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PROACTIVE SERVICES ECOSYSTEM FRAMEWORK

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Abstract

Collaborative-Networks (CN) have experienced a fast evolution in the last two decades. The collaboration among independent entities or professionals supported by Information and Communication Technology (ICT) has attracted the research community to establish the conceptual basis for this scientific discipline. Service Orientation has been one of the key selected paradigms for that conceptual basis. Nevertheless, the service concept itself does not have a common understanding in the Business and ICT worlds. In the former, client satisfaction, resources management and business process models are some example concerns, whilst the later deals with interoperability, remote function calling or communication protocols.

If for example an enterprise provides some service, it may hire specialists to wrap such service into web-services, expecting to reach worldwide potential new clients. In fact, nowadays Web Services and Service Oriented Architectures (SOA) are the technological elements most commonly used. However, these are passive elements in the sense they do not perform any action towards pursuing business interests, which constitute a limiting factor from a business perspective. Another approach for the above mentioned enterprise is to follow the Multi-Agent Systems (MAS) approach, as the pro-activity is a keyword in such contexts. Nevertheless, as MAS approaches are not so commonly used and not so robust yet, the worldwide potential set of new clients is reduced; which also constitutes an inhibitor factor from the business perspective.

This dissertation proposes a Pro-Active Services Ecosystem Framework, gathering inspiration from both the SOA and MAS research areas, trying to bridge the business and ICT worlds through the base concepts for the creation of a Services' Ecosystem where business services are represented in a pro-active manner towards pursuing business interests, like finding collaboration opportunities or improving the chances each CN member has to see its services selected among competitors, for example. This work also includes a prototype system applied / validated in the area of a Professional Virtual Community of Senior Professionals.

Keywords:

Collaborative-Networks, Services-Ecosystem, Pro-Active Service Entity

Resumo

As Redes Colaborativas (RC) têm evoluído bastante nas últimas duas décadas. A colaboração entre entidades independentes ou profissionais, suportada pela utilização de Tecnologias de Informação e Comunicação (TIC) tem atraído a comunidade científica para estabelecer a base conceptual desta disciplina científica. Uma abordagem orientada pelos serviços tem sido escolhida como um dos paradigmas chave para esta base conceptual. No entanto, o próprio conceito de serviço não colhe um entendimento comum nos mundos de negócios e das TICs. No primeiro, satisfação dos clientes, gestão de recursos ou modelação de processos de negócio são alguns exemplos de preocupações, enquanto no segundo o foco está em questões de interoperabilidade, invocação remota de funções ou protocolos de comunicação.

Se, por exemplo, uma empresa fornece um determinado serviço, pode contratar especialistas para criar um invólucro para tal serviço utilizando Serviços-Web, esperando atingir potenciais clientes num mercado global. De facto, actualmente, os Serviços-Web e as Arquitecturas Orientadas pelos Serviços são os elementos tecnológicos mais utilizados. No entanto, um dos maiores problemas destes elementos é a sua passividade, no sentido de não executarem nenhumas tarefas perseguindo objectivos de negócio, facto que constitui um factor limitador da sua utilização numa perspectiva de negócio. Outra possível abordagem para a referida empresa é a escolha de uma abordagem de Sistemas Multi-Agente (SMA), uma vez que a pro-actividade é uma palavra chave nestes contextos. No entanto, uma vez que os SMA não são tão utilizados e ainda apresentam problemas de robustez, o conjunto de potenciais clientes a nível global é reduzido, facto que constitui igualmente um factor inibitivo numa perspectiva de negócio.

Esta dissertação propõe uma *Pro-Active Services Ecosystem Framework*, inspirada nas áreas AOS e SMA, tentando estabelecer uma ponte entre os mundos de negócio e das TIC, através dos conceitos base para a criação de um Ecosistema de Serviços onde serviços de negócio são representados de uma forma pro-activa, com o objectivo de perseguir interesses de negócio, como procurar oportunidades de colaboração ou aumentar as hipóteses dos serviços representados serem escolhidos, por exempo. Este trabalho inclui ainda um sistema protótipo aplicado / validado numa Comunidade Profissional Virtual de Séniores.

Palavras-chave

Redes-Colaborativas, Ecosistema de Serviços, Entidade de Serviços Pro-activa

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Acronyms

AAL – Ambient Assisted Living

BPEL – Business Process Execution Language

CIM – Computer Integrated Manufacturing

CN – Collaborative Network

CO – Collaboration Opportunity

CO_Board – Collaborative Opportunity Blackboard

FIPA – Foundation for Intelligent Physical Agents

JADE – Java Agent Development Environment

LAN – Local Area Network

MAS – Multi Agent System

PVC – Professional Virtual Community

RE – Requirements engineering

RMI – Remote Method Invocation

RPC – Remote Procedure Call

SOA – Service Oriented Architecture

SOAP – Simple Object Access Protocol

SotA – State of the Art

SP – Senior Professional

UDDI – Universal Description, Discovery and Integration

VBE – Virtual Breeding Environment

VE – Virtual Enterprise

VO – Virtual Organization

VT – Virtual Team

WAN – Wide Area Network

WS-BPEL – Web Service BPEL, former BPEL4WS

WSDL – Web Service Description Language

XML – eXtensible Markup Language

XPDL – XML Process Definition Language

> You don’t have to
> be great to start,
> but you have to
> start to be great.
> (Zig Ziglar)

1. Introduction

This chapter points out the main problems addressed in this dissertation. At a glance, the static mechanisms that current information and communication technology approaches use for modelling the services CN members provide do not actively represent such services. Rather, they focus on interoperability issues that although constituting key technical aspects, do not cope with CN members expectations of an active service representation towards business interests. The chapter starts detailing these problems as the base for the identified Research Questions and posts the hypothesis of such active representation of CN members’ services. The followed research method is shortly described, as well as the Active Ageing application area. The chapter ends with a description of this dissertation structure.

1.1. Motivation Towards the Research Question

The usefulness of the Internet for enterprises or professionals, namely in terms of the revenue that can be extracted from it, depends, to some extent, on the active usage these actors make from such resource. If for example a given enterprise creates a web-page to show and sell some kind of products or services, the medium/long-term objective naturally is an increment of the sales of such products or services. Nevertheless, this webpage, at least in a classical form, is a passive element. In fact, the web-page does not perform any pro-active action in order to attract more visitors. In other words, the initiative remains on the client side (or on the search engines). If the client does not visit the web-page, nothing happens. Furthermore, for the client to reach this web-page he or she must also have the initiative of using some search engine and, if that page belongs to the result of some search criteria, hopefully he or she will click the link and finally reach the mentioned web-page. Although some actions can be performed by the enterprise, the web-page element itself does not perform any dynamic action to improve the chances of belonging to the results of such search criteria or being selected to be clicked among the result links. To some extent, this can be considered as a gap between the business perspective or expectations and the traditional approaches offered by the Information and Communication Technology (ICT) counterpart because the mentioned technological elements do not perform an active representation of the business interests.

The same gap exists in the services area. The understanding of the service concept itself is quite distinct in the two worlds as highlighted in (Chesbrough and Spohrer, 2006; Horn, 2005; Maglio and Spohrer, 2008). From the business side, some of the main concerns are related to meetings with clients, the client satisfaction, resources management, marketing strategies or business process modelling. From the Information and Communication Technology side, although the developments around the service concept have gained the attention of the research community, the focus has been put elsewhere. Interoperability issues, remote procedure calling, information exchange formats and standard interaction protocols are some example elements that gained the ICT research community attention. The inexistence of a common focus or intersection between these two perspectives is what constitutes the mentioned gap between the views of services in these two worlds, namely ICT & Business.

If, for example, a company is willing to provide some services through the Internet, probably it will hire some specialists that can wrap such services into web-services. The objective of that company is to achieve a worldwide potential set of new clients that somehow can call such web-services. However, these technological elements are passive entities in the sense they do not perform any action to attract or find new clients. In other words, they stay still waiting for a client initiative: finding and calling the web-service. Furthermore, these computational elements are designed with a focus on a remote procedure calling and thus especially addressing interoperability constraints, rather than other aspects that a business perspective needs to tackle, like the client satisfaction, resources management, among others, as mentioned.

On the other hand, companies and professionals tend to specialise themselves in order to get a privileged position in the market. This trend was introduced by the globalization, where the obstacles based on the geographical location, or distance, have been strongly reduced. As a result, companies and professionals started to compete at a global “unknown” level, instead of the traditional “well-known” local market. Based on these aspects, a new trend has emerged, in the last two decades, taking advantage of computer networks for the establishment of partnerships. As a result, the Collaborative Networks (CN) scientific field has risen, as mentioned in (Afsarmanesh et al., 2004; Camarinha-Matos, 2007; Camarinha-Matos and Afsarmanesh, 2005; Camarinha-Matos and Afsarmanesh, 1999; Katzy et al., 2004). In fact, establishing partnerships among independent entities in order to gather distinct competences and share risks is not a new practice. But the usage of ICT tools and mechanisms is the factor that facilitates the emergence and operation of CNs, and thus supports this scientific discipline. Complementarily, ICT brings new support to other perspectives such as the management of contracts between the CN members, for example.

When a CN member finds a business opportunity that requires more skills or competences than the ones it is able to provide, this becomes a collaboration opportunity and it will try to find such skills in the network it belongs to. Resorting to the collaborative network infrastructure, the process may be straightforward; assuming the data available in such infrastructure is up-to-date in what concerns the availability of CN members. As a result, a workflow model may be defined and a set of potential partners, or CN members, may be selected in order to perform the needed services. From the perspective of those CN members that have not been selected, the technological elements that represent their competences or skills have also frustrated their expectations because they did not perform any action towards being selected for that collaboration opportunity. As a desirable scenario, the CN infrastructure could be conceived as a business Services Ecosystem, in which the members of the network would be modelled by computational entities that could actively represent them, maybe inspired by an “ambassador-like” role. As a result, collaboration opportunities could be addressed through the usage of proper ICT tools and mechanisms, which would more adequately satisfy the business interests and availability of each CN member, according to some configuration made by that member.

One additional problem of current technological approaches is the fact that they consider services as independent elements, even though they may be provided by the same entity. In other words, if one entity provides service X and service Y and if these two types of services are needed in some specific collaboration opportunity, two queries are traditionally made to a service repository, trying to find out potential providers for each service. The possibility of getting integrated proposals is not considered and, as a result, having the same provider selected to provide two distinct services within the same collaboration opportunity remains a coincidence.

This research work addresses the above mentioned problems in the collaborative networks context, as summarized in Table 1-1.

Table 1-1 - Problems addressed in this research work

Limitations of current ICT mechanisms	Business Interests
Passive representation of services tackling: • Remote Procedure Call • Information Format • Interoperability • Interaction protocols	Active representation of services tackling: • Resources management • Business Process Modelling • Client's Satisfaction • Quality of Service • Marketing initiatives
Service-related computational elements stay still waiting for a client's initiative, both to find and call the service afterwards.	Service representatives should not stay still waiting for a client's initiative and rather behave towards finding new clients or improving service selection chances, for example.
Service Catalogues may become outdated when some providers become unavailable, even if for a short period.	Retrieving potential partners' outdated info leads to a less efficient response to a collaboration opportunity. It is thus important to identify potential partners that are actually available.
Discovery and selection of service provider mechanisms consider services as independent entities, even though two or more services may be provided by the same entity.	The reduction of the number of partners to be involved in a Collaboration Opportunity is likely to reduce costs. In order to do so, there should exist mechanisms optimizing consortia with fewer partners, as some may provide more than one service.

In a metaphorical way, this dissertation intends to contribute to the creation of a bridge between the business world and the ICT world, in a context where collaboration opportunities are addressed through the composition of the services that several CN members provide, so they may address a wider range of business opportunities, sharing skills and risks.

Therefore, the main research question may be stated as:

Research Question 1

Is it possible to create a collaborative services ecosystem in which the members of a collaborative network are modelled by computational elements that actively represent their business interests, inspired by an "ambassador-like" role?

Additionally, based on the client perspective and the growing demand for quality of service within the context of partnerships introduced by the Collaborative Networks, and the assumption of an active representation of services made by some computational elements, two other research questions are identified:

Research Question 2

What could be an adequate Quality of Service (QoS) assessment mechanism that benefits from an active representation of the services from CN members, towards providing accurate and up-to-date data for clients to choose between competitor proposals?

Research Question 3

What could be a suitable mechanism that would rely part of the service composition processes on the computational elements that actively represent CN members' services?

Obtaining effective answers to these research questions will lead to the possibility of creating a computational environment where service representation is made in a non-static manner, behaving towards business success. In order to clarify the main aspects included in these three research questions, as well as the objectives of this research work, Table 1-2 highlights the key words or elements of each one and includes a brief clarification note.

Table 1-2 - Clarifying the research questions' key elements

R.Q.	Element	Brief Clarification Note
1	create a collaborative services ecosystem	… an environment, based on the service concept where the CN members get support for collaboration purposes, rather than a simple market …
	active representation of the services	… an environment where the computational elements that represent the services provided by CN members, may behave like ambassadors that actively represent the interests of whom they are representing …
	represent their business interests	… business success is considered as the major goal, thus the creation of computational elements oriented towards this direction is strongly desired …
2	new Quality of Service assessment mechanism	… based on the above mentioned active representation of services and the actual QoS demands from clients, a new QoS mechanism needs to be built …
	providing accurate and up-to-date data	… avoiding outdated information that service catalogues may have, namely concerning the availability of service providers …
3	… relying part of service composition processes on the computational elements that represent such services …	… if computational elements represent services in an auto-initiative basis, acting as ambassadors of CN members, than it would be reasonable to give them some extra tasks, like helping the service composition processes, even if only a partial contribution results from that.

1.2. Hypothesis

Based on the identified research questions and the clarification made, the main hypothesis adopted in this research work, including some elements from the proposed solution, is stated as:

Hypothesis 1

If the representation of services offered by Collaborative Network members is made using elements of Pro-Activeness, these enterprises, professionals or organizations can benefit in terms of the chances they have to see their abilities selected and a better fitness between them and the clients can be achieved. This representation can then be built upon an aggregation construct (including distinct services an entity can provide) and embedding behaviours towards finding new Business Opportunities and promoting the represented Services, all in an auto-initiative basis.

This hypothesis highlights two key elements addressed in this dissertation: Pro-Activeness and Aggregation of distinct services from an entity.

Based on the research questions 2 and 3, two other hypotheses are also suggested:

Hypothesis 2

If a new Quality of Service Mechanism is created, based on distinct QoS characteristics, that can benefit from an active service representation, forming QoS Criteria it might be possible to feed up a collaborative Services Ecosystem with QoS data that may help finding the best match whenever a choice has to be made between two competing service provision proposals.

Hypothesis 3

If a service modelling framework based on active computational elements is created, it will be possible to delegate part of the responsibilities of service composition processes on such elements.

As mentioned before, clients demand more quality of service. In order to comply with this demand, hypothesis 2 can be extended asking clients to participate in the QoS Mechanism, using QoS Criteria to express their satisfaction concerning service provisions. This evaluation would also feed up the QoS data stored in the Services Ecosystem. In fact, nowadays whenever someone buys services or products, it is typical that he or she would appreciate to know the satisfaction of previous clients. Storing this QoS knowledge from clients will naturally improve the existing QoS assessment mechanisms.

