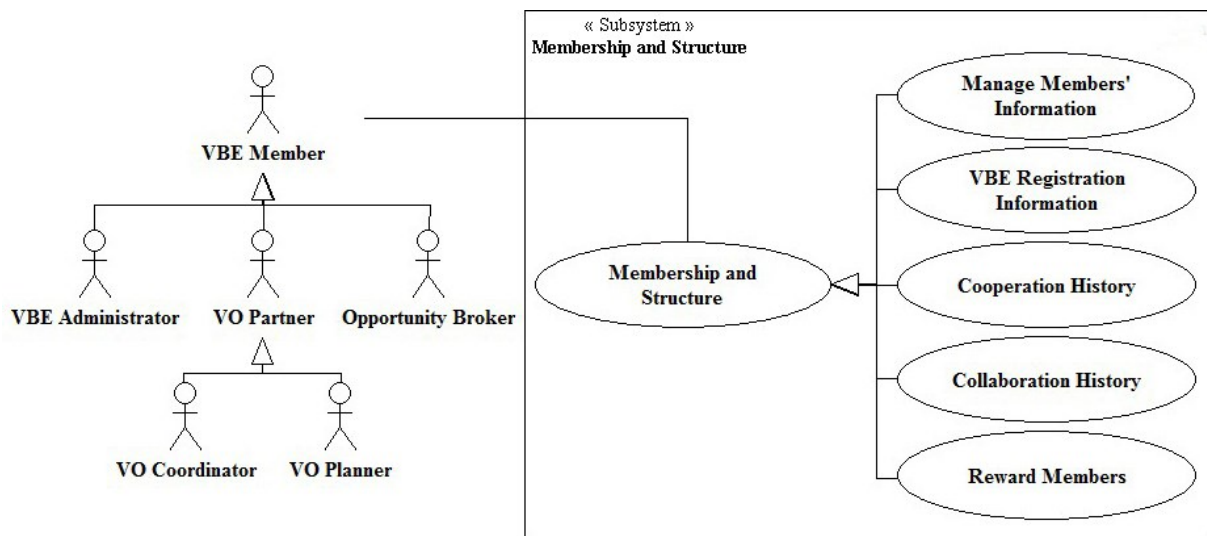
Figure 6 - Membership and Structure Subsystem Use Case Diagram

Use Case	Description
Manage Members' Information	CRUD operations that provide functionalities to submit, store, access, delete, and modify the member's organization information.
VBE Registration Information	Information about the organization presence in the VBE. It includes registration date and member's rights and roles.
Cooperation History	Record of organization's past events inside the VBE consortium.
Collaboration History	Record of organization's past events inside VOs.
Reward Members	Evaluate and reward appropriate and proactive behavior within the VBE. The evaluation is based in Cooperation and Collaboration History records.

Table 1 - Description of Membership and Structure Subsystem Use Case Diagram

3.3.2. Profile and Competencies Subsystem
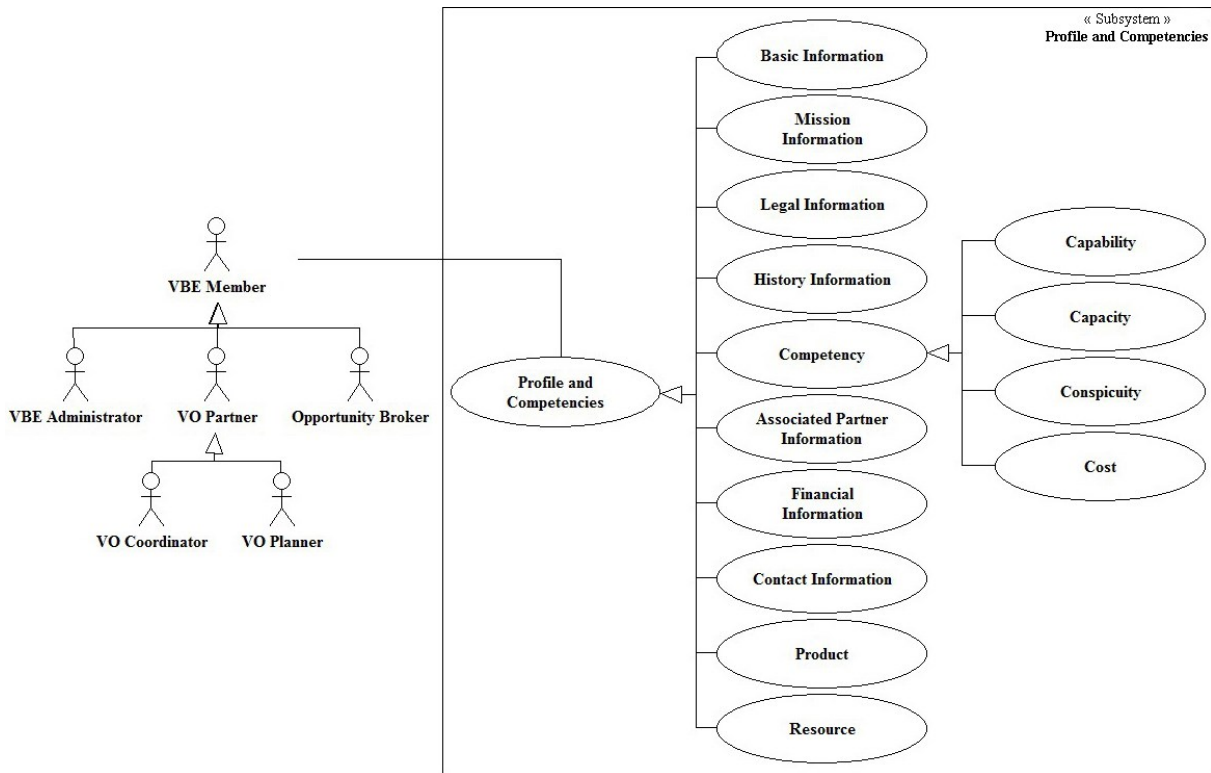
Figure 7 - Profile and Competencies Subsystem Use Case Diagram

Use Case	Description
Basic Information	Data that identifies and characterizes an organization namely, name, location, creation date, domain of activities, number of employees and general description.
Mission Information	Organization's vision, mission, strategy, and targeted group (i.e. sector)
Legal Information	Organization's legal name, legal status, and legal address
History Information	Record of past events at the organization. It includes history designation, history description, date, products produced and practices applied.
Associated Partner Information	Information about a second organization which has some business relations with the member organization. It includes partner name, type of relationship, and duration of collaboration. This information can be useful to support a future invitation to join as new VBE member.

Use Case	Description
Financial Information	Confidential information about the member organization which can we only be seen by VBE Administrator and selected partners (e.g. opportunity broker) and that aims to check the financial stability of the member organization in order to participate in VOs. It includes total sales, total revenue, balance sheet, operational costs and reporting period.
Contact Information	Organization's contacts such as address, phone, fax, email, and website.
Product	Goods and services that results from the member's organization activity. It includes name, description, class (i.e. product or service), production strategy and contribution to sales.
Resource	Organization's resources. It comprises resource class (human, physical, ICT and organizational), name, description and quantity.
Competency	What an organization can do. Is characterized by competency name, class, description, and also by four fundamental components: Capability, Capacity, Cost and Conspicuity.
Capability	Information that defines what an organization is able to do (e.g. processes and activities). Comprises capability name, description, class, and related resources (processes/activities input) and products (processes/activities output).
Capacity	Represent currently free resources needed to perform one specific capability. Comprises a description of how capacity rates and capabilities are related, a measure unit, and a capacity rate.
Conspicuity	Evidence documents that provides proof of the validity of the competency information provided by the organization. Comprises a conspicuity document name, a description about how the document validates the competency information, conspicuity class (e.g. recommendation letter, license, certificate, patent, award), document title, document ID (e.g. patent number), issuer and validity period.