Concerning hypothesis 3, the inclusion of active representatives of the services offered by CN members can help the service composition processes, delegating parts of these processes on them, such as finding business opportunities or bidding on existing collaboration opportunities according to a pre-defined level of autonomy. In an extreme scenario, or for some application domains, computational elements may evolve towards handling all the preparation of a collaborative work, while the human role is reserved for configuration and monitoring aspects.

Finally, if the active representation of services is inspired on some form of “diplomatic” representation (services represented by some kind of “ambassadors” in the services ecosystem) other functionalities may also arise from that fact. For example, if a service representative somehow finds out that one service it represents could be added to a business process model being built, with a clear benefit to the final client, it may take the initiative of suggesting the inclusion of this other service in such business process.

1.2.1. An Application Case – Senior Professionals PVC

The above mentioned problems can be identified in several industrial and services sectors, involving enterprises, other not for profit organizations or free-lancer professionals. One area that particularly illustrates these problems is the area of supporting the extension of the professional life of Senior Professionals (SP). In this context, senior persons have the asset of a life-long experience and, in many cases, the willingness to continue giving their contribution to the society. In fact, many senior professionals, either by economic reasons or simply by a desire to continue involved in the socio-economic system, want to remain active, even after retirement. Nevertheless, they do not benefit from an adequate environment that could foster their contribution.

The organization of these persons around Professional Virtual Communities, providing them the needed computational means to continue their active professional life after retirement follows a global concern. In fact, as science evolves in several areas, like health-care, longer life expectations also evolve. As a result, the existing retirement model is clearly becoming obsolete and a trend for after retirement work is happening in many countries in the world, as mentioned in (Cheng et al., 2007; Collom, 2008). The demographic trends towards an ageing society are also putting unbearable pressure on the pension systems, which calls for a new look on the life course.

Within this context, an example activity that already happens supported by senior professionals associations is the consultancy and mentoring activity. In fact, the talents attained in such life-long experience are an asset that older people like to share, namely in the entrepreneurship field.

In a foreseen scenario the Senior Professionals (SP), members of a PVC, would have access to computational entities that actively represent the consultancy services they are willing to provide to entrepreneurs. In such scenario a third actor, other than the SPs and the entrepreneurs, would also exist - an Intermediary or Broker. This actor would be responsible to establish the bridge between the other two actor kinds. In a first stage, an entrepreneur could ask for help interacting with such Intermediary, when he or she is building a new business. Then, the Intermediary would be responsible to create a workflow model, identifying and including the services that the entrepreneur would need. Next, the Intermediary would launch a Call for Proposals within the above mentioned Services Ecosystem. Afterwards, in a second stage, the representatives of each SP services, that would always be checking for new collaboration opportunities, could try to match the expertise of the SP they represent and the service needs included in open Calls for Proposals. In a success case, the SP service representatives would create and post a bid for the SP to be the one providing such services. At the end, the Intermediary, along with the client, would select the bids that best fit their needs. Figure 1-1 shows the main stages of this process in a diagram.

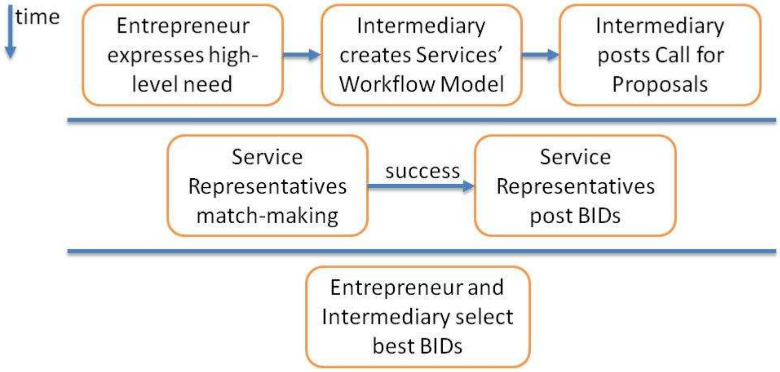


Figure 1-1 - Foreseen scenario simplified process diagram

It is important to notice that the computational resources representing the services offered by each SP would be a supporting tool that the SP would configure in a first place and that would actively represent his or her interests, namely:

1 – finding collaboration opportunities where the corresponding services could participate;

2 – improving the chances for the services to be selected among competitors;

3 – after the collaboration agreements have been reached, notifying the SP when he or she should start the service provision and receiving “task done” notification from such SP.

This application scenario will be used along this dissertation, as a way to help identify requirements and as part of the validation process.

This application case has been established based on the experience of three senior professionals’ consultancy associations: APCS (“*Associação Portuguesa de Consultores Séniores*”), Share (“*Associação para a Partilha do Conhecimento*” - http://www.share.pt) and SECOT (“*Seniors Españoles para la Cooperación Técnica*” - http://www.secot.org). A close contact has been established with these associations, resulting in valuable inputs for this work, particularly the case of SECOT that participated as a partner in the European funded research project ePAL (extending Professional Active Life).

1.3. Research Method

In methodological terms, this research work followed the traditional research method, as represented in Figure 1-2. This figure is, however, a simplified representation as various iteration cycles are needed among some of these steps.

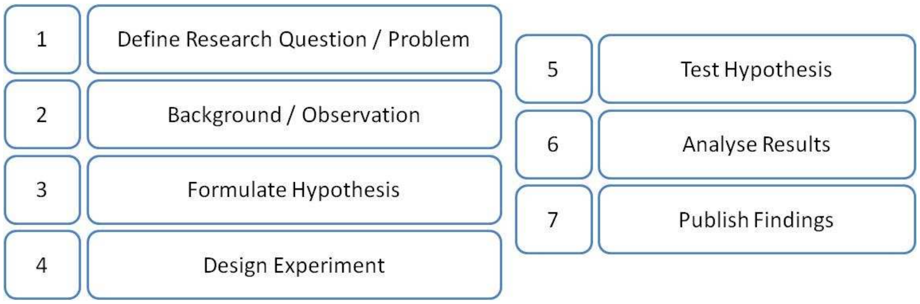


Figure 1-2 – Traditional Research Method steps

Definition of the research question / Problem

The definition of the research question is one of the most important steps in research. Typically addressing a topic where things are done in a way that the researcher somehow thinks he or she may do it in a better way. Beyond the main research question, other related research questions may also be added. In the case of this research work, both the research topic selection and the identification of the main research question evolved through a long iterative process. At a later stage, two extra research questions were also identified, as mentioned before.

Background / Observation

After the focus problem has been established, and the research question(s) identified, the next task is to study the state of the art in the research area, as well as other related research areas. This step of the research method can result in a rewinding of the process back to the main question definition or simply result in minor improvements.

The result of this process in this particular research work led to a shift in the positioning of the original research topic. In the beginning, the focus was placed in Service Oriented Architectures (SOA), but after this study of the state of the art, and an analysis of the research work performed by the multi-agent systems (MAS) research community, our own research work was better located somewhere in the borderline between the two worlds: SOA and MAS.

As mentioned before, what distinguishes this work from other service oriented approaches is the introduction of an active representation of the services that CN members are willing to provide. This active representation will benefit CN members in pursuing their interests while participating in collaboration opportunities.

Hypothesis Formulation

The third step of this process is the elaboration of an approach to address the above mentioned problems, foreseeing a solution and formulating a hypothesis. In the case of this research work, although the main hypothesis has also experienced an evolution, the initial idea was that somehow an active behaviour element should be added to the computational service constructs. The business perspective was also present from an early stage, as a major “driving force”. The hypotheses concerning a new quality of service mechanism and the business process modelling, partially relying on the active computational representatives of services, came in a later stage, as well as the corresponding research questions.

Design Experiment

“Design an experiment” is an expression that suggests some chemistry with some smoke around and explosions, from time to time. Nevertheless, this step of the research method is crucial in order to clearly plan how the hypothesis will be tested. In the information and communication technology area, the typical tasks in this step are the design of prototype systems and identifying application scenarios. The concepts and models created herein are the ones that will be tested and hopefully extended in future work. The case of this research work was not an exception and this step involved the design of a logical architecture for the *proof of concept* prototype systems.

Test Hypothesis & Analyse Results

Testing the hypotheses that were formulated and processing the results is one of the last research steps. Typically, a systematic approach is selected towards conducting this step. Nevertheless, there are cases where real tests cannot be made and mechanisms like simulation have to be adopted. The task of analysing results tries to interpret the data resulting from such experimentation or simulation. This may be quantitative or qualitative data. The interpretation should be made “against” the literature mentioned in the state of the art. In other words, tackling the elements from the research question(s) and hypothesis (es) is mandatory.

In the case of information and communication technology, and in the case of this research work, this was the time for the prototype development and validation in the selected scenario. In this particular case, the Pro-Active Services Ecosystem Framework was developed, applied and assessed in a scenario of a consultancy PVC of Senior Professionals, as mentioned before.

Publish Findings

Finally, a synthesis process is conducted towards the publication of the major findings. These publications are crucial in order to gather peer validation and feedback. This feedback should then be used in order to improve and consolidate the findings.

In the case of this research work, although the ultimate goal was the preparation of the dissertation, the publication of intermediate results was of particular importance because of these two factors. The intermediate presentation of results in international conferences also brought a motivation factor that introduced extra-energy in the research work.

1.4. Research Context: Participation in Research Projects

This research work benefited, to a large extent, from the knowledge and experience acquired through the participation on a number of European-funded research projects, both before and during the PhD research period: Before the PhD started (Prodnet II – Production Planning and Management in an Extended Enterprise; Fetish-ETF – Federated European Tourism Harmonization – Engineering Task Force); During PhD work (Ecolead – European Collaborative networked Organisations LEADership initiative; ePAL – extending Professionals Active Life; BRAID - Bridging Research in Ageing and ICT Development), which are illustrated in Figure 1-3.

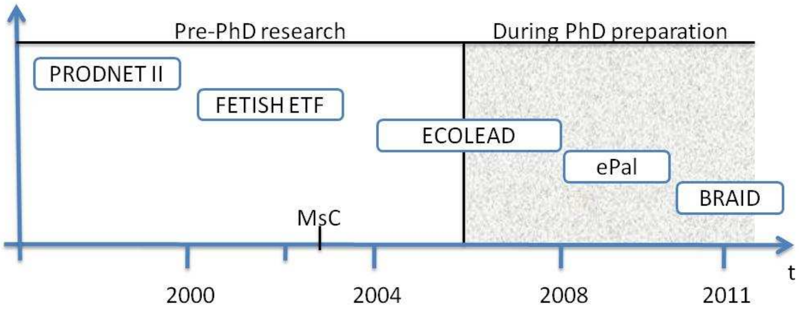


Figure 1-3 - Inspiring / Contributing Research Projects

As a member of the CoDIS (Collaborative Networks and Distributed Industrial Systems) group of Uninova, the interaction with various other related projects carried out by the group greatly helped the author in the understanding of the state of the art and acquisition of background information. In order to establish the relevance of these projects to this research work, a short description of each follows:

PRODNET-II – 1996 – 1999 (4th FWP - ESPRIT - 22647)

Production planning and management in an extended enterprise

The PRODNET-II project was a pioneer project in the Virtual Enterprises research area. The aim of the project was to design and develop an open platform and the adequate IT protocols and mechanisms to support Virtual Industrial Enterprises. PRODNET-II was focused mainly on Small and Medium size Enterprises (SMEs), in order to support them with means to inter-operate with several value-chain networks. The architecture of the developed infrastructure employed the standards and technologies in communication, cooperative information management, and distributed decision making that were emerging on that time.

The participation in the PRODNET II project was a first contact with the research activity and has constituted a base contribution for this research work, namely in what concerns the initial understanding of the ICT infrastructures to support collaborative work among distinct independent entities, through workflow enactment.

Fetish-ETF – 2000 – 2003 (5th FWP - IST-1999-13015)

Federated European Tourism Information System Harmonization – Engineering Task Force

The general goal of FETISH-ETF was to integrate the fragmented tourism information systems and their IT-based services into a federation of distributed resources that are presented through a single infrastructure to end users and other service provider enterprises.

In FETISH-ETF, the Virtual Enterprise paradigm was applied in order to promote and reinforce the proper cooperation among service provider enterprises that can work together in order to offer new high-level value-added services, which are in turn defined as a composition of other basic services and / or other existing value-added services.

The participation in the FETISH-ETF project was of particular importance in a preparatory phase for this research work, namely in what concerns the understanding of service orientation and service composition, as well as the involved barriers.

ECOLEAD – 2004-2008 (6th FWP – IP - 506958)

European Collaborative networked Organisations LEADership initiative

ECOLEAD was an Integrated Project aiming to create strong foundations and mechanisms needed to foster a collaborative and network-based industry society in Europe. The project was built with 3 vertical focus areas: VO Breeding Environments, Dynamic Virtual Organizations and Professional Virtual Communities. Additionally, two horizontal major research areas were also addressed in the project: the theoretical foundation for collaborative networks and the horizontal ICT infrastructure.

The technological infrastructure developed in ECOLEAD, ICT-I, was of particular interest as a inspiration contribution for this research work. Furthermore, the developments on partners search and consortia formation helped in the understanding of the process of responding to business opportunities.

The interaction with the large number of groups in the project was crucial for a better understanding of the theoretical foundations and practical challenges in different classes of collaborative networks.

ePAL – 2008 – 2010 (7th FWP - CSA-215289)

extending Professionals Active Life

ePAL was a roadmap project aiming to identify innovative ways that best facilitate the development of active life process. The ePAL vision is that of an effective transformation of the current situation regarding retirement and the barriers to active ageing in Europe. The EU has estimated that over the period 1995 to 2015, the 50-64 age range is increasing by approximately 25%. If this issue is not fully addressed in the near future there will be serious economical and social repercussions in Europe. The project defined structural solutions towards involving senior professionals in the socio-economic system. Furthermore, it identified a set of recommended actions to overcome the foreseen situation, both covering societal, organizational and technological perspectives.

The participation in this project was of particular interest, in order to get insight understanding of the needs of Senior Professionals, as well as the potential of supporting a contribution for their active life after retirement.

BRAID – 2010 – 2012 (7th FWP - CSA-215289)

Bridging Research in Ageing and ICT Development

BRAID is a special roadmap project in the sense that it is building a Research and Technological Development (RTD) agenda by consolidating previous roadmap initiatives. The project is also launching consolidation and consultation mechanisms towards identifying and characterizing the main challenges for producing a vision for the support of socio-economic integration and well-being of the increasing number of senior citizens in the European landscape.

The participation in this project is of particular importance, especially at the challenges identification perspective, namely in what concerns all the constraints that seniors face in the later stages of their life.