Use Case	Description
Cost	Represent the cost of delivering a product/service in relation to a capability and capacity. Comprises a description on how cost and capabilities are linked, item for which the cost is provided, and cost value (i.e. monetary price)

Table 2 - Description of Profile and Competencies Subsystem Use Case Diagram

3.3.3. Assets Management Subsystem
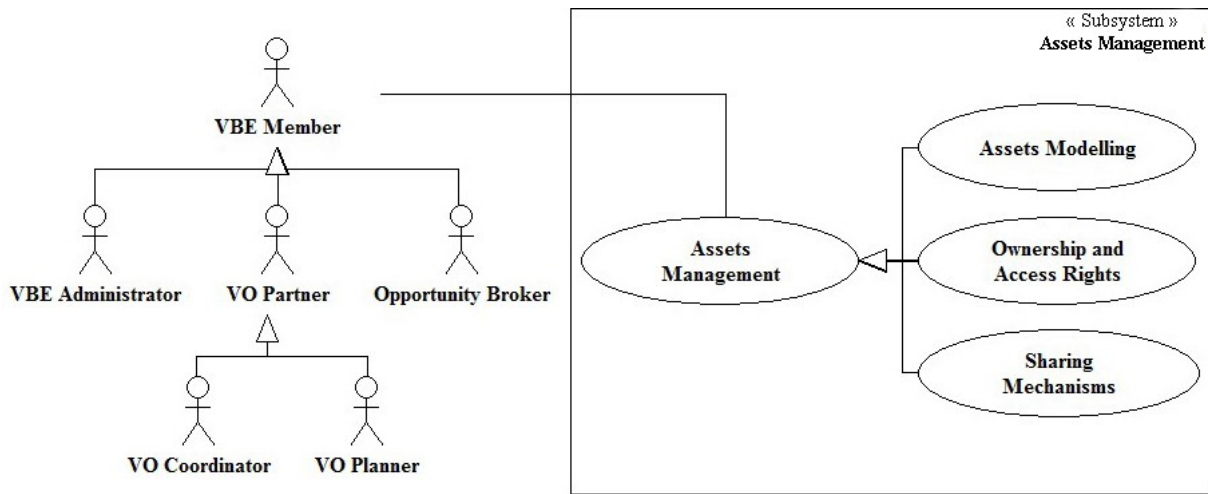
Figure 8 - Assets Management Subsystem Use Case Diagram

Use Case	Description
Assets Modelling	Assets' type (e.g. document, book, flyer, audio, video, software, link to other sources, etc.). Assets' class (e.g. lessons learned, general policies, information of interest, sample contracts, general legal documents, information about historic performance, etc.).
Ownership and Access Rights	Functionality to manage who owns the asset and who has permissions to access and change it.
Sharing Mechanisms	Functionality to manage asset sharing among users and platform subspaces (e.g. VOs, groups, events).

Table 3 - Description of Assets Management Subsystem Use Case Diagram

3.3.4. Virtual Collaboration Spaces Subsystem
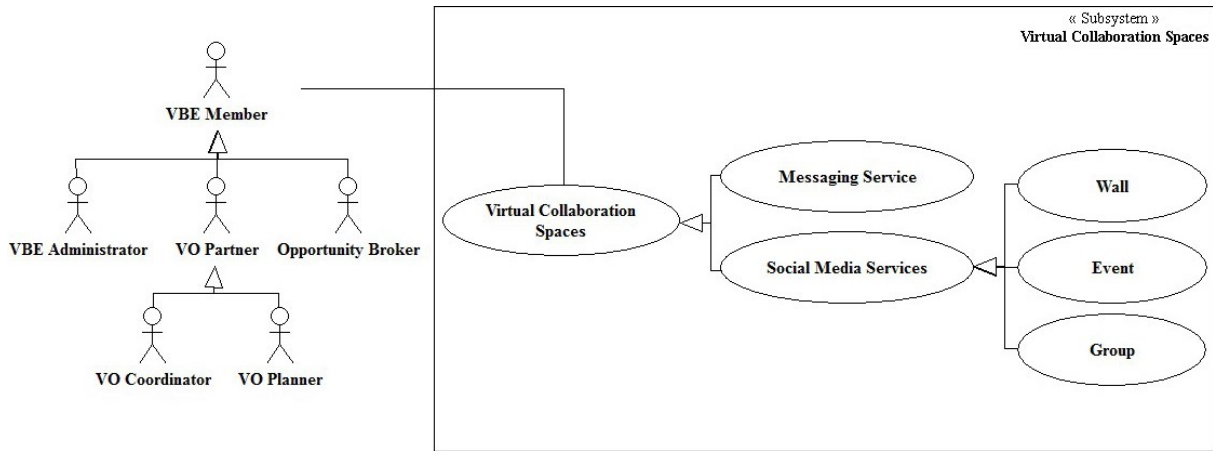
Figure 9 - Virtual Collaboration Spaces Subsystem Use Case Diagram

Use Case	Description
Messaging Service	Instant messaging service that allows real-time text transmission over the Internet and attachments send.
Social Media Services	Social media functionalities that aim to increase collaboration inside VBE's and VO's.
Wall	Institutional page of an organization inside the VBE. In this space organizations can share information with other members (e.g. what they are doing).
Event	This functionality allows organizations to promote initiatives in order to join several member organizations around a common interest.
Group	The groups' functionality aims to create a small collaboration space where organizations with a common and compatible goal can share information and work together to achieve that goal.

Table 4 - Description of Virtual Collaboration Spaces Subsystem Use Case Diagram

3.3.5. Consortia Formation Mechanisms Subsystem
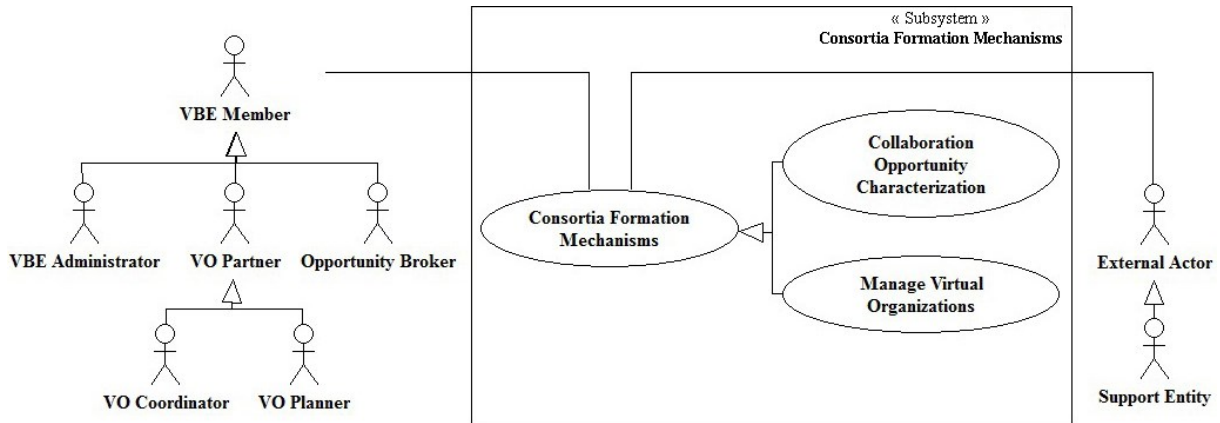
Figure 10 - Consortia Formation Mechanisms Subsystem Use Case Diagram

Use Case	Description
Collaboration Opportunity Characterization	Functionality that supports Opportunity Brokers in defining and characterizing an identified Collaboration Opportunity. Comprises the decomposition of the CO into items that can be individually mapped to the competencies required to accomplish CO objectives. As a result, this functionality will also help to find the most suitable members for joining a VO.
Manage Virtual Organizations	CRUD operations that provide functionalities to create, access, modify and dissolve Virtual Organizations.

Table 5 - Description of Consortia Formation Mechanisms Subsystem Use Case Diagram

3.3.6. Class Diagram

A generic conceptual class diagram was developed aiming to define the system structure at the level of classes, its features and relationships. Due to the limited space to display the class diagram as a whole, this has been divided into five components according with the related features.

Figure 11 presents the class diagram main component covering the platform main actors (organization and its employees), and some features as evaluation, rewarding, social media services and assets management.
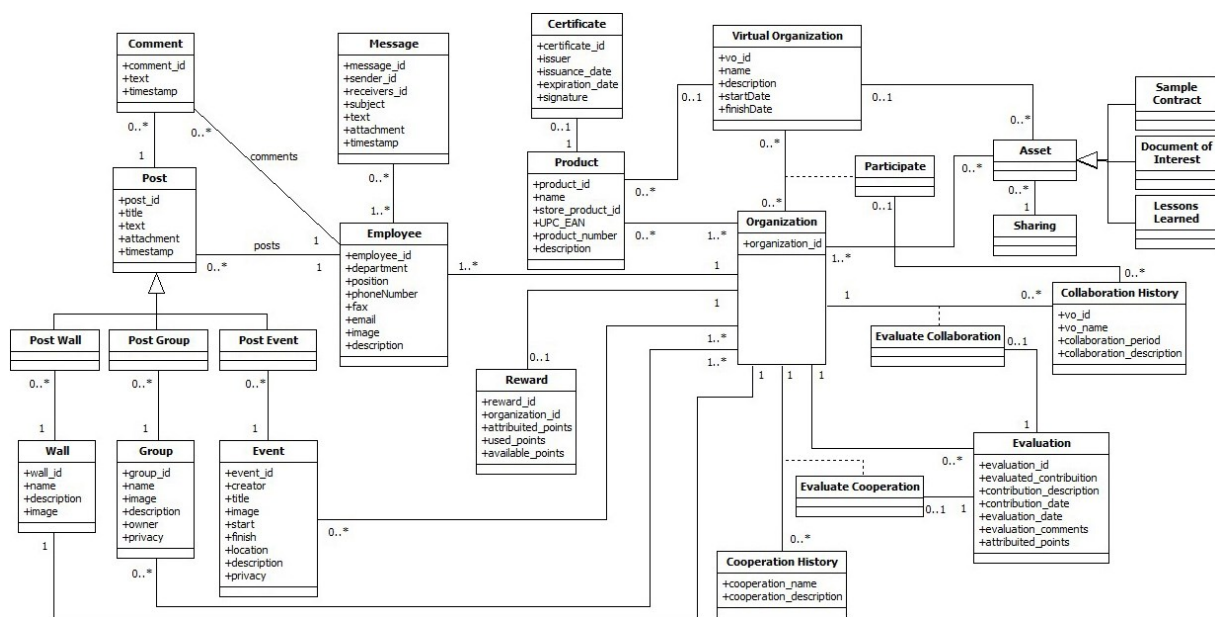
Figure 11 - Class Diagram Main component

Figure 12 exhibits the profile component of the class diagram which comprises the specific set of identifying characteristics about each organization.
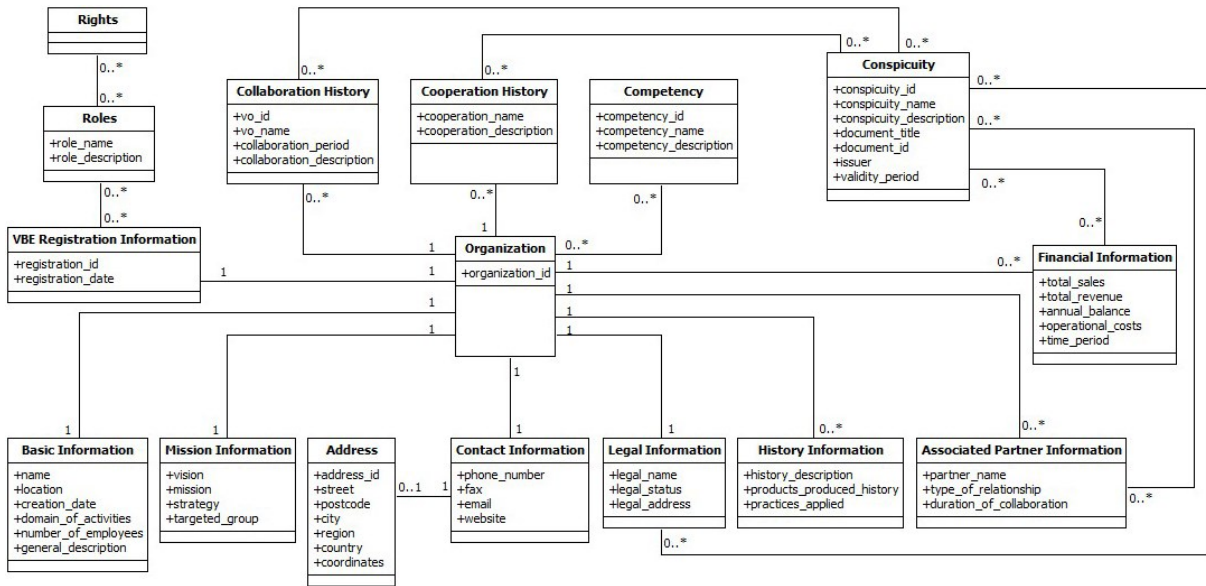
Figure 12 - Class Diagram Profile component

Figure 13 shows the class diagram competency component which represents up-to-date information about what an organization can do.
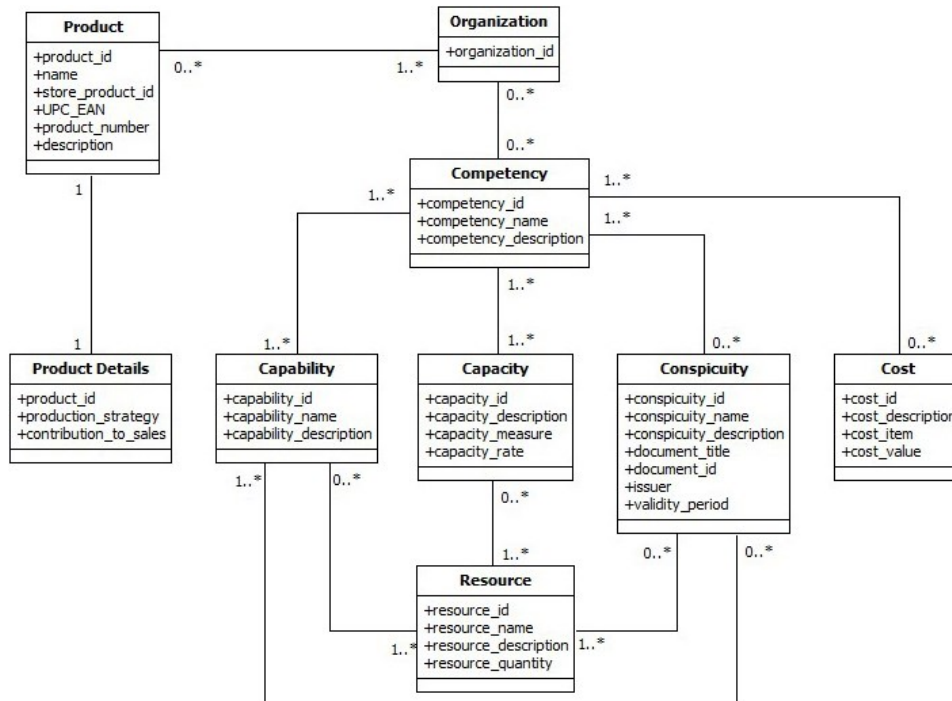
Figure 13 - Class Diagram Competency component