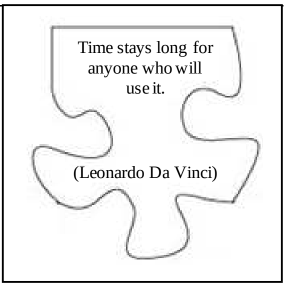
1.5. Structure of the Dissertation

The remaining of this dissertation is structured as follows:

- Chapter 2 – Background and Literature Review – this chapter covers the state of the art in the scientific fields related to this research work. It first identifies the most relevant contributing research areas and then addresses the main achievements and challenges each one faces. The chapter ends highlighting other related research initiatives.
- Chapter 3 – Pro-Active Services Ecosystem Framework – this chapter presents the conceptual framework created to model services offered by Collaborative Network members within a collaborative Services Ecosystem, introducing pro-activeness in such modelling elements. The auto-initiative characteristic of these modelling constructs has the aim of representing CN member's services in an ambassador like manner, towards pursuing the business success through the introduction of behaviours that can, for example, find new business opportunities or increase selection chances among competitors. A collaborative Services Ecosystem is also introduced as a space that induces and supports a smooth collaborative environment, enhanced by a quality of service mechanism that will be introduced in this Chapter, as well.
- Chapter 4 – Logical Architecture – This chapter addresses the logical architecture created to support a *proof of concept* prototype system. The chapter starts with the description of the software lifecycle phases, followed by the Requirements Engineering phase and ending with the system specification documentation that form this Logical Architecture. The tools used in this process are the i-star framework and UML. The former is used for the requirements engineering phase. The later is used, through Use Case diagrams and Class Diagrams, in a first stage to define the skeleton of the ICT systems to be developed. Sequence and State Transition Diagrams are also used to model how the systems developed based on this architecture should behave.
- Chapter 5 – Experimental Development and Validation – this chapter presents the validation of this research work, which is made through 5 validation elements: 1 - the description of the developed prototype system; 2 and 3 - two benchmarking exercises made in order to compare both the approach and the solution to other existing initiatives;

4 and 5 - peer validation based on publications and gathering specialists opinion through a presentation followed by a survey.

- Chapter 6 – Conclusions and Future Work – this chapter summarizes the achievements of this dissertation. A list of the aspects or elements contributing to a progress beyond the state of the art is highlighted. The discussion of future work dimensions and doors opened by this active representation conclude the dissertation.



Time stays long for anyone who will use it.

(Leonardo Da Vinci)

2. Background and Literature Review

The aim of this chapter is to synthesize current research related to the baseline of the proposed Pro-Active Services Ecosystem Framework. This synthesis starts with the identification of the most relevant contributing research areas and organizes them into three groups: the application area, a conceptual group and a technological group. It then proceeds detailing the state of the art of these contributions in Sections 2.2, 2.3 and 2.4, respectively. Afterwards, Section 2.5 highlights key research initiatives related to the addressed problems and the concluding section discusses the chapter contents.

2.1. Inspiration Lines

As mentioned in the Introduction Chapter, the Pro-Active Services Ecosystem Framework (PASEF) is conceived on top of a conceptual and a technological baseline, and is motivated by the requirements of the selected Application Scenario domain. The first one is represented by two pillars: Collaborative Networked Business Ecosystems and Services Science. The second one includes two major contributors: Service Oriented Architectures and Multi-Agent Systems. The selected Application Scenario domain focuses on ICT and Ageing. This Chapter visits these contributing areas, highlighting background concepts, identifying the state of the art and existing bottlenecks.

The selected application scenario focusing on Active Ageing, as represented by the ICT and Ageing research area, has already an active research community. In fact, a considerable amount of work has been done in this area, motivated by the increased expectation of a longer and healthy life, the increasing demographic unbalance leading to an ageing society in the developed countries, as well as the need for keeping sustainable economies under such demographic trends. Section 2.2 details the challenging elements of this area and clarifies the focus of this dissertation, within that group.

Regarding the conceptual baseline, Collaborative Networks is major pillar of this work, providing mechanisms and tools for a better understanding and support of collaboration between independent entities. Still at the conceptual contribution's level, the inspiration on the services paradigm links to the so called Services Science. Although still in an early stage, this research area has been maturing towards establishing a bridge between the business and the ICT service worlds. Section 2.3 describes the state of the art related to these conceptual contributions.

The existing technological approaches and the corresponding underlying concepts that also inspire PASEF are the Service Oriented Architectures (SOA) and the Multi-Agent Systems (MAS), along with another small contribution from blackboard architectures. The SOA contribution is of special importance as the base for the Services Ecosystem that PASEF embodies. The MAS contribution provides the basis for the notion of pro-activeness. In particular, as the PASEF approach provides a representation of the CN members through some form of "ambassador", a similarity can be found between concepts defined in PASEF and the MAS concepts. Section 2.4 describes these technological inputs.

Figure 2-1 illustrates the underlying conceptual baseline, the technological inspiration approaches, as well as the Application Scenario domain on top and PASEF in the middle. This figure partially corresponds to the outline of this chapter that ends with the identification of some key research initiatives based on MAS and / or SOA approaches applied to the CN field, as explained in Section 2.5.

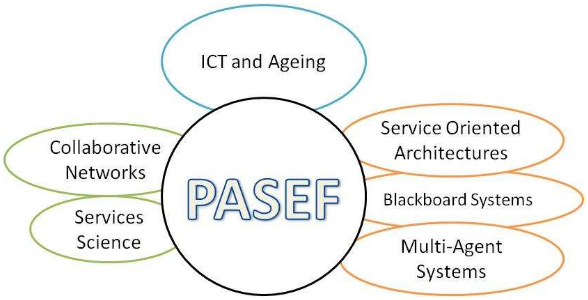
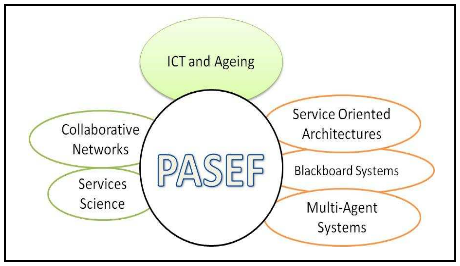


Figure 2-1 – PASEF and the contributing dimensions

2.2. ICT and Ageing



Collaboration among Senior Professionals (SPs) is the chosen target motivating scenario of PASEF, as mentioned before. In fact, the development of solutions for Senior Professionals who want to keep their active life after retirement is a trend that has been pulling the research community of ICT and Ageing in the last years. One of the major factors inducing this need is the extension of a longer and healthy life expectation. One particular demonstration of this evolution can be extracted from the comparison of the actual age pyramid and the foreseen demographic distribution in the year of 2050, as illustrated in Figure 2-2 and Figure 2-3, which addresses the Portuguese case, taken as a mere example that replicates quite similarly to other developed countries or regions. These figures show that by 2050 there will be a much larger number of people older than 50, than the numbers of the same age frame in 2009.

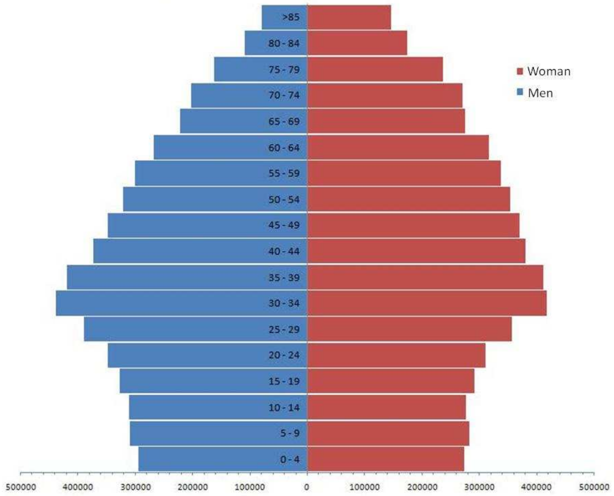


Figure 2-2 - Portuguese age pyramid 2009

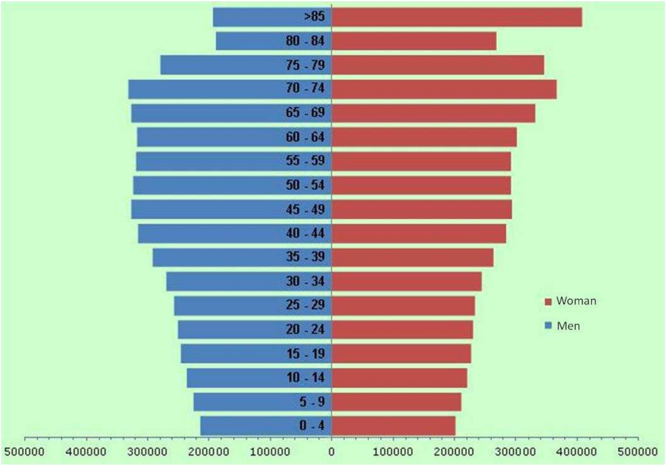


Figure 2-3 - Portuguese age pyramid 2050

This demographic evolution can be analysed according to two dimensions:

1. Individual-dimension – through a longer life expectation, with reasonable health conditions, people have the possibility to remain active professionally, although this might happen in distinct circumstances or conditions. In fact, several persons prefer to keep their professional activity.
2. Societal-dimension – at an integrated analysis, the society as a whole also gets older. Social problems are raised at the economic / sustainability level forcing the redefinition of the societal models concerning active / professional life or retirement policies. In fact, as the relation between the number of persons that are retired and benefit from pensions on one hand and persons in a working age that contribute to such pensions through taxes, on the other hand, is evolving as longer-life expectations increase. In other words, "with relatively fewer people working and greater numbers claiming pensions, the long-term sustainability of this 'intergenerational contract' is in danger" (Camarinha-Matos et al., 2010b).

These two dimensions require reactions from several areas of the society and computer science is not an exception. In particular, the areas of ICT and CN have the possibility to give a major contribution to the current and foreseen situation. Two contributions from these areas have been addressed lately especially under two perspectives:

1. Finding out the mechanisms to provide care to older people, not directly considered in this research work, but also worth to mention, and
2. Finding out mechanisms to provide older people the possibility of having an active life at these later ages, the main application focus of this dissertation.

The first perspective has gained the attention of the research community as illustrated in Figure 2-4 that highlights some research projects along the timeline.

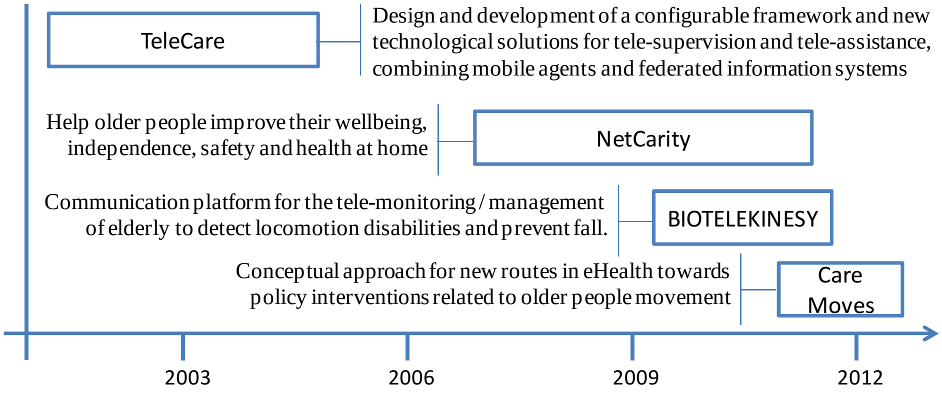


Figure 2-4 – Examples of Research Projects targeting elderly care

The following paragraphs shortly describe these projects:

- TeleCARE ("A Multi-Agent Tele-Supervision System for Elderly Care" – www.uninova.pt/~telecare) - One of the earliest research initiatives tackling the first perspective, was the European Commission funded research project TeleCare that aimed at the development of a "configurable framework for virtual communities focused on supporting assistance to elderly people", as presented in (Camarinha-Matos and Afsarmanesh, 2001). In this project, "the main innovative aspects introduced (… were …) tele-supervision and tele-assistance, based on the integration of multi-agent-systems and federated information management approaches, introducing the concept of federated agency".
- NetCarity ("Ageing successfully, Ageing in Place" – www.netcarity.org) – Another initiative, this time tackling an Ambient Assisted Living (AAL), is the project NetCarity, which proposed a networked multi-sensor system for elderly people, both concerning healthcare, safety and security in their home environment. This initiative also addressed the commercial opportunities and challenges brought by AAL, as detailed in (Consortium, 2010).
- CareMoves ("Figuring Movement in Old Age Homecare" – caremoves.wordpress.com) – the CareMoves project has the focus on the locomotion of aged people. In this project, movement is considered as the base of "important challenges and emerging tensions in old age homecare", and the project aim is to contribute scientific knowledge that might be used as a base for the IT development policies aimed at alleviating tensions in care. It also aims to construct novel theoretical intersections between anthropology, science & technology studies, human-computer interaction, and care science.
- BIOTELEKINESY (www.biomed.ntua.gr) – this project also tackles the motion area, trying to address monitoring and assessment devices to gather information towards a prevention of motion disabilities, as well as the consequent fall risks. The target beneficiaries of the results of this project are both seniors, healthcare providers and healthcare systems.

A broader and systematic view of the need to develop the means that support an active life after retirement was presented in (Camarinha-Matos et al., 2004), based on an increase of longer life expectation, as well as the need to support sustainable economies. This time, the focus was on finding new emerging collaborative forms, namely the possibility to gather life-long experience from older people to help entrepreneurs.

As mentioned in (Camarinha-Matos and Afsarmanesh, 2010), one of the domains addressed by Active Ageing research is to "support active ageing and facilitating better use of the talents and potential of retired or retiring senior professionals", as one of the proposals for active life for seniors. This is the dimension tackled by this dissertation. Continuing a professional life, even if under a "lighter" model, is a possibility and the willing of several senior professionals.

In fact, three main aspects can be identified concerning the current early retirement of people in many countries:

- The retirement age is far from the age when elderly people's working capabilities start decreasing.
- Many senior professionals prefer to continue working, although under a more flexible schema, instead of starting a process of a lonely experience.
- The knowledge attained during a life-long experience is an asset that the economy thanks and elderly persons feel glad to share.

There are already several associations of Senior Professionals created to support senior persons' needs, namely addressing these tree perspectives. Table 2-1 shows some of the associations that have been contacted within the scope of the ePAL project (Camarinha-Matos et al., 2010c). As a remark, PASEF development is inspired on the needs identified in contact with two Portuguese associations of senior professionals: APCS ("*Associação Portuguesa de Consultores Séniores*") and SHARE ("*Associação para a Partilha do Conhecimento*" - http://www.share.pt). These are not for profit associations, composed of senior professionals that have a life-long experience and the willingness to share that experience with younger people, towards a positive contribution to the society. Another association that has been studied, and from which a contribution was attained, was the Spanish association SECOT ("*Seniors Españoles para la Cooperación Técnica*" - http://www.secot.org).

Table 2-1 – Senior Professionals Organizations Successfully Contacted within ePAL project

Org. Name	Country	Org. Name	Country	Org. Name	Country
ASEP	Austria	SES	Germany	FRAE	Spain
BSC-I	Belgium	ISES	Italia	Jubiqué	Spain
SENA	Belgium	Seniores	Italy	SECOT	Spain
SWB	Denmark	PUM	Netherlands	Sen@er	Spain
NESTOR	Finland	APCS	Portugal	UDP	Spain
AGIRabcd	France	SHARE	Portugal	REACH	UK
ECTI	France	COGAMA	Spain	RSVP	UK
EGEE	France	CONFEMAC	Spain		
OTECI	France	CONJUPES	Spain		

The results from the contact with these associations revealed several aspects, as detailed in (Camarinha-Matos et al., 2010c). An interesting aspect is that the things that the involved Senior Professionals mostly value are the level of professionalism, dignity, commitment, honesty and independency. Another interesting element identified is that "most of these associations state as principal goal giving professional help to young people, SMEs and other organizations that cannot afford to pay commercial (consultancy) companies”. Nevertheless, despite these noble aspects, these associations face some barriers on their activities, namely concerning two limitations of their *status quo*:

1. These associations are mainly self-sustained, with private or public sponsorship in some cases. They have a reactive approach, mainly addressing the requests from the outside and they “do not seem to have effective means of going to the market finding opportunities. As a consequence, most associations refer that they do not acquire enough activities for all their members”.
2. In terms of ICT tools or infrastructures other then email functionality, word processors or primitive databases, dedicated software needed for their administrative and operational activities are not used or simply does not exist. “One example of this necessity is the use of collaborative tools to cooperate with external entities or management tools to dynamically find and select experts for an assignment”.