Independently of the domain field of a VBE there are profile and competency elements that are common to all VBEs and others that are business domain related. Figure 14 displays the classification component of the class diagram which represents a domain extension that provides support for different VBE domains.
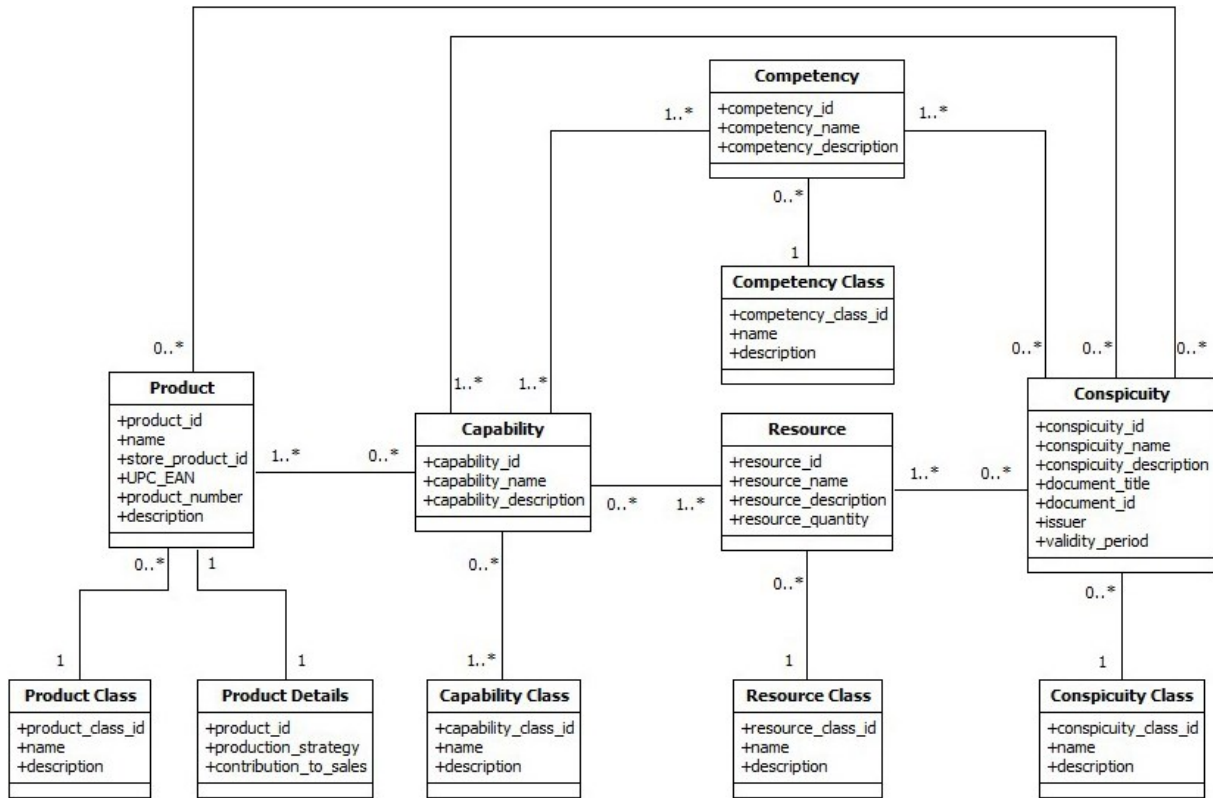
Figure 14 - Class Diagram Classification component

Finally, Figure 15 presents the collaboration component which covers some virtual collaboration spaces subsystem features, namely collaboration opportunity characterization and the management of virtual organizations.
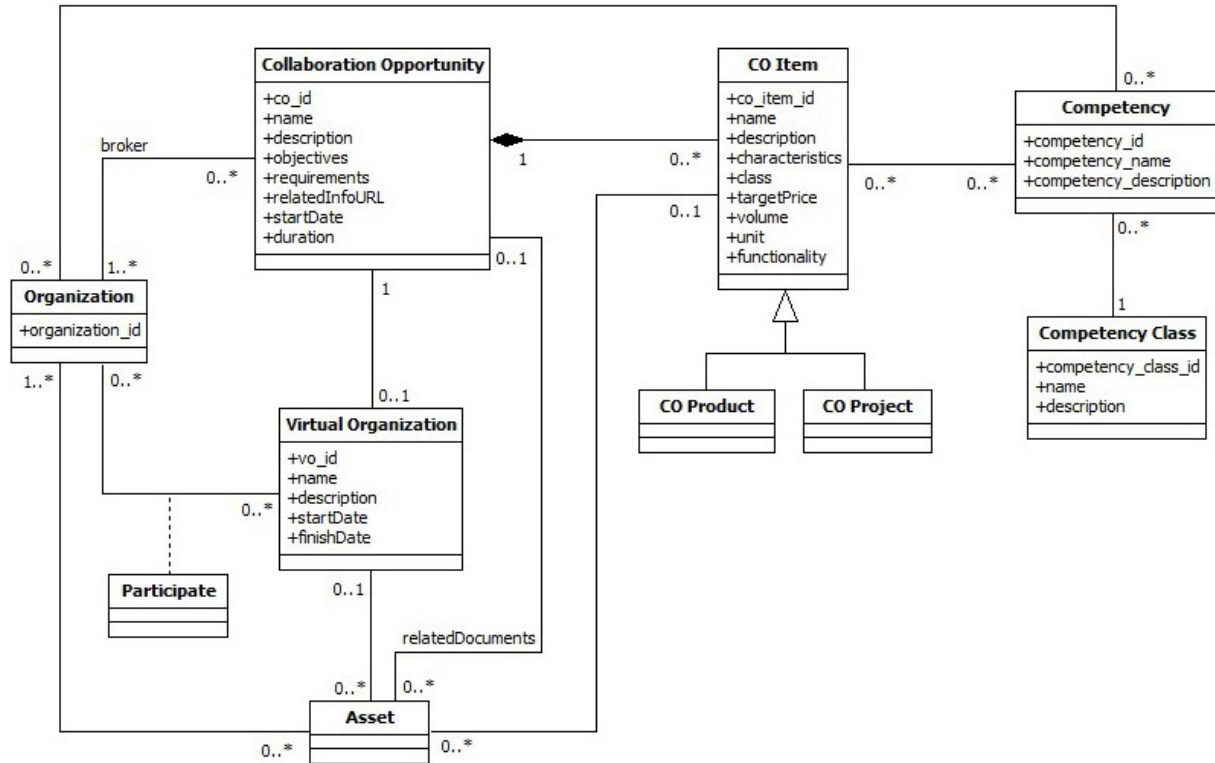
Figure 15 - Class Diagram Collaboration component

3.4. Analysis and Design

3.4.1. Interaction Diagrams

As an example of CRUD operations, two processes were modelled using interaction diagrams, namely, the registration of an organization (Figure 16) and the submission of a new collaboration opportunity in the platform (Figure 17).