These two limitations, along with the above mentioned help to entrepreneurship motivate some of the developments addressed in this dissertation. For instance, PASEF will address the mentioned reactive approach of these organizations by proactively pursuing market opportunities. In fact, various research works are being supported by distinct institutions in order to tackle Active Ageing and particularly ICT and Ageing research area. Among these initiatives, some address roadmap definitions, in order to identify areas in need for further research, a fact that demonstrates the recognition of the importance of this area on one hand, and the need for new mechanisms and approaches, on the other hand. These facts also show that research and development related to this area will continue in the near future. Figure 2-5 shows five examples of EU funded roadmap initiatives.

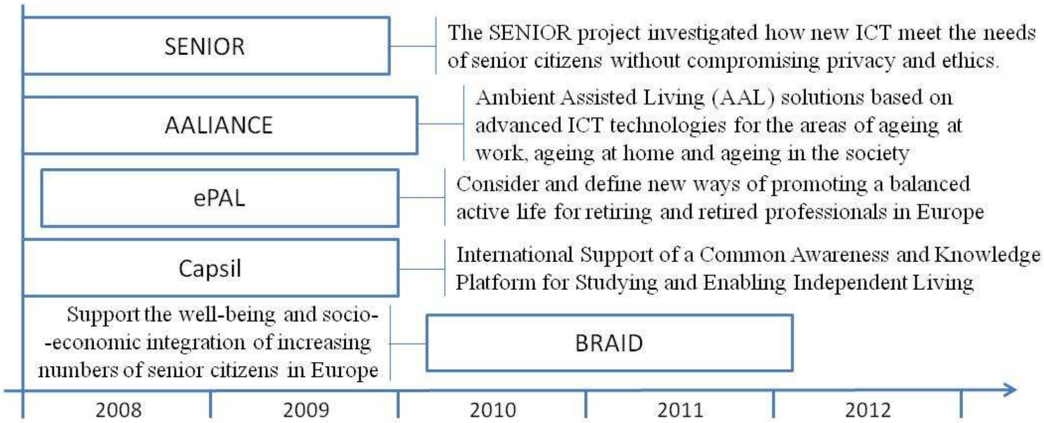


Figure 2-5 - Sample EU funded Roadmap initiatives

The following list shows the diversity of distinct perspectives tackled by these projects:

- SENIOR (Social, Ethical and Privacy Needs in ICT for Older People – www.seniorproject.eu) – As the demographic evolution takes place, people that reaches older ages tend to have higher formation and a greater empathy with technology. This new scenario created by the arrival of the "new older generation" will therefore be marked by the need to define the ethical and privacy frameworks that should be constructed to protect senior citizens from misuse and abuse of ICT. This is SENIOR project's mission which reports on good practices, ethical guidance and designing a dialogue roadmap, as detailed in (Mordini et al., 2009).
- AALIANCE (The European Ambient Assisted Living Innovation Alliance – www.aaliance.eu) – This roadmap project focuses on Ambient Assisted Living (AAL) taking benefit from ICT technologies. Three areas of ageing are identified: ageing at work, ageing at home and ageing in the society. The project addresses these areas through proposing a R&D roadmap, standardization requirements and policy recommendations, also identifying the opportunities risen up by the demographic evolution, as detailed in (Broek et al., 2010).
- ePAL (extending Professional Active Life – www.epal.eu.com) – The main vision behind ePAL is that "the collaborative networks paradigm, supported by advanced community building and collaboration ICT platforms, can provide a new approach to active ageing" (Camarinha-Matos and Afsarmanesh, 2009). This roadmap project has produced a set of actions, activities and steps to facilitate a better use of the talents and potential of retiring and retired persons, as further detailed in (Camarinha-Matos et al., 2010a). These actions were divided into three perspectives: social, organizational and technological perspectives (this last group of actions is particularly connected with this dissertation as further detailed bellow).
- CAPSIL (International support of a Common Awareness and knowledge Platform for Studying and enabling Independent Living – www.capsil.org) – CAPSIL targets independent living based on established clinical requirements. The main objective of this project was to launch a series of workshops in the US, EU, and Japan, with two fundamental goals:
    1. To develop a detailed CAPSIL Roadmap for EU research to achieve effective and sustainable solutions to independent living based on an in-depth analysis of clinical requirements and the ICT scenarios developed or under development.
    2. To support ageing research by proposing procedures to incorporate all of these diverse solutions into WiKi entries which describe interoperable ICT solutions to clinical requirements for independent living that can then be deployed.

- BRAID (Bridging Research in Ageing and ICT Development) – (braidproject.eu) BRAID, which builds on top of the results of the previous four initiatives, aims at characterising key research challenges and producing a vision for a comprehensive approach in supporting the well-being and socio-economic integration of increasing numbers of senior citizens in Europe. The project has three main objectives:
    - Create a dynamic ICT and Ageing roadmap that addresses older people's needs not otherwise well met in previous initiatives.
    - Instantiate a strategic research agenda that tracks and builds upon existing, emerging and disruptive technologies and that responds to the changing socio-economic conditions of stakeholders.
    - Expand the BRAID networks of contacts to build a self-sustaining co-ordination mechanism which reaches out across the heterogeneity of stakeholders.

Among these initiatives, it is worth to highlight the technologic actions (T1 … T6), identified for the next years by the ePAL project roadmap, as detailed in (Camarinha-Matos et al., 2010c). Table 2-2 lists these elements briefly explaining how this dissertation addresses some of them.

Table 2-2 – Technological Actions identified in ePAL roadmap

#	Action	Short Description	Address in the Dissertation?
T1	Developing conceptual models	Establish formal conceptual models for people’s professional lifecycle and the support environment for active ageing.	The elaboration of a common Ontology for communities of SPs, identified within T1, is addressed, to some extent, by a Services Taxonomy definition support made by Services Ecosystems administrators.
T2	Generating adaptive solutions	Develop and integrate self-adaptive and configurable technology solutions in ICT collaboration environments facilitating technology acceptance and enabling customization for/by seniors.	Not addressed
T3	Building collaboration platforms	Develop open ICT collaboration platforms for communities of senior professionals that promote human interaction and socialization and are enhanced by affective computing, context awareness, and trust establishment.	The trust building perspective is addressed, to some extent, both by a new QoS assessment mechanism and the continuous performed monitoring made by the Services Ecosystem.
T4	Building collaboration tools	Design and develop collaboration support tools and systems to facilitate value creation, considering the specific needs of senior professionals.	Not directly addressed, although the pro-active representation of services can contribute to value creation.

#	Action	Short Description	Address in the Dissertation?
T5	Leveraging legacy	Develop environments that empower seniors to leave a legacy capitalizing on their valuable and transferable personal / professional experience.	The creation of reward mechanisms considered in this action is addressed, to some extent, by the QoS assessment mechanism.
T6	Elaborating behavioural models	Develop approaches that discover patterns and model "the evolution of senior professionals' interests and their involvement in the socio-economic system" and "the behaviour and emotional health of senior professional networks".	Although not in the exact same direction of the identified sub-actions, the introduction of SP's service representatives with possible behaviour configuration, also fosters the inclusion of SPs in the socio-economic landscape.

Another interesting work in this area has been presented in (Fornasiero et al., 2009), which focus on manufacturing. There, Fornasiero presents a research project called Flexibly Beyond, which "studied and experimented innovative models for the enhancement of the role of senior workers and prolongation of their working life". The focus of this project was on the European industry sectors of apparel and footwear.

Yet another interesting research project was also identified focusing the perspective of an active life in later ages, called "Cooperative ActiveAGE Support Trust (CAST)". This project follows the notion that "experienced executives aged 50-75 are 'reservoirs' of resources and expertise, especially valuable to younger entrepreneurs and professionals aged 25-50 for them to develop their business or sustain the quality of their careers and projects with solid partners" (Potter and Leighton, 2005).

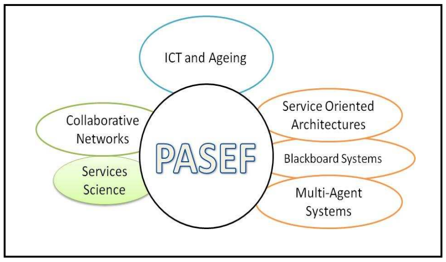
These projects and other initiatives, like (Camarinha-Matos and Ferrada, 2006; Cheng et al., 2007; Collom, 2008; del Cura et al., 2009; Potter and Leighton, 2005), show the strong activity of the research community, as well as the commitment of funding agencies, concerning this research area.

Moreover, this research trend is also aligned with the Lisbon Strategy, where major society guidelines were identified: "An active ageing strategy requires a radical policy and culture shift away from early retirement towards three key lines of action: providing the right legal and financial incentives for workers to work longer and for employers to hire and keep older workers; increasing participation in life-long learning for all ages, and improving working conditions and quality in work" (Ivan-Ungureanu and Marcu, 2006).

This *status quo* - in need for new solutions and mechanisms - was the base inspiration for the selection of Active Ageing as the example area for the *proof of concept* application of PASEF, in order to contribute for the usage of ICT and CN knowledge towards the mentioned paradigm shifting. The envisioned scenario of PASEF helps Senior Professionals to keep their active life after retirement, through the usage of an ICT system that represents the services they are willing to provide, in a pro-active manner. The behaviour of these elements can be configured to follow the SP's business interests, namely looking up for new Collaboration Opportunities, or improving the selection chances for the represented services.

2.3. Conceptual Baseline

2.3.1. Services Science



The notion of service, although attracting substantial attention in recent years, still suffers from the lack of a precise characterization. Various partial attempts to define service can be found in the literature but a general consensus is still missing.

For example, (Sheth et al., 2006) states that "a service is a provider-client interaction that creates and captures value". This is a broad definition and the main elements are the identification of the two actors, the client and the provider, and the focus on value creation / interchange. A more detailed definition can be found in (Chesbrough and Spohrer, 2006): "A service is a change in the condition of a person or a good belonging to some economic entity, brought about as the result of the activity of some other economic entity, with the approval of the first person or economic entity". In this case, naturally the same two actors and the value perspective are included but two other elements are added: 1 – a service results on the change of the condition of a person or a good (probably belonging to the client), and 2 – that change results from an activity performed by the provider. Yet another definition found in (Jim et al., 2007): "Service can be defined as the application of competences for the benefit of another, meaning that service is a kind of action, performance, or promise that is exchanged for value between provider and client. Service is performed in close contact with a client; the more knowledge-intensive and customized the service, the more the service process depends critically on client participation and input, whether by providing labor, property or information". One can state that this definition puts the focus on the client interaction. All these three definitions are agnostic on a technological perspective and especially focus on the interaction between client and provider, value creation and the activity that has to be performed for the service to take place.

A more technology-oriented definition can be found in (Ferrario and Guarino, 2009; Ferrario et al., 2011), stating that “a service is present at a time t and location l iff, at time t an agent is explicitly committed to guarantee the execution of some type of action at location l, on the occurrence of a certain triggering event, in the interest of another agent and upon prior agreement, in a certain way.” This definition is particularly applicable in the context of PASEF, given the fact that it includes the commitment aspect, coping with the business perspective, the temporal and logistics facet, coping with the management, and it can be materialized into a technological implementation, for example using the multi-agents paradigm and / or service-oriented architectures.

On the other hand, this definition also points out for an existing gap between the business and the ICT worlds. The parallel between this definition and the existing technological approaches diverges in the main points of the definition – the temporal and geographical constraints. In the case of a Web-Service, for example, the temporal constraint is only achieved when the Web-Service is called, whilst the localization constraint is not considered.

On the other hand, the services sector has experienced a growing importance path, especially in the last two decades. In fact, the world labour has partially moved from agriculture and manufacturing into the services sector, as shown in Table 2-3 (Maglio et al., 2006). It is interesting to notice that the service designation appeared in opposition to agriculture and manufacturing, in 1930s, according to (Chesbrough and Spohrer, 2006). At that time, the first two sectors of economy were the major sectors in terms of employment and “services was a residual category for other activities that didn’t fit into agriculture and manufacturing”. Nowadays the services sector is the one with higher employment ratio in developed countries.

Table 2-3 - From agriculture and manufacturing to services (% of jobs)

Nation	World Labour (% of total)	Agriculture %	Goods %	Services %	Services Growth (% increase in last 25 years)
China	21.0	50	15	35	191
India	17.0	60	17	23	28
U.S.	4.8	3	27	70	21
Indonesia	3.9	45	16	39	35
Brazil	3.0	23	24	53	20
Russia	2.5	12	23	65	38
Japan	2.4	5	25	70	40
Nigeria	2.2	70	10	20	30
Bangladesh	2.2	63	11	26	30
Germany	1.4	3	33	64	44

Nevertheless, despite the growth of this tertiary sector in the world’s economy, productivity in this sector is low, when compared with the manufacturing industry, as presented in (Abe, 2005). One of the commonly accepted factors that dictate the low-productivity is that the service sector is based heavily on the intuition and experience of employees, rather than on systematic processes. Therefore, unlike the two older sectors of agriculture and manufacturing, few mechanisms exist devoted to assess productivity in the services sector. The magnitude of this phenomenon gains a particular meaning when the dimension of the baseline grows from one service to the integration of distinct services from independent entities forming service systems. In other words, “service system complexity is a function of the number and variety of people, technologies and organizations linked in the value creation networks, ranging in scale from professional reputation systems of a single kind of knowledge worker or profession, to work systems composed of multiple types of knowledge workers, to enterprise systems, to industrial systems, to national systems and ultimately to global service systems” (Maglio et al., 2006).

As a result of this situation, and as foreseen in (Horn, 2005), the new concept of “Services Science” has emerged with the goal to increase productivity in the services industry, promoting innovation and creating greater viability and transparency when assessing the value of investments in services. According to (Spohrer et al., 2007), “Services Science aims to understand and catalogue service systems and to apply that understanding to advancing our ability to design, improve and scale service systems for practical business and societal purposes.” The attention that the research community has been giving to the Services Science has already produced systematic results, as shown in Table 2-4 and Table 2-5 highlighting some references and their contribution. Figure 2-6 distributes the same publications in a timeline.