A registered user, normally acting as an employee of a VBE member applicant, will be able to register its organization on the platform in a three step registration process. This registration process comprises the provision of basic and contact information about the organization along with its competencies, and also information about the employee that will represent the organization on the platform. Figure 16 represents the user interaction with the system during the organization registration.
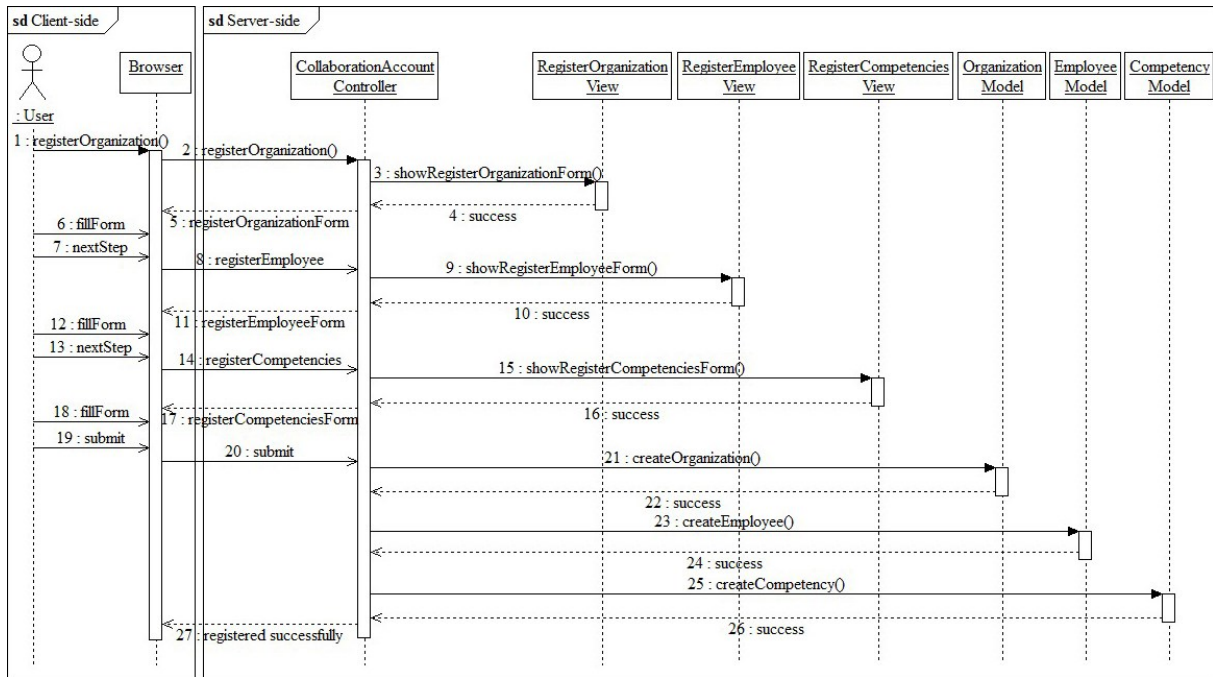
Figure 16 - Interaction Diagram of Organization Registry

After a VBE member has identified a new business opportunity for which it lacks the required competencies or resources, it can find the most suitable partners to participate in that business opportunity through the creation and characterization of a new collaboration opportunity. Figure 17 represents the interaction between the employee that represents the VBE member and the system during the creation of a new collaboration opportunity on the platform. After the creation of a new collaboration opportunity it's possible to decompose it in small collaboration opportunity items.
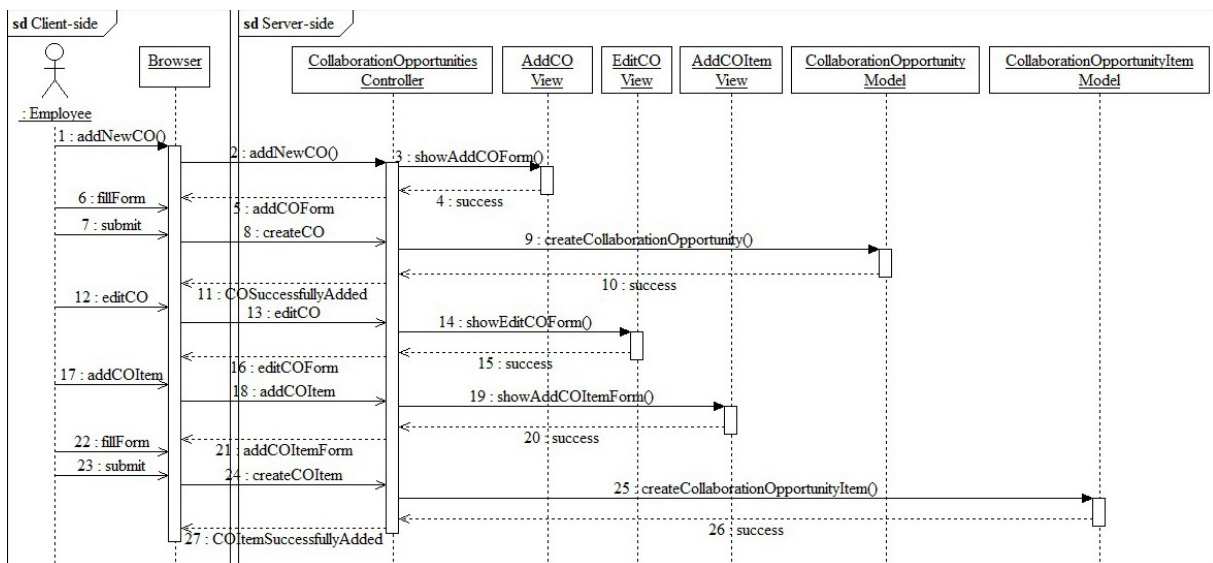
Figure 17 - Interaction Diagram of a new Collaboration Opportunity Submission

3.5. Implementation

3.5.1. Component Diagram

The following component diagram (Figure 18) represents the platform implementation architecture based on the MVC model. The packages inside the main MVC building blocks, describe a set of related components.
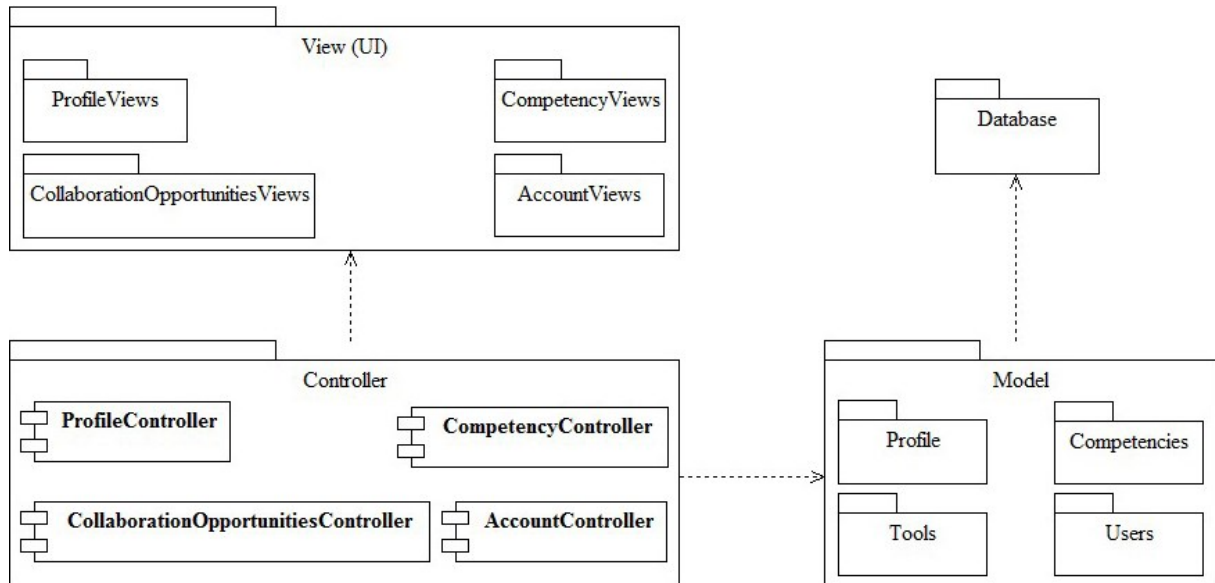
Figure 18 - Component Diagram

3.5.2. Development Platform

Table 6 presents the tools and technologies used to implement the prototype.

Design	UML tool	StarUML 5
	Integrated development environment	Visual Studio .NET 2013
	Web application framework	ASP.NET MVC 5
	Programming language	C# and Javascript
Development	Markup language	HTML
	Style sheet language	CSS
	JavaScript library	JQuery 2.1 and Angular.JS 1.3
	Front-end framework	Bootstrap 3
Data Storage	Object-relational mapping	Entity Framework 6
	Database	Microsoft SQL Server 2012

Table 6 - Development Tools and Technologies

The reasons behind the tools and technologies chosen varied.

For the platform design and, despite of have been discontinued, StarUML was chosen due to still be a very powerful, free and easy-to-use UML modeling tool.

For the platform development and data storage, the choice over the main tools (IDE and Database) were for Visual Studio and SQL Server due to their quality, widely usage and also because Microsoft was one of the partners of the AAL4ALL project, thus guaranteeing continuous support.