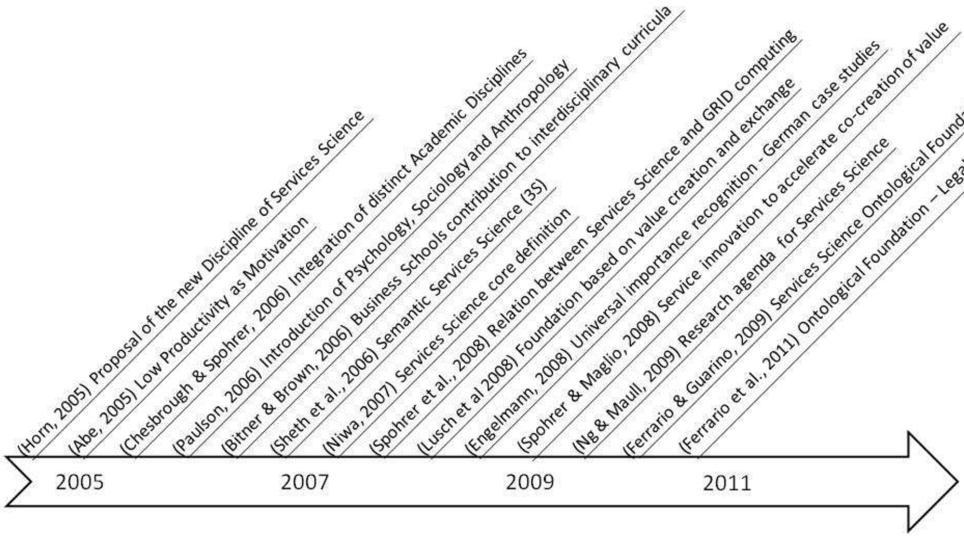


Figure 2-6 – Services Science selected publications over time

Table 2-4 – Services Science selected references (I)

Reference	Innovative Contribution
(Horn, 2005)	The author defined the new discipline of Services Science as a melting of technology and business understanding of services and stating how crucial it is to the “next wave economy”. This new academic discipline gathers inputs from ongoing work in computer science, operations research, industrial management and social and legal sciences, in order to develop the skills to a services-led economy.
(Abe, 2005)	This work compares the Services Sector to the manufacturing sector in what concerns productivity, concluding that the later has much more systematic mechanisms than the former in this respect, as services specially rely on intuition and experience of employees. This is pointed out as the main motivation for the Services Science that takes these elements investigating them scientifically, through the existing academic disciplines in order to raise productivity and create visible assessment to investments.
(Chesbrough and Spohrer, 2006)	The paper argues for a Services Science discipline to integrate distinct academic areas, attaining the knowledge they may provide towards a fast advancement of service innovation.
(Paulson, 2006)	The author argues that although technology is a key element of Services Science, a better understanding of human behavior is critical. The field calls on the resources of social sciences such as psychology and sociology, as well as anthropology, which could provide useful information about the way people and groups work and interact.
(Bitner and Brown, 2006)	This work addresses the evolution and discovery of the Services Science academic discipline in Business Schools, arguing that the initiative from the Arizona State University illustrates what can be accomplished when universities worldwide address the need to create comprehensive interdisciplinary curricula for Services Science.

Table 2-5 - Services Science selected references (II)

Reference	Innovative Contribution
(Sheth et al., 2006)	Sheth et al. propose the Semantic Services Science (3S) model, arguing the benefits from semantics in view of a broader vision of Services Science by using service descriptions that capture technical, human, organizational, and business value aspects.
(Niwa, 2007)	The authors propose the definition of the core of Services Science as an integration of existing sciences. First three key elements of service activities: clients' problem definitions, problem solving by using clients' domain knowledge, and communication with clients. These elements are respectively related to systems science, knowledge management and cognitive science, in order to define a Services Science framework.
(Spohrer et al., 2008)	This paper explores the relation between the Services Science and the GRID computing areas, comparing the notions of resource, entity, service, interaction, and success criteria for the two areas.
(Lusch et al., 2008)	The authors address the conceptual foundation of the Services Science through a logic based on value creation and exchange.
(Engelmann, 2008)	Engelmann addresses the importance of the services sector in Germany and the work that has been done in that country, arguing that research and development still needs to be universally recognized.
(Spohrer and Maglio, 2008)	The emergence of Services Science is addressed, highlighting the need for systematic service innovations to accelerate co-creation of value.

Reference	Innovative Contribution
(Ferrario and Guarino, 2009)	The authors propose an Ontological Foundation for Services Science, based on the objective of allowing the smooth interaction of people and computers with services in the actual world. The authors emphasize the role of social and business-oriented services, whose consideration is needed to evaluate the global quality of e-services in relation to their ultimate social benefits, taking the overall impact on the organizational structure into account.
(Maull and Ng, 2009)	A Services Science research agenda is suggested, considering it as an integrative discipline of engineering, technological and social sciences for the purpose of value co-creation with customers.
(Ferrario et al., 2011)	Ferrario et al. consider services as the core element of the new organizational paradigm of Service Oriented Systems and make an analysis under the perspective of formal ontology, with a special attention to the legal aspects. The authors consider services as events, in opposition to goods, arguing that they are not transferable, as they cannot be “owned”. The paper is based on the central notion of commitment, analyzing the relationships between the various agents that participate to these services / events playing their roles, with specific responsibilities.

In line with this new research field of Services Science, the new academic discipline with the same name is also emerging towards fostering the knowledge on this field. For this reason, some of the above mentioned references may be highlighted given their contribution in this perspective. What is becoming a common understanding states that the new discipline must have a trans-disciplinary curricula, in distinct teaching institutions, as mentioned in (Bitner and Brown, 2006) that particularly focuses the Business Schools’ initiatives. Nevertheless, engineering schools can also have a role here, namely in terms of development of support frameworks. In fact, the education is one of the main drivers for new sciences and particularly for the Services Science as identified in (Kejing et al., 2009). The main objective is to “merge technology with an understanding of business processes and organization – a combination of recognizing a company’s pain points and the tools that can be applied to correct them”. These authors also highlight the multidisciplinary nature of Services Science, pointing out that “as the world becomes more focused on services, what we need is not only the insights from more disciplines, but more importantly the collaboration of scholars from several disciplines examining the same challenge.”

In order to embed the new discipline of Services Science, a research agenda was identified in (Maull and Ng, 2009), highlighting five issues for knowledge production:

1. The need for more appropriate simplification in services;
2. The need to understand the whole as well as all the parts;
3. The need to look forward;
4. The roles of technology changes in the service systems and vice versa; and
5. The need to integrate social sciences (and business), engineering and technology for customer value co-creation.

In fact, the research community started to pay special attention to this topic in the late 2000s, according to (Spohrer and Maglio, 2008), when IBM started a joint effort with universities, researching services from the viewpoint of social engineering systems. One can sate that this was the starting point of Services Science. More recently, the designation of “Services Science, Management and Engineering” (SSME) was suggested in (Chesbrough and Spohrer, 2006). According to these authors, “this expanded name for Services Science is useful in that it speaks directly to the need for a multidisciplinary approach that spans across existing academic silos”.

Although a common Services Science definition has not yet been reached, a simple statement from (Paulson, 2006) argues that “in essence, Services Science represents a melding of technology with an understanding of business processes and organization”. In another perspective, “Services Science aims to categorize and explain the many types of service systems that exist, as well as how service systems interact and evolve to co-create value” (Maglio and Spohrer, 2008). Nevertheless, it is commonly accepted that Services Science has four main fields of focus: business strategy, business process, human resources, and fundamental technology (Abe, 2005), as presented in Figure 2-7.

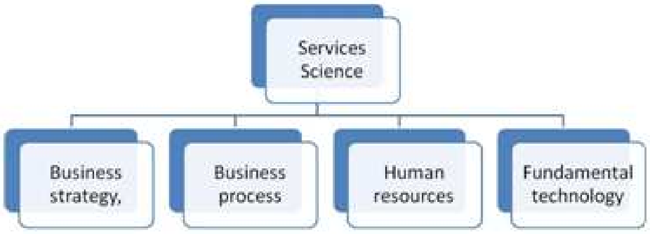


Figure 2-7 – Main focus of Services Science

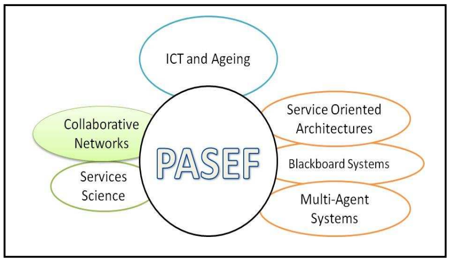
A brief description of each of these branches follows:

- Business Strategy – In Services Science there is the need to identify how to analyse business strategy in a scientific manner and how to conduct modelling towards introducing quantitative forecasting and reasoning, and how to transform business strategy into something predictable.
- Business Process – Services Science use of applied mathematics, operations research, management or computer sciences towards optimizing business processes. Some example aspects from this field may include investigation of business models, formulation and diffusion of industry standards, definition of performance management criteria, *et cetera*.

- Human Resources – Services Science also tackles the preparation of human resources to dynamic business environments, where they might need to respond to changes with speed and flexibility.
- Fundamental Technology – This dimension of Services Science encompasses business performance management, information integration, security and privacy, as well as supporting a smooth communication between providers and clients.

Therefore the multidisciplinary approach to systematically study services, given the previous ad-hoc approaches based on intuition and employees experience, although still in an early stage, is already an innovative approach, given the fact that all these four pillars represent ongoing research areas. According to (Maglio et al., 2006), “the challenge lies not simply in formally modelling the technology or organizational interactions, but in modelling the people and their roles as knowledge workers in the system”.

2.3.2. Collaborative Networks



Collaboration among distinct independent entities is an old practice. The usage of Information and Communication Technology to support such collaboration and break out the barriers of geographical distribution, along with actual market turbulence and the so-called globalization are some of the pillars of the new Collaborative Networks scientific area.

This area has gained special attention from the research community in the last two decades. According to (Camarinha-Matos and Afsarmanesh, 2005, 2008c), there is already a sound empirical knowledge, and a preliminary theoretical foundation for collaborative networks. The “emergence of the virtual enterprise (VE) / virtual organization (VO) paradigm falls within the natural sequence of the restructuring processes in traditional industrial paradigms that is enabled by advances in information and communication technology”. According to the same authors, “the idea of VE/VO was not invented by a single researcher; rather it is a concept that has matured through a long evolution process.”

In fact, this scientific discipline can be included in the path of systems integration, towards a global integration level. As represented in Figure 2-8, inspired in (Camarinha-Matos and Afsarmanesh, 2005), systems integration, in what concerns industrial informatics, started in the early 70s at the cell level, when robots and other machines dedicated to specific functionalities had to be integrated. Later, in the 80s, distinct cells started to be integrated and, in the 90s, the integration of distinct departments from enterprises was the focus of the so-called computer integrated manufacturing (CIM). Nowadays the integration between independent enterprises or entities is a major topic addressed by the research community.

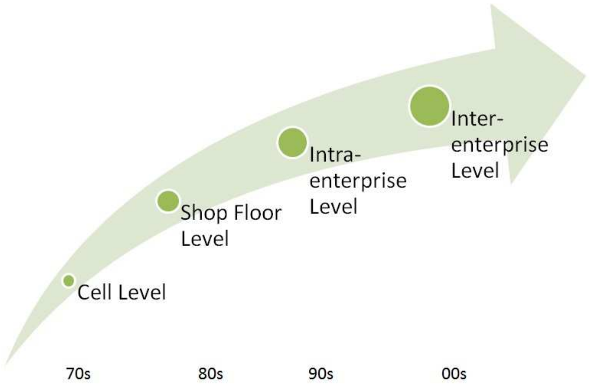


Figure 2-8 - Systems Integration Evolution

Along its history, the CN area has been enriched with a set of base concepts for formalizing the several types of consortia that are formed for collaboration purposes, among distinct entities, through the usage of ICT systems (Afsarmanesh et al., 2004; Camarinha-Matos and Afsarmanesh, 2005; Rabelo and Pereira-Klen, 2004), namely:

- Virtual Enterprise (VE) – "A virtual enterprise is a temporary alliance of enterprises that come together to share skills or core competences and resources in order to better respond to business opportunities, and whose cooperation is supported by computer networks" (Camarinha-Matos and Afsarmanesh, 1999). Case-studies can be found in (Grefen et al., 2000), for example, concerning the cooperation within service outsourcing in the electronics industry, based on the CrossFlow European research project. In this example, workflow means may be used to the enactment of services provided by independent organizations. In this case, cross-organizational transaction management and process control provide the flexibility for real world logistics and insurance companies.
- Extended Enterprise – The concept of Extended enterprise is a particular case of VE, where a "dominant enterprise 'extends' its boundaries to its suppliers". An example can be considered in the automotive industry, where a main company is surrounded by several suppliers. In this example, the main company "dictates" the rules which suppliers try to follow making an effort to remain in this group.
- Virtual Organization (VO) – "The concept of Virtual Organization extends the VE concept, covering organizations other than for profit enterprises, e.g., the open-source

software development communities' movement constitutes a good example of a virtual organization where the results of existing systems prove the effectiveness of these structures, as shown in (Gallivan, 2001).

Typically, these forms of collaboration fall within a limited time-frame period, corresponding to the collaboration opportunities originating them. Nevertheless, the effort needed for the formation of these organizations, or the existence of some kind of trust among the involved CN members, among other factors, demand more stable structures that last beyond particular collaboration opportunities. In order to support stable and long term structures, composed of entities that are prepared and willing to collaborate, from which a VO or a VE could emerge, the concept of Virtual Organizations Breeding Environment was defined.

- Virtual Organizations Breeding Environment (VBE) – "represents an association or pool of organizations and their supporting institutions that have both the potential and the will to cooperate with each other through the establishment of a base long term cooperation agreement".

The scientific community has also addressed the case of individual professionals, instead of enterprises or other organizations. In this context, the concepts of Virtual Team and Professional Virtual Community correspond to the VE / VO and VBE, respectively:

- Virtual Team (VT) – "is a group of professionals that come together in order to share competences and skills to tackle a specific Business Opportunity."
- Professional Virtual Community (PVC) – is "the combination of concepts of virtual community and professional community. Virtual Communities are defined as social systems of networks of individuals, who use computer technologies to mediate their relationships. Professional communities provide environments for professionals to share the body of knowledge of their professions."

A more extensive taxonomy of CN forms can be found in (Camarinha-Matos and Afsarmanesh, 2008c). Figure 2-9, retrieved from that source, shows how the above mentioned concepts, as well as other concepts defined in the CN scientific area, are related with each other forming a taxonomy.

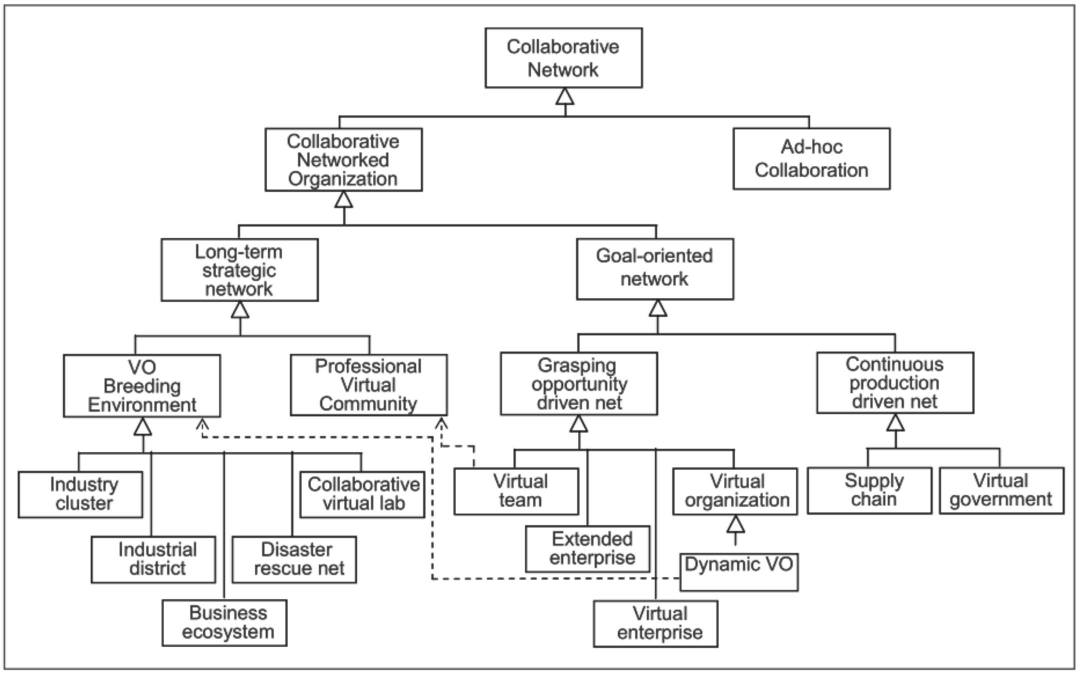


Figure 2-9 - Examples of Classes of Collaborative Networks
(Camarinha-Matos and Afsarmanesh, 2008c)

The area of Collaborative Networks gathers all these concepts. The main objective of this scientific discipline is the establishment of the theoretical foundations to support and foster the collaboration among independent entities. Some example perspectives are the legal perspective, the underlying needed ICT support infrastructures or assessing the preparedness and the willingness of CN members to participate in some VO, as explored in (Rosas and Camarinha-Matos, 2008). In fact, although the collaboration between independent entities does not constitute a new phenomena, *per se*, as mentioned before, the potential global geographical distribution rises challenges also addressed by this scientific field, like dealing with inter-cultural barriers or supporting business process enactment.

Moreover, the CN discipline also studies VTs /VOs in distinct stages of their life-cycle. One early example of life cycle model is represented in Figure 2-10, which proposes 4 distinct stages (Camarinha-Matos and Afsarmanesh, 1999).

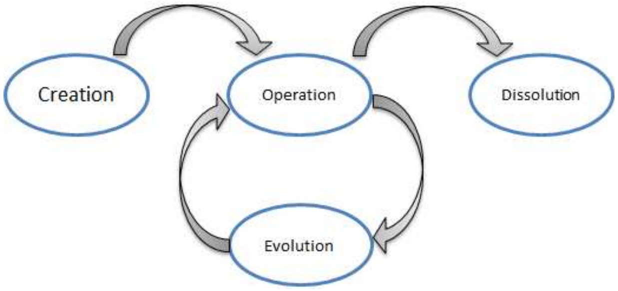


Figure 2-10 – A typical CN Life Cycle

These stages are described as follows:

- Creation – This phase addresses issues like partners search, selection or negotiation and contract establishment. It includes the processes and mechanisms needed for the creation of consortia towards a collaborative accomplishment of the triggering Collaboration Opportunity goals. In (Camarinha-Matos and Afsarmanesh, 2005), this phase was further divided into two sub-phases: (i) Initiation and the recruiting sub-phase, where a common ICT infrastructure is implemented, while potential organizations to join the CN are recruited; (ii) Foundation sub-phase where support systems are set up, founding members are registered, and the set of governance principles and rules that will guide the CN life cycle are defined, as well as the ontology to be adopted.
- Operation – the phase coping with all the mechanisms needed for the partners to perform their tasks / activities in order to achieve the pre-defined common goals. These mechanisms may include workflow management, or distributed information exchange and sharing.
- Evolution – potentially, during the CN activity, some partners may leave or join the group, leading to the need for the CN to evolve. Furthermore, the roles of partners within the group can be redefined. In this phase, mechanisms similar to the ones of the creation phase are also included, like partners search and selection, or negotiation mechanisms.
- Dissolution – finally, the phase that has to cope with all the mechanisms and processes needed after the Collaboration Opportunity results, or common goals, have been accomplished. This stage includes mechanisms like after delivery assistance services.

The Creation and Operation phases are the ones that got more attention from the research community in a first phase, given the fact that they are the first ones needed to support real cases in industry. The Evolution phase was addressed, afterwards, benefiting from the similarity between the needs of that phase and the creation phase. The less addressed phase has been the dissolution phase, as mentioned in (Hormazábal et al., 2009).

The main objectives of CN studies for the Creation and Evolution phases of the life cycle of a team of professionals is to support the process of forming a consortium, on one hand, and provide more success probabilities, on the other hand. In fact, creating such collaborative structures, based on unknown potential partners from an open universe, like the Internet, adds much more uncertainty than restricting to a "local" universe, like a Professional Virtual Community (PVC), where better / accurate information about the members might be attained. PVCs act as places where registered members aim at collaborating with each other. Furthermore, the contractual perspectives or technological infrastructures used may already be prepared. This last factor contributes to shorten the time-frame period of the creation phase.

Figure 2-11, inspired in (Afsarmanesh et al., 2008), represents the formation of a collaborative team, composed of professionals, highlighting the distinction between starting at an open universe *versus* starting at a "local" universe – the PVC universe. In other words, a PVC works as an environment able to facilitate all mechanisms needed for the formation of a collaborative team of professionals. The tasks are divided into two processes: the process of joining the PVC and the process of creating a Virtual Team as a response to a Collaboration Opportunity. The first process involves a collaboration agreement, the set-up of a common infrastructure and sharing common principles. The second process involves light tasks, such as partner's selection among peers, contract negotiation, which is faster than the one based on an open universe because the PVC might have negotiation process mechanisms established *a priori*, and finally an infrastructure slight configuration, as the first set-up process had already been accomplished in the first process.

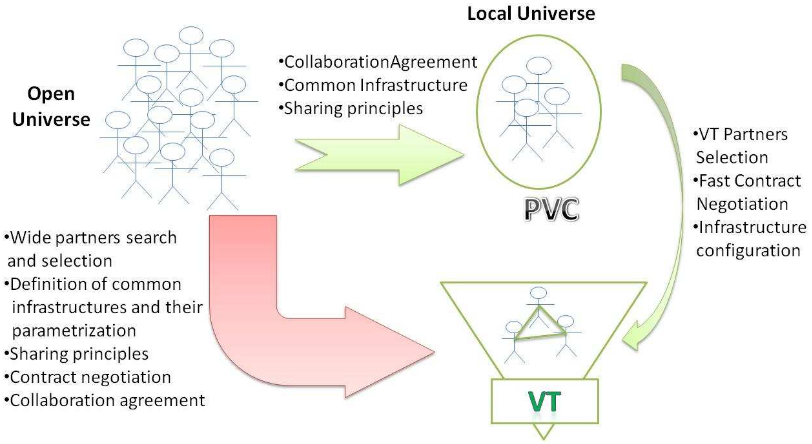


Figure 2-11 – Two paths towards the formation of a Virtual Team

The work of detailing more the creation phase of a VE / VO has been carried out in (Camarinha-Matos et al., 2005) and later extended in (Camarinha-Matos et al., 2008b), as represented in Figure 2-12. The authors pointed out 7 distinct stages in this VE / VO creation phase:

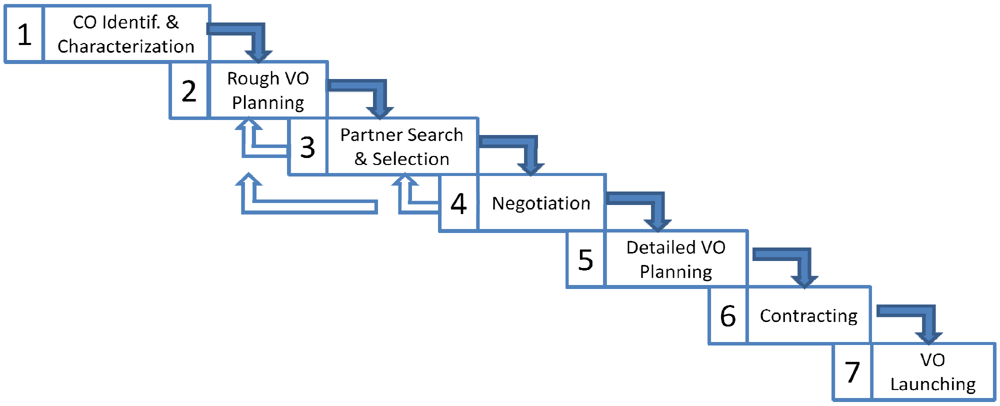


Figure 2-12 - VE / VO Life Cycle - Creation Phase

These stages are:

1. Collaboration Opportunity Characterization: this step involves the identification and characterization of a new Collaboration Opportunity (CO), which triggers the formation of a new VO.
2. Rough VO planning: determination of a rough structure of the potential VO, identifying the required competences and capacities, as well as the organizational form of the VO and corresponding roles.
3. Partners search and selection: this step is devoted to the identification of potential partners, their assessment and selection.
4. Negotiation: is an iterative process to reach agreements and align needs with proposals.
5. Detailed VO planning: once partners have been selected and collaboration agreements are reached, this step addresses the refinement of the VO plan and its governance principles.
6. Contracting: involves modelling of contracts and agreements as well as the contracting process itself, before the VO can effectively be launched.
7. VO launching: the last phase of the VO creation process, i.e. putting the VO into operation, is responsible for tasks such as configuration of the ICT infrastructure, instantiation of the collaboration spaces, assignment and set up of resources, notification of the involved members, and manifestation of the new VO in the VBE.

This division is of particular importance, as it will be described in Section 3.2.4, where the Business Process Modelling is covered; namely given the mapping between the Rough Planning stage and the abstract Business Process Model concept that will be introduced, on one hand, and the mapping between the Detailed VO Planning stage and the executable Business Process Model concept that will also be introduced, on the other hand.

It is also worth to analyse these seven phases of the CN lifecycle from a services perspective, particularly considering services that will be provided by human actors, although supported by ICT elements. This last factor is of particular importance because the service provider is not a computational resource that is expected to be available all the time. Table 2-6 addresses this analysis highlighting particular constraints for the services perspective and further details added by the human service provision factor.

Table 2-6 - CN Creation analysis in a service perspective, applied to Senior Professionals

#	CN Creation Phase	Services Perspective	Human Service Provider Constraints
1	Collaboration Opportunity Characterization	Hierarchical mechanism should be used for the composition of services, allowing the definition of CO in a higher level at a first place and detailed services level in a second stage. Service skeletons or interfaces that are commonly accepted should be used.	
2	Rough VO planning		Human Service Providers should also use common interfaces for the services they are willing to provide.
3	Partners search and selection	Identify and select those entities that can provide the needed services.	Scheduling constraints have to be considered and some negotiation iterations may take place.
4	Negotiation		
5	Detailed VO planning	Consider the possibility of service providers become unavailable at *runtime*. The inclusion of one “second choice” selection can be considered.	
6	Contracting		
7	VO launching	CO execution engines should be able to launch each service at the right moment / in a pre-defined order. Monitoring mechanisms and recovering from failures should be considered.	Since the provision is made by humans, the inclusion of ICT systems can help humans start their services and deliver the corresponding results.

In fact, the creation phase of CNs is the main focus of this dissertation, although the operation phase is also addressed. In this early stage of a CN, studying the profile and competences of potential partners and their subsequent selection are two mandatory issues to consider. In these two fields several initiatives were also identified in the literature, some of which are highlighted in Table 2-7 and Table 2-8.

Table 2-7 – Competences / Skills Profiling research initiatives

Reference	Innovative Contribution
(Ermilova and Afsarmanesh, 2006)	Ermilova and Afsarmanesh propose a “Profiling and Competency Management System (PCMS)”, based on three levels: VBE Member, VO and VBE. These competences appear in the profiles of these three elements and characterize what such VBE can offer to the market and society.
(Fazel-Zarandi and Fox, 2010)	The authors tackle Human Resources Management and propose a formal ontology for competency management and consider three reasoning problems related to HRM, namely: determining the set of skills of an individual, conducting competency gap analysis, and determining whether an individual satisfies a set of requirements.
(Rosas et al., 2009)	Rosas et al. divide competences in two levels: hard competences and soft competences. This paper focuses in the later group as competences from a “behavioral perspective” that the involved organizations must be apt to exercise towards the collaboration success. The authors propose a model integrating these two kinds of competences allowing the construction of competences profiles.
(Hlaoittinun et al., 2010)	This paper tackles the optimization of assignment of tasks to human resources according to their competency levels.

The profiling of CN members including the description of their competences is a mandatory element for the creation of a VO in response to a Collaboration Opportunity. In fact, this is the base element for finding CN members that are able to provide some service and become potential partners, usually made through a match-making process, for example. In this research work, this profiling / competences is also addressed and discussed in Chapter 3.

Table 2-8 - Partners’ Selection research initiatives

Reference	Innovative Contribution
(Crispim and Sousa, 2008)	The authors propose an iterative and interactive exploratory process to help the decision maker identify the companies that best suit the needs of each particular project for the corresponding partners’ selection.
(Jarimo et al., 2006)	Jarimo et al. propose an understanding of partners’ selection as a work-allocation problem, applying multi-objective criteria from goal-programming techniques. Virtuelle Fabrik case-study is addressed.
(Jarimo and Korpiaho, 2008)	This paper addresses the application of mathematical decision-analysis in a multi-criteria partners’ selection. The proposal takes into account historical data in order to assess robustness of potential partners.
(Camarinha-Matos and Macedo, 2010)	The authors address the Value Systems adopted by the CN members and the needed alignment towards collaboration success. A proposal for the definition of values and their evaluation is made. The paper also proposes a formal conceptual model for Value Systems and discusses its application on the management of CN context.
(Oliveira and Camarinha-Matos, 2008)	This initiative highlights the need for negotiation before the selection process, in order to make decisions concerning roles, task allocation, defining VO operation conditions, etc. The paper proposes a wizard as an environment that supports the negotiation among VO partners.

Reference	Innovative Contribution
(Rosas and Camarinha-Matos, 2008)	This initiative considers the analysis of factors from a “soft” nature, as organization's character, willingness to collaborate, or affectivity / empathy relationships. These elements are then used to assess the readiness of such organizations to collaborate and propose an assessment mechanism aiming to determine how prepared organizations are to join a VO.
(Msanjila et al., 2008)	Msanjila et al. address the problem of trust in the CN context as a pre-condition for a smooth collaboration, especially for the partners' selection task. The authors propose an objective approach for assessing the trust level and establishing trust relationships among organizations, through defining: the hierarchy of trust elements, the impacts of various values of trust criteria on the trust levels, and the causal influences among different trust criteria. Three VBE trust objectives are identified: 1) among VBE member organizations; 2) between VBE members and VBE administration; and 3) between the external stakeholders and the VBE itself.

After the CN members profiling including their competences characterization, the partners’ selection process may take place, promoting potential partners to members of a VO. The issues involved in this process are addressed in Chapter 3, namely considering scenarios of several potential partners from which one has to be selected. The use of trust elements, as suggested by Msanjila et al. or multi-criteria mechanisms as Jarimo et al. propose, are some of the needs addressed in Chapter 3.