The choice over the MVC pattern was due to its ability to separate the different aspects of the application (input logic, business logic, and UI logic) making it easier to manage complexity, while providing a loose coupling between these elements. Additionally, MVC offers better support for test-driven development (TDD).

Entity Framework was used to enable a code-first approach making it possible to create the database on the fly based on model classes previously created.

To help in the frontend development the choice fell in Bootstrap due to its ease of use, simple integration, the responsiveness it offers, enabling the development of websites that adjusts dynamically taking into account the characteristics of the device used (desktop, tablet, mobile phone), its customization capability and the increase in the speed of the development it brings.

Two JavaScript libraries were also used to help in the website development, jQuery and AngularJS. While the first one was used to ease the use of JavaScript, the second was chosen to dynamically rewrite pages rather than loading entire new pages from a server making the platform more user friendly.

3.5.3. Demonstration of Prototype

For the prototype demonstration the same two features previously modeled through interaction diagrams were choose (organization registration and submission of a new collaboration opportunity) along with the presentation of some core screens. The demonstration is presented through the use of several print screens and their descriptions. However, a more detailed demonstration is available in video (Portuguese audio) on the Internet. It can be accessed through the URL: http://youtu.be/0kMzxTRXhn4

Home Page

The collaborative platform is one of three platforms developed at ISCTE - University Institute of Lisbon under the AAL4ALL project. The goal was to present a unified platform covering a space where AAL4ALL members could collaborate in new business opportunities, a space where AAL4ALL members could sell their products and services, and an e-learning and recreational space for seniors. Figure 19 presents the main page which holds the three mentioned platforms.
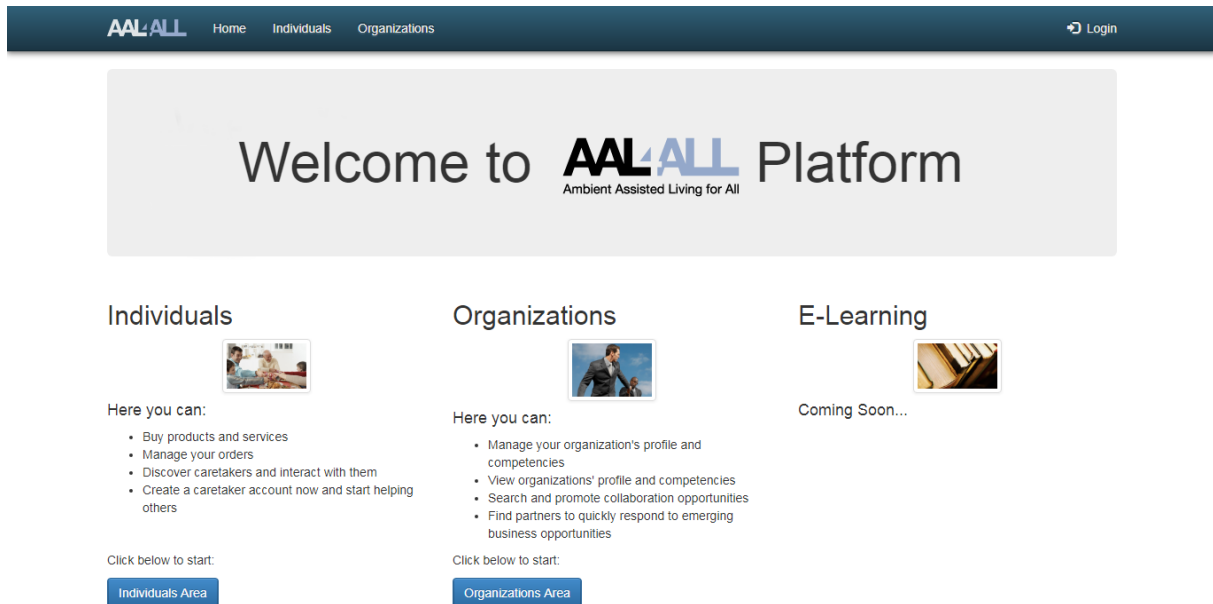
Figure 19 - Platform Main Page

Members List

The members' list page presents all the organizations registered on the platform allowing an authenticated user to know more about each organization (e.g. profile and competencies) by accessing the organizations' pages on the platform (Figure 20).

Figure 20 - Members List

Organization Page

The organization page is the space of an organization on the platform containing its membership, profile and competencies information as well as its assets (Figure 21). Some information available in the organization page is public while another is not. Therefore, the information displayed in this page depends on the user permissions.
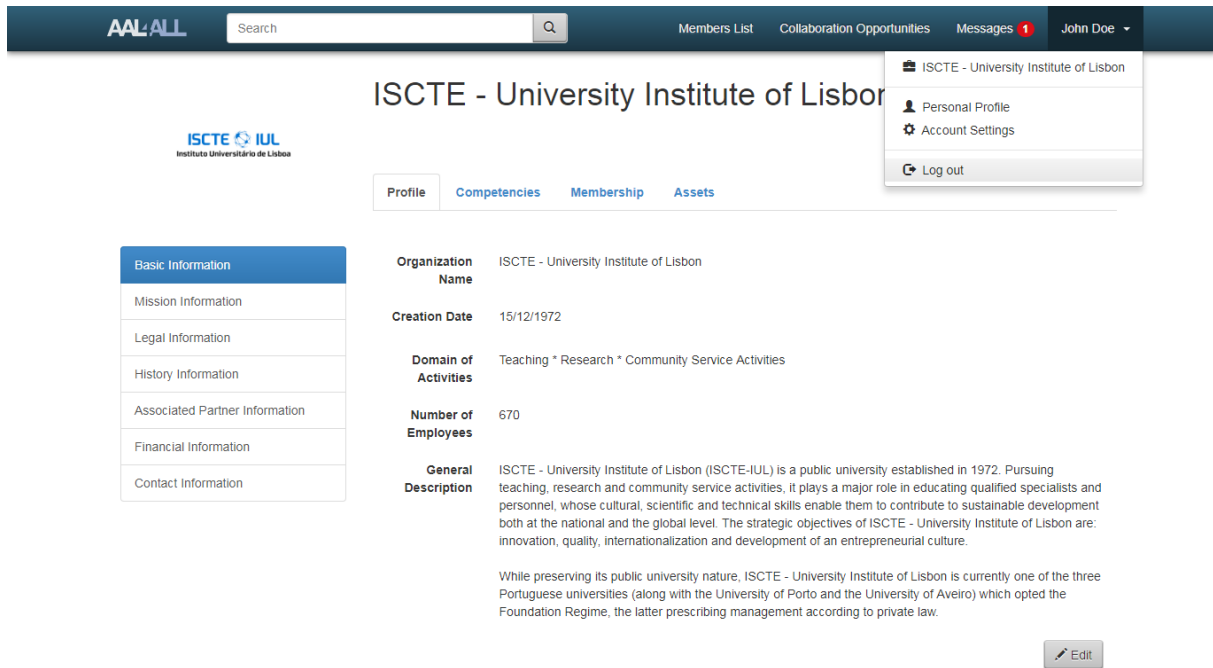
Figure 21 - Organization Page