Another aspect that is also closely related to the selection of partners is historical data concerning their performance in previous collaborative experiences. For that reason, the performance measurement mechanisms gain special interest and have been considered in several research initiatives. The creation of an ecosystem that fosters the collaboration among distinct entities, as the proposal presented in this dissertation, needs to support performance measurement mechanisms in order to feed up the available data stored with this kind of information. In later stages, this data will also contribute the selection of partners. In this particular case, the ecosystem itself will track collaboration cases storing performance data for future use. Table 2-9 highlights some of these research works.

Table 2-9 - Performance Measurement research initiatives

Reference	Innovative Contribution
(Baldo et al., 2008)	Baldo et al. address the selection of the performance indicators that should be applied to drive the partners search through the proposal of a modelling process designed to support finding appropriate performance indicators that can be used to compare and to suggest organizations that are able to fulfil business requirements.
(Francisco et al., 2010)	The authors address the help that performance management systems give to decision makers assessing the alignment among participants in a CN. A dynamic performance management system is proposed.
(Kim and Kim, 2009)	This initiative propose a generic framework for Performance Management based on the Balanced Scorecard approach, establishing cause-and-effect relationships between performance indicators to define a generic strategy map.

Reference	Innovative Contribution
(Macke et al., 2010)	The authors tackle "soft elements", like social capital in the competitiveness within collaborative networks, through identifying inter-organizational social capital elements and their relation with collaborative networks' competitiveness. Three social capital dimensions are identified: structural, relational and cognitive.
(Abreu and Camarinha-Matos, 2010)	This work addresses the social capital importance for the success of a CN. The authors highlight the lack of models that may support the measurement of social capital and propose the usage of social network theory to assess the value of social capital of CN members on a VBE.
(Seifert et al., 2008)	Seifert et al. address the support on the formation of VOs, using performance measurement to identify and evaluate the optimal network configuration. The proposal is based on the storage of past performance information upon which potential partners may be evaluated in the selection process.
(Stich et al., 2005)	This paper argues that new forms of performance measurement need to be developed, considering the new characteristics of CNs. The paper suggests an alternative benchmarking approach, which is more suitable for today's need of flexible adaptation of organisations towards market requirements.
(Odenthal and Peters, 2006)	This initiative tackles the reorganization of the supply chain in the aerospace industry, within the research project AerViCo - Aerospace Virtual Company, where employee performance behaviour was addressed towards increasing labour productivity.
(Martins et al., 2003)	This initiative tackles the quality into enterprise management within a virtual enterprise context. The authors propose the inclusion of all the lifecycle phases into the scope of quality management in a third-party auditing mechanism integrated with the virtual enterprise model.

As the main inspiration approach for this dissertation is service orientation, it is worth to mention some of the initiatives that connect the CN area and such approach. In fact, several research initiatives have addressed CN challenges through this service orientation paradigm. Some example initiatives are shown in Table 2-10.

Table 2-10 – Other examples of service oriented initiatives in CN

Reference	Innovative Contribution
(Franco et al., 2009a, 2010)	Franco et al. propose a first notion of service aggregation through the concept of Service Entities as the base element to support structural and functional Collaborative Networked Organizations (CNO) modelling.
(Shen et al., 2007)	Shen et al. target the interoperability constraints existing in a collaborative environment and propose the usage of web-services along with software agents towards service selection and integration in a collaborative environment. This work focuses the manufacturing schedule problem.
(Herfurth and Weiß, 2010)	In this paper, the authors tackle the e-procurement issue in the area of industrial services. A classification of services is made concerning trade-ability, intangibility and labour intensity. The authors propose a conceptual model highlighting the interaction between client and provider, where Collaborative Networks are considered as strategy, among trust between buyer and seller.
(Osório et al., 2010)	Osório et al. tackle the transportation systems infrastructure as a collaborative network of service providers. This work addresses the discussion of an approach to the required ICT-based intelligent infrastructure towards forming a collaborative network among the transportation services stakeholders.

Beyond the base CN organizational forms and the life-cycle study, several other facets of the CN discipline are also relevant and worth to consider for the construction of PASEF. The following list highlights three particularly relevant ones:

- Elderly Care – the research area of collaborative networks opened several challenges. The EU funded research project ThinkCreative, was launched in order to identify what those challenges were in distinct world regions (Camarinha-Matos and Afsarmanesh, 2004). At that time, one of the early articles tackling the application of CN to elderly care was identified in (Camarinha-Matos et al., 2004), among other collaborative forms that were appearing.
- CN Services Lifecycle Support – Another challenging example can be found in (Salkari and Hytonen, 2006), where services lifecycle are addressed. In this particular case, as enterprises provide their services through VOs, they establish short-term contracts for the provision of such services. Nevertheless, clients are starting to demand services' lifecycle support that would require long-term commitment.
- Reference Modelling – the work on the creation of reference models for the CN scientific discipline has also gained much attention by the research community in the last decade. Some examples of this effort are:
  - (Camarinha-Matos and Afsarmanesh, 2008a, 2008b) – defining the reference model framework of ARCON.
  - (Berasategi et al., 2011) – defining the TALAI-SAREA© framework, which includes a reference model, a set of analysis tools and a methodology for implementing the Collaborative Networked Innovation processes within a Collaborative Networked Organisation.
  - (Msanjila and Afsarmanesh, 2008) – addressing the differences, preferences and interpretations of trust among CN members.
  - (Abreu and Camarinha-Matos, 2008) – addressing the benefits taken in the participation on a Collaborative Network.

2.4. Technological Baseline

The Pro-Active Services Ecosystem Framework is based on the services paradigm, as mentioned before. Thus, Web-Services and Service Oriented Architecture are a major contribution for this work. The second major technological contribution comes from the Multi-Agent Systems area. Finally, the area of Blackboard Systems also contributes for the creation of this framework.

Figure 2-13 highlights the main characteristics of each of these three contributing areas that are crucial for the creation of PASEF.

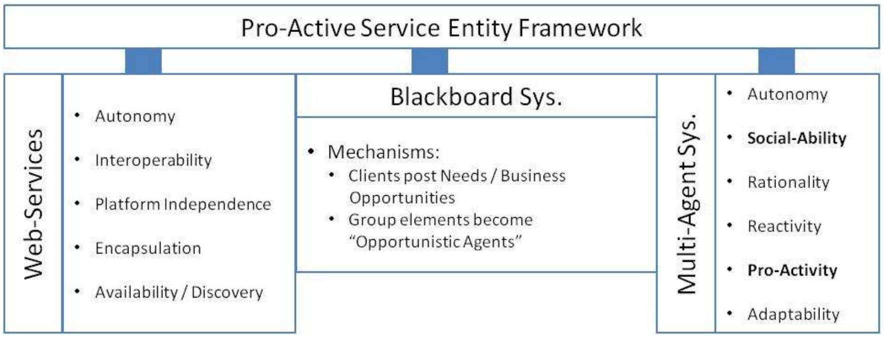
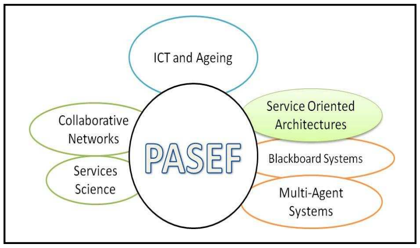


Figure 2-13 - PASEF technological inspiration areas



2.4.1. Web-Services, Service Oriented Architectures and Cloud Computing

Web-Service is a concept that has been introduced as a software system designed to support interoperability between electronic devices over a network, according to the W3C (World Wide Web Consortium). In other words, it constitutes a mechanism that wraps some functionality or service from a provider, which can be called or invoked by a client, potentially from a remote location. As web-services may be compared with methods or functions, they may receive input and produce result data. Two hypothetical examples:

1. “Translator” might be an entity that provides a translation service between the most commonly used European languages. In this case, the input data of the corresponding web-services would be the text to translate the original language of the text and the destination language. The result would be the translated text. A client for this example could be a web-site written in a specific language, but displaying flags for the functionality of layout in any of the available distinct languages. Whenever a person visits this site and clicks one of these flags, the website would show the content in the desired language. Behind the scenes, between the moment when the person clicks the flag and the translated content is shown, the web-server receives the request, calls the europe.translator.org web-service and forwards the resulting translated text or content to the original client’s browser.

2. “Travel” might be a tourism booking entity with the focus on integrated tour packages. In its web-site it might show special weekend packages with flight information, accommodation and local tour booking facilities. Whenever a person selects a specific weekend program and clicks “book”, he or she would be booking all the services included in that weekend package. Behind the scenes, between the click and the resulting confirmation, the web-server would call all the web-services corresponding to the elements of that package.

Web-services came in a sequence of technological approaches for integrating distributed systems. One can state that this sequence evolved with two main goals: 1 – hiding complexity from the developers, on one hand, and 2 – solving interoperability constraints, on the other hand. Some of the main elements of this evolution are listed below:

- Sockets - the method to connect two distributed systems was made through sockets that introduce a pipe between them, through which data can be sent and received. One of the major limitations of this approach *per se*, is that the two systems had to know all the details from each other in order to use it, both concerning location, data format and so forth.
- RPCs – later on, the Remote Procedure Calls were introduced, restricting the communication to function calls that might be made remotely. There, a middleware software layer was developed in order to deal with interoperability constraints between the client and the server. These were the Client stub and the Server Stub. The main limitation of this approach was the need for the development of these stubs and the fact that they are dependent on the development environment.
- RMI – the Remote Method Invocation mechanism is the implementation of the RPCs in an object oriented (OO) environment, whilst RPC worked in a functional environment. Although it might seem simple to make the transformation from a functional model to OO, this process is much more complex given the possible endless relations or connections between objects. For example, if Adam, an object from the class CPerson, is used as an input parameter of a method, there are two possibilities for the implementation of the call: 1 – making a copy of Adam and calling the method; 2 – making the call of the method with a reference to Adam as a parameter. Problems do exist in the two hypotheses. In 1, any update to Adam would leave the original Adam outdated. Furthermore, if CPerson is connected to CDepartment, which is connected to CEnterprise, and CPerson is also connected to CFamily, the amount of objects that might have to be copied is endless. Somewhere references have to be introduced. The main problem with

the references is that the network connections might become broken, and even if that occurs in a short time-frame, the whole integration process is compromised.

- CORBA – on top of RMI, the Common Object Request Broker Architecture was introduced mainly in order to normalize the method invocation either in the same address space or not (same host or remote host on the network). This interoperability achievement was made through the usage of an IDL (Interface Definition Language), towards creating a mapping between client and server environments. This architecture is widely used, but it still suffers from some of the limitations of RMI and RPCs, namely the middleware development effort needed. Furthermore, the need for an IDL definition dictates that the Objects within a CORBA environment are not independent or autonomous. As a result of this limitation, CORBA usage is mainly restricted to LANs.

The Web-Service approach tackles this “independence” limitation, trying to follow the evolution trend towards Wide Area Networks (WAN) environments, through the usage of standards that evolved in the last two decades. Figure 2-14 shows the introduction of these standards in a timeline. At the beginning, in the 90s, the eXtensible Mark-up Language (XML) had a major impact in systems integration because it was created with the design goals of simplicity, generality and usability over the Internet. One of the first initiatives taking benefit from XML was the creation of a protocol for exchanging structured information – the Simple Object Access Protocol (SOAP). This was the base protocol for the appearance of the Web Services providing a basic messaging framework upon which web services can be built. Later on, in 2007, the Message Transmission Optimisation Mechanism (MTOM) was proposed by the W3C as a recommendation towards supporting the transmission of attachments.

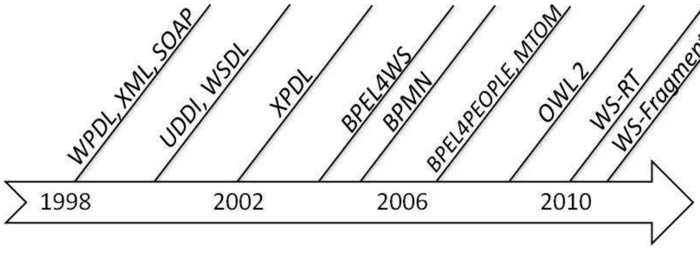


Figure 2-14 – Web-service related standards

In this first phase of Web-Services, it became possible for any enterprise to publish its web-services in the Internet, aiming to reach a worldwide range of new potential clients. As time proved, these worldwide potential new clients’ benefit did not happen. Many Web-Services were not used / exchanged mainly because they were not known by such worldwide potential client set, especially at the SME level. Only big companies took advantage of this new approach, based on their “marketing machinery”. Moreover, the need for a service description that could help the systematic service call did not exist at that time. This was also an inhibitor factor for a wider usage of this technological approach.

Because of these two problems (neither standard service description nor mechanisms to find services were available) the creation of the Universal Description, Discovery and Integration (UDDI) was launched and the Web Service Description Language (WSDL) created.

The UDDI approach “was born” in August 2000 aiming at providing central registries where clients could find services through a brokerage mechanism. At that time the authors had a vision of a world in which consumers of Web Services would be linked up with providers through a public or private dynamic brokerage system. The mechanism was simple, but the public form of UDDI turned out not to be realistic / profitable, neither used as widely as envisioned. In 2006, IBM, SAP and Microsoft announced closing their UDDI nodes.

WSDL was first created for combining two service description languages: NASSL (Network Application Service Specification Language) from IBM and SDL (Service Description Language) from Microsoft. WSDL can be described as a XML specification including collections of methods that can be called over the network, called “network endpoints”. Through this description, the client can check available services, select the desired one(s) and make the effective call(s) using SOAP.

Although this approach did not succeed publicly, the “machinery” was built and the corresponding knowledge attained. Nowadays, distinct forms of UDDI are working, but rather than the Universal scale, local or economically restricted scales are being adopted, as foreseen in (Charles and Christoph, 2008). In fact, this technological evolution mostly became restricted to environments that could be controlled, instead of open. One example of usage of UDDI is the Microsoft BizTalk server.

Nevertheless, after the appearance of UDDI, technically speaking, it became possible for one system to find Web-Services and make the service calls, through the usage of WSDL and SOAP. At this point of the Web-Service evolution distinct branches followed diverse directions. One example of research has tackled the scheduling problems using XML-RPCs, as discussed in (Varela et al., 2003) and further detailed in (Varela et al., 2004). Nevertheless, the main research focus was pointed to service composition. In other words, the possibility to create services that could result from the composition of “simpler” services from potentially independent entities. This was the advent of the Service Oriented Architectures (SOA), in the year of 2006. At that time, technologies like the XML Process Definition Language (XPDL), Business Process Execution Language for Web Services (BPEL4WS) or Business Process Modelling Notation (BPMN) have contributed to a boost of this web-service evolution to a higher integration level.

XPDL is an XML language created for interchange of process design, in 2002. It is based on the Workflow Process Definition Language (WPDL), created in 1998 to support workflow automation. These two languages were created by the Workflow Management Coalition that, itself was created in 1993, as an association composed of stakeholders with interests in business process modelling and workflow management. The aim of the coalition was the development of standards and it already counts more than 300 members including universities, developers, consultants or research groups. BPEL4WS was created based on WSFL (from IBM) and XLANG (from Microsoft) – two similar approaches to describe process state transition mechanisms. These initiatives provided a language for the specification of Executable and Abstract business processes. There were two versions (1.0 and 1.1) but from version 2.0 the name was changed to WS-BPEL, following a trend to harmonize all the web-service related standards with the WS-prefix. Nevertheless, the commonly used name is simply BPEL. Finally, BPMN is a graphical representation for specifying business processes in a business process model. This standard was created by the Business Process Management Initiative in 2005.