Collaboration Opportunities

This page lists all collaboration opportunities added by registered organizations allowing an authenticated user to see each one in detail and, edit or remove it, if it is the creator of that collaboration opportunity (Figure 22).
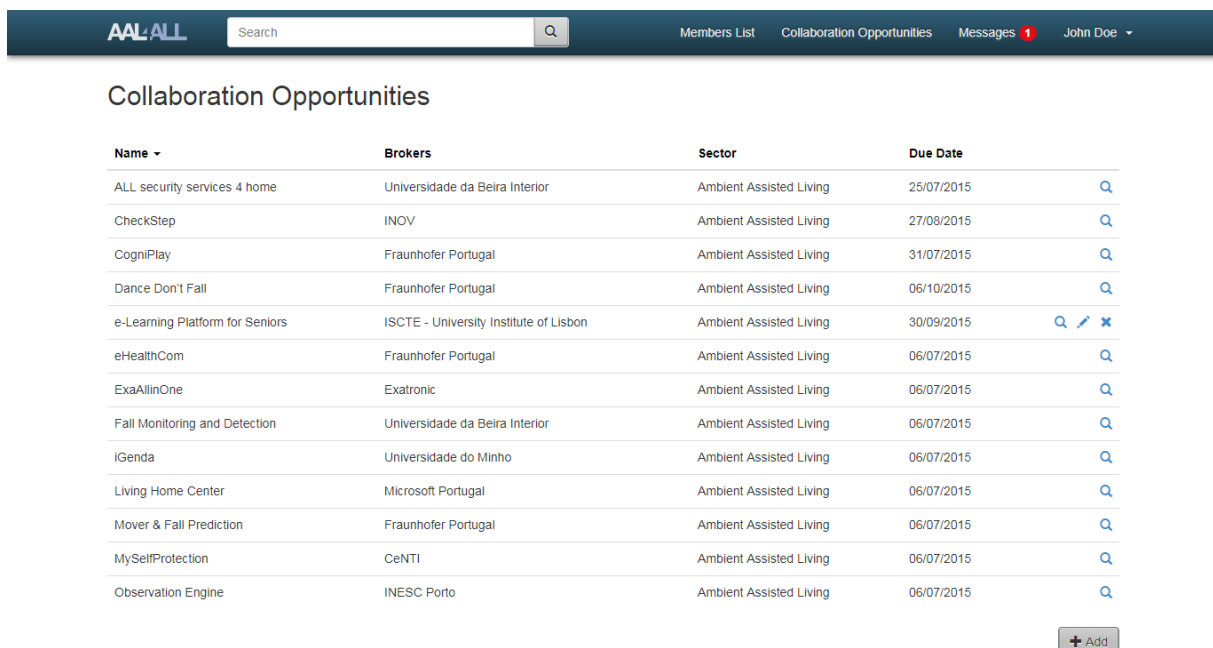
Figure 22 - Collaboration Opportunities

Organization Registration

As previously mentioned in the interaction diagrams section, the organization registration is a three-step process done by a registered user (normally an employee) on behalf of a VBE member applicant. The first step (Figure 23), comprises the filling of basic and contact information about the organization.

Figure 23 - Organization Registration: Organization Information

After completing the form, the registered user clicks on "Next" button to go to the next step of the registration process which consists in filling a form with the information about the employee that will represent the organization on the platform (Figure 24).

Figure 24 - Organization Registration: Employee Information

After completing the second step, the registered user clicks on "Next" button to go to the last step of the registration process, the organization's competencies form (Figure 25). After adding the competencies own by the organization, the registered user clicks on "Submit" button to finish successfully the registration process.

Figure 25 - Organization Registration: Organization's Competencies

Submission of a new collaboration opportunity

As stated in the interaction diagrams section, a VBE member, that identifies and wants to develop an emerging business opportunity but lacks some necessary competencies or resources, can find the right partners to participate and evolve that opportunity by creating and characterizing a new collaboration opportunity on the platform. Figure 26 presents the form to be filled by a VBE member in order to add a new collaboration opportunity.

Figure 26 - New Collaboration Opportunity Form

After completing the form, the registered user clicks on "Save" button to submit the new collaboration opportunity. Afterwards, the user can go to the newly created collaboration opportunity page and enrich it by decomposing it in small collaboration opportunity items. Figure 27 shows the collaboration opportunity item form to be filled.

Figure 27 - Collaboration Opportunity: Add New Collaboration Opportunity Item

4. Results Evaluation

The collaborative platform prototype presented in this dissertation was evaluated by the leaders of eight partners of the AAL4ALL consortium. The evaluation was carried out through a demonstration of the proof-of-concept prototype developed, followed by a questionnaire comprising seven closed-ended questions. The questions aimed to assess, through the opinion of the respondents, the utility of a platform like the one developed, in the daily life of organizations' collaboration activities.

As can be seen in Figure 28, the most of the respondents agree that a platform as the one introduced in this dissertation would benefit collaboration among organizations.
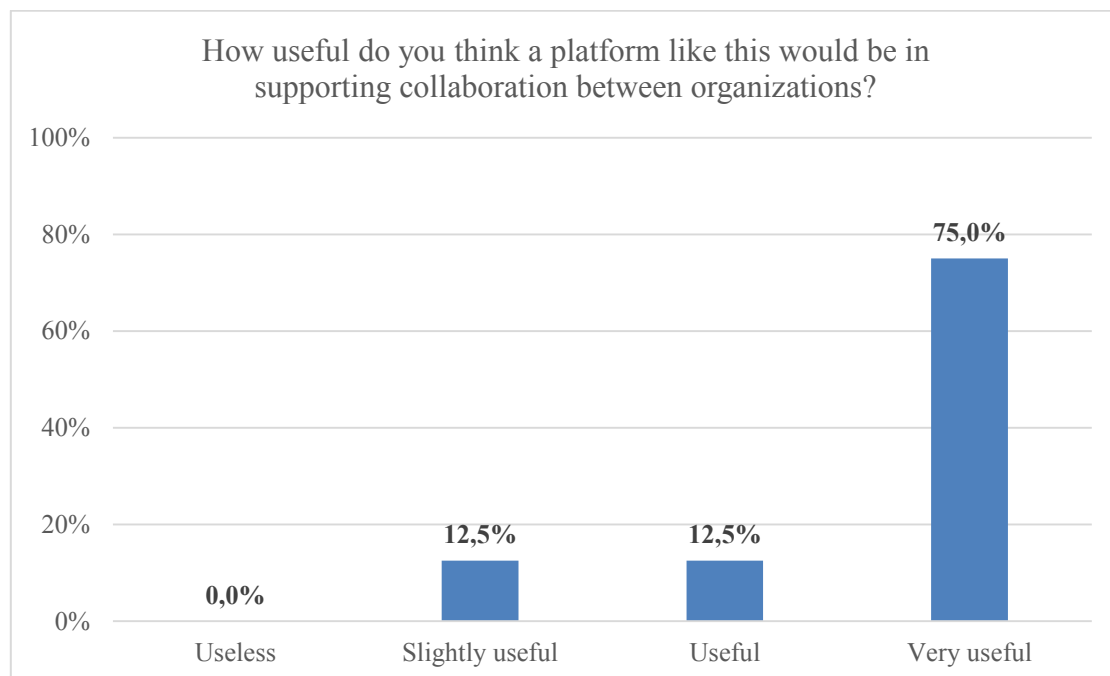
Figure 28 - How useful is a collaborative platform

The respondents were also asked about how they evaluate the importance of each one of the following features on a collaborative platform:

- F1 - Profile and Competencies Management
- F2 - Collaboration Opportunity Characterization
- F3 - Rough Planning
- F4 - Partner Search and Suggestion
- F5 - Agreement Negotiation

- F6 - Assessment

Figure 29 presents the answers' distribution.

How do you evaluate the importance of each one of the following features on a collaborative platform?
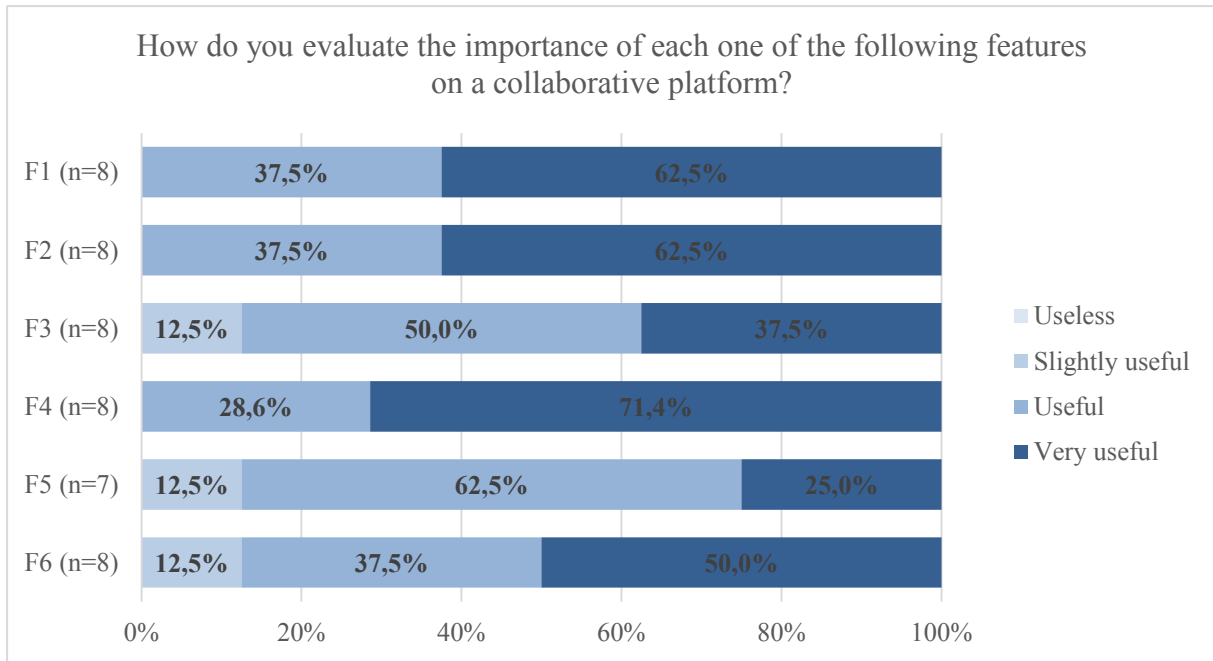
Figure 29 - Importance of each feature on a collaborative platform

By analyzing the answers and although all features were considered useful by the majority of the people polled, the Partner Search and Suggestion was the most important feature for the respondents followed by the Profile and Competencies Management and the Collaboration Opportunity Characterization. At the other end, the Agreement Negotiation was considered the least important feature in a collaborative platform.

5. Conclusions

During the AAL4ALL project, some functional requirements were identified for the AAL Ecosystem layer of the conceptual architecture. Aiming to respond to some of those requirements, the work conducted within this dissertation proposed to answer the research problem ("*What platform can boost collaboration among members of AAL4ALL towards the creation of new Ambient Assisted Living products and services?*") by doing a state-of-the-art research over collaboration's forms, models and tools, selecting the ones that best fitted the reality of the AAL4ALL consortium, and designing and developing a platform prototype taking into account those findings.

In the literature review (chapter 2), it became evident the importance that collaborative networks have, nowadays, in joining fully independent and geographically dispersed entities with different cultures, goals, social capital and ways of operating towards the achievement of common or compatible goals. It also became clear that, the form of collaboration that best fits the AAL4ALL project is the Virtual organization Breeding Environment (VBE) due to the heterogeneous nature of the AAL Ecosystem, the need for supporting as well as the VBE's ability to quickly establish alliances in order to respond to emerging business opportunities forming the so-called Dynamic Virtual Organizations (Dynamic VOs). Furthermore, the importance of tools/features to support the VO creation process was also highlighted.

The platform prototype was developed (chapter 3), starting with the modelling of the business processes identified by Camarinha-Matos et al. (2012) for the AAL Ecosystem layer using the Rational Unified Process and UML. For the requirements definition, the focus was given to some business processes for which the associated functionalities were modeled, followed by the development of a generic conceptual class diagram aiming to define the system structure at the level of classes, its features and relationships. Later on, for the analysis and design part, two processes were modelled using interaction diagrams as example. In the implementation, a component diagram was created representing the platform implementation architecture based on the MVC model, and the tools and technologies used to implement the prototype were presented.

Finally, the analysis of the questionnaire results (chapter 4), highlighted that a collaborative platform like the one presented in this work is considered useful and its adoption would be well accepted among the partners of the AAL4ALL consortium.

5.1.   Future work

Following the findings of this work, the first outlined suggestion is the implementation of some of the gathered requirements like the assets management subsystem and the virtual collaboration spaces subsystem. Another suggestion is the development of new requirements to enrich the platform features that support the VO creation process like the partner search and suggestion, and rough planning. Additionally, the development of new requirements regarding other business processes not covered in this work can be carried out like the Governance Policies Specification or the Providers-Users Linking Mechanisms.

The results of the questionnaire showed an interest of the partners in the platform. Thus, the last outlined suggestion is the delivery of the platform to be used by the AAL4ALL consortium after a stable release is ready.

References

Afsarmanesh, Hamideh, Camarinha-Matos, Luís M. and Ermilova, Ekaterina. VBE Reference Framework. *Methods and Tools for Collaborative Networked Organizations.* s.l. : Springer, 2008, pp. 35-68.

Ambient Assisted Living for All. *AAL4ALL Website.* [Online] June 2011. http://www.aal4all.org/.

Ambient Assisted Living Joint Programme. *Ambient Assisted Living Joint Programme.* [Online] May 2015. http://www.aal-europe.eu/about/objectives/.

Baldo, Fabiano, Rabelo, Ricardo J. and Vallejos, Rolando V. An ontology-based approach for selecting performance indicators for partners suggestion. *Establishing the Foundation of Collaborative Networks.* Guimarães : Springer, 2007, pp. 187–196.

Camarinha-Matos, Luís M. and Afsarmanesh, Hamideh. Collaborative networks: a new scientific discipline. *Journal of Intelligent Manufacturing.* 2005, Vol. 16, pp. 439-452.

Camarinha-Matos, Luís M. and Afsarmanesh, Hamideh. *Collaborative Networks: Reference Modeling.* s.l. : Springer, 2008.

Camarinha-Matos, Luís M., Afsarmanesh, Hamideh and Ollus, Martin. ECOLEAD: A Holistic Approach to Creation and Management of Dynamic Virtual Organizations. *Collaborative Networks and Their Breeding Environments.* Valencia : Springer, 2005a, pp. 3-16.

Camarinha-Matos, Luís M., Oliveira, Ana Inês, Demsar, Damjan, Sesana, Michele, Molina, Arturo, Baldo, Fabiano and Jarimo, Toni. VO Creation Assistance Services. *Methods and Tools for Collaborative Networked Organizations.* s.l. : Springer, 2008, pp. 155-190.

Camarinha-Matos, Luís M., Rosas, João, Oliveira, Ana Inês and Ferrada, Filipa. A Collaborative Service Ecosystem for Ambient Assisted Living. *Collaborative Networks in the Internet of Services.* Bournemouth : Springer, 2012, pp. 117-127.

Camarinha-Matos, Luís M., Silveri, Ivan, Afsarmanesh, Hamideh and Oliveira, Ana Inês. Towards a Framework for Creation of Dynamic Virtual Organizations. *Collaborative Networks and Their Breeding Environments.* Valencia : Springer, 2005b, pp. 69-80.

Concha, David, Romero, Tania, Romero, David, Galeano, Nathalie, Jimenez, Guillermo and Molina, Arturo. Analysis & Design of a Collaboration Opportunity Characterization Tool. *IFAC Proceedings Volumes.* Seoul : Elsevier, 2008, Vol. 41, 2, pp. 12891-12898.

Demsar, Damjan, Mozetic, Igor and Lavrac, Nada. Collaboration Opportunity Finder. *Establishing the Foundation of Collaborative Networks.* Guimarães : Springer, 2007, pp. 179-186.

Garcia, Nuno M. and Rodrigues, Joel Jose P.C. *Ambient Assisted Living.* s.l. : CRC Press, 2015.

United Nations. *World Population Ageing 2013.* Department of Economic and Social Affairs, Population Division. New York : United Nations, 2013.

United Nations. *World Population Prospects: The 2015 Revision, Key Findings and Advance Tables.* Department of Economic and Social Affairs, Population Division. New York : United Nations, 2015.