The support for Business Process Modelling has mainly evolved in the systems integration perspective. In the case of BPEL4WS, for example, the tasks composing the modelled processes are supposed to be executed by Web-Services. Nevertheless, there are many business processes where the tasks are executed by humans or where there is a strong human interaction in the process. These cases are not considered by these standards. In fact, despite the success and acceptance of web-services, their absence of human interaction is a significant gap for several real-world application scenarios.

The BPEL4People is an extension of WS-BPEL for people, former BPEL4WS. This specification is being defined along with the WS-HumanTask standard specification. This later standard is devoted to roles, assignments and logical people groups concepts. The former specification of BPEL4People models all the business processes, this time including the possibility for human tasks, other than the restriction to computational elements.

Following a distinct perspective, more recently in (Franco et al., 2009a; Franco et al., 2009b), the Service Entity concept was proposed, introducing a first notion of an aggregation mechanism for distinct Web-Services provided by the same entity. Franco’s proposal groups information concerning a service provider plus the services provided, all within the same construct – the Service Entity.

Another research branch related with web-services is concerned with the complexity of the above mentioned standards, namely: SOAP, WSDL, etc. The Representational State Transfer (REST), first introduced in (Fielding, 2000), is an architectural style based on Uniform Resource Identifiers (URI), similarly to the WWW URLs (Uniform Resource Locators), which manipulates resources through their representation, meaning that what we see in a webpage, for example, is the representation of the corresponding resource at that time / state. Updating the webpage will "transfer" the representation to a subsequent state. In other words, according to this author, "Representational State Transfer is intended to evoke an image of how a well-designed Web application behaves: a network of web pages (a virtual state-machine), where the user progresses through an application by selecting links (state transitions), resulting in the next page (representing the next state of the application) being transferred to the user and rendered for their use". As the resource evolves, the representations follow that evolution. This architectural style works over HTTP in a client-server model. At a glance, the REST style implements the basic operations that can be made over resources, that are Get, Put, Post and Delete. In other words: Read, Create, Update and Delete, which are the four HTTP methods. This mapping between REST and HTTP is the reason why several authors in the literature consider the World Wide Web as the largest RESTfull example.

In 2006, the W3C introduced the Web-Service Resource Transfer (WS-RT) specification, following a similar approach. The base idea was to form an essential core component of a unified resource access protocol for the Web services space. This specification is also based on the definition of standard messages to control resources, namely: "get", "put", "create", and "delete". Later on, the WS-RT became outdated with the introduction of the WS-Fragment that is a specification defining how meta-data can be used to associate Web-Services and Resources considering that the most commonly used situations do not need the entire resources but rather parts (or fragments) of them.

Figure 2-15 represents a simplified view of the Web Service evolution, highlighting some key aspects especially meaningful in the context of this research work.

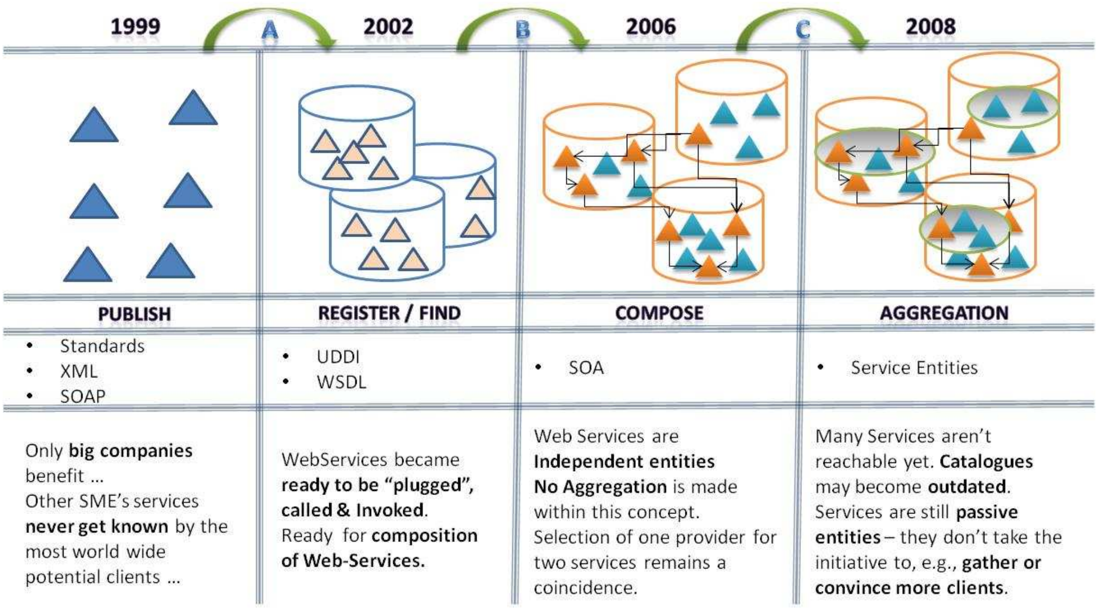


Figure 2-15 - Web-Service evolution

Although the web-services or the service oriented architectures are suitable in many scenarios, a number of limitations can also be identified:

1. Passiveness - Providers may publish and register web-services, making their functionality available for clients to discover and call, but these constructs stay still waiting for the clients' initiative. In other words, they do not perform any action in order to attract clients or promote their functionality.
2. Difficult WS Selection - if the list resulting from a query made to a catalogue has a large number of items, a problem arises on how to make a selection.
3. Lack on WS Selection Chances Improvement Mechanisms – in the same case of large number of matching available Web-Services, the providers face a problem on how to improve the chances that their Web-Services have to be selected.
4. Outdated Catalogues - there are scenarios where Web-Services change their availability frequently. In such scenarios, the information in the catalogues may easily become out of date. If for example, one considers consultancy services provided by senior professionals to entrepreneurs that are about to start their own business, the availability of such seniors may change frequently. Some possible reasons for this change are health issues or simply some leisure break that some of these service providers may take.
5. Lack on WS Aggregation Mechanisms – Web-Services created better conditions for software composition purposes. Nowadays, a workflow definition can support a composition of Web-Services, in order to achieve a higher level goal, or a higher

complexity level functionality, that may itself become a Web-Service, as well. However, having one of these higher level Web-Services composed of several simpler services, each one from a distinct provider, might be far from the optimal network. If more than one network configurations may be made, choosing fewer partners may bring advantages. In other words, under similar circumstances it could be desirable to select two services from the same provider, instead of two distinct providers, which could lead to higher costs related to agreement reaching processes. The aggregation of distinct services from the same provider within a single construct would improve this possibility. Another reason is the reduction of the dilution of responsibilities. In other words, the division of responsibilities among a considerable number of partners introduces complexity, namely to deal with problems that might appear.

SAAS, PAAS, IAAS and the Cloud

The evolution of the web-services / service oriented architectures in particular and distributed systems in general has triggered a corresponding evolution in the commercial environments resulting in the so-called Cloud-Computing, or simply the cloud. At a glance, the Cloud-Computing can be defined as "an on-demand access to a shared pool of configurable computing resources that can be rapidly provisioned and released with minimal management effort or service provider interaction" (Mell and Grance, 2011). In fact, it is a common understanding that not much innovation was brought by the Cloud Computing itself. For example, according to (Armbrust et al., 2009), "Cloud Computing is a new term for a long-held dream of computing as a utility, which has recently emerged as a commercial reality." Another positive perspective of this new paradigm can be found at (Buyya et al., 2009; Rajkumar, 2008) stating that Cloud Computing is a step towards the vision that "computing will one day be the 5th utility (after water, electricity, gas, and telephony)."

Concerning the definition of what Cloud Computing is, a common definition does not exist yet, as usual when new areas appear or old ones evolve. Nevertheless, a possible definition states that cloud computing is "a large-scale distributed computing paradigm that is driven by economies of scale, in which a pool of abstracted, virtualized, dynamically-scalable, managed computing power, storage, platforms, and services are delivered on demand to external customers over the Internet" (Foster et al., 2008). From this definition, three key aspects can be highlighted:

1) the distributed computing paradigm – in a limited usage of the cloud, all the resources, computing power and storage may be distributed, without the need to know their exact location or the owner of the corresponding physical machines;
2) the potential to cope with large and very-large scale scenarios – the cloud may provide large-scale computational power and storage;

3) the delivery on demand – in a cloud environment, at least the ones provided by the major commercial players, the resources become available only upon request and there is no need for an allocation *a priori*.

In fact, an indelible innovation aspect of this "era" is that a single free-lancer or a small enterprise may now take use of a potential large computing power through an "on demand basis". In other words, if some new idea intends to scale to large sets of clients, there is no need for big *a-priori* investments on computing resources - the resource allocation is made as it becomes needed.

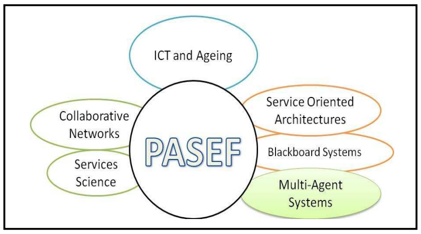
Some major players in this "Cloud era", like Amazon (through the Amazon Elastic Compute Cloud (Amazon EC2)), Google (through the Google Cloud Computing) or Microsoft (through the Microsoft Cloud Power), are investing mainly in computing power and storage, each of them with a particular approach. The services delivered by these players can be divided into three categories (Vaquero et al., 2008):

- Infrastructure as a Service (IAAS) – the computing resources, both at the storage and processing level, are dynamically assigned on demand. This is the lowest abstraction level, providing users the means to control some details of their cloud usage, like storage properties or computing power needs.
- Platform as a Service (PAAS) – in the middle abstraction level, the resource management is transparent for the customers through the usage of a software platform upon which systems run.
- Software as a Service (SAAS) – the top abstraction level is based on the notion that distinct kinds of customers have similar needs and that the same services can fit to large sets of situations. One example of this is the usage of online office applications, like word processors.

The scepticism of many decision makers, concerning the adoption or entrance in the cloud still inhibits a faster evolution. In fact, "if the organization uses a cloud based solution, it should maintain its own data backups in addition to those saved by the cloud provider. This is generally far easier with IAAS than with the other two models" (Viega, 2009). On the other hand, the same author highlights the centralization risky perspective: "with people now having more data and code residing on the same few sites, such sites become more tempting targets" for malicious initiatives.

The discussion on this "Web-Services, service Oriented Architectures and Cloud Computing" section have addressed the main technological evolution and limitations of these technological approaches. In fact, Web-Services do not cope with clients expectations, namely because they remain passive representatives of business services. On the other hand web-services are considered as independent entities and no aggregation between services from the same provider is made. Nevertheless, major evolution has been carried out, namely in what concerns the support for business processes, through initiatives like BPEL, or in what concerns the support of services that are intended to be executed by humans, through initiatives like BPEL4People, which is the application case of this dissertation.

2.4.2. Multi-Agent Systems



The Software Agents and Multi-Agent System paradigm introduced new mechanisms and concepts to model enterprises or entities. These systems can be characterized by four key properties, as mentioned in (Wooldridge, 1998):

- Autonomy – agents operate without the direct intervention of humans or others, and have control over their actions and internal state;
- Social-Ability – agents are able to cooperate with humans or other agents in order to execute their tasks and achieve their goals;
- Reactivity – agents perceive their environment, and respond in a timely fashion to changes that occur in it;
- Pro-Activity – agents do not simply act in response to their environment, they are able to exhibit goal-directed behaviour by taking the initiative.

Furthermore, Wooldridge also identified a set of five other properties concerning the behaviour of agents: Mobility – the ability of an agent to move around an electronic network; Veracity – the assumption that an agent will not intentionally communicate false information; Benevolence – the assumption that agents share common goals, and that every agent will therefore always try to do what is asked for; Rationality – the assumption that an agent will act in order to achieve its goals, and will not act as such a way as to prevent its goals being achieved - at least insofar as its beliefs permit; Learning – the assumption that an agent will adapt itself to fit its environment.

In fact, the usage of the MAS paradigm has provided the potential for the creation of a new set of mechanisms that are being used in several initiatives in a wide range of industrial or economical application scenarios. One particularly interesting work based on this new paradigm is detailed in (Kinny and Georgeff, 1997), that targets the complexity of modelling industrial scenarios of hundreds or thousands of agents inspired in Object Oriented techniques that have already addressed similar scale-ability problems.

The design and development of underlying MAS frameworks has also gained the attention of the research community and several proposals do exist with distinct characteristics. Other than the needed characteristics pointed out by Wooldridge, as listed above, two main characteristics a MAS framework has to provide are the ability for the agents to communicate with each other and the need to maintain efficiently the current state of executing agents, as highlighted in (Graham et al., 2003), while describing the DECAF MAS Framework.

Another early interesting initiative, found in (Ferber and Gutknecht, 1998), proposes a meta-model for the analysis and design of organizations in multi-agent systems, called AALAADIN, that is based on the organizational concepts of groups, roles and structures. The result is another MAS framework called MADKIT. The Adaptive Agent Architecture is a third early example of a MAS framework detailed in (Kumar and Cohen, 2000). These authors highlight fault-tolerance of MAS and propose a solution based on team-work between agents.

The existence of several proposals of MAS development frameworks and the need for standardization on the MAS community has induced the creation of two standardization initiatives, compared in (Islam et al., 2010):

- FIPA – the Foundation of Physical Professional Agents (http://www.fipa.org/), an IEEE Computer Society standards organization that promotes agent-based technology and interoperability of its standards and other technologies. One of the initiatives compliant with the FIPA standards that has an active community is JADE (Java Agent Development Framework), detailed in (Bellifemine et al., 2005; Bellifemine et al., 2007) developed in Italy jointly by CSELT (*Centro Studi e Laboratori Telecommunicazioni*) in conjunction with the Computer Engineering Group of the University of Parma.
- MASIF – Mobile Agent System Interoperability Facility, which is an initiative from the OMG group, focusing on the mobile agents branch. One of the initiatives with an active community for the case of MASIF is the Aglets API, described in (Lange et al., 1998; Lange and Oshima, 1998) originally developed at the IBM Tokio Research Laboratory.

One can state that these two MAS development frameworks belong to the group of most commonly used frameworks. A comparison between these two initiatives can be found in (Król and Zelmozer, 2008), that slightly highlights JADE, in the perspective of performance. Another MAS framework comparison, that can be found in (Gupta and Kansal, 2011), considers the Aglets solution better in terms of mobility of the agents, but the JADE solution gets a better classification in what concerns security.

In what concerns the application areas where MAS has played a major role, several examples can be found in the literature, like the example of the manufacturing sector. In this case, distinct approaches are proposed, taking benefit from distinct characteristics of the MAS. One of the early initiatives is presented in (Shen and Norrie, 1999), conducted a survey on the possible applications of MAS in the Manufacturing sector. Another early initiatives melding MAS and Manufacturing is presented in (Barata et al., 2001), where the authors tackle the distributed manufacturing systems and real-time applications and discuss the usage of Multi-Agent systems for that purpose. Later on, in (Barata and Camarinha-Matos, 2002), a proposal is made for the usage of agents to model manufacturing resources and the authors propose a contract based approach towards pursuing cooperation among this group of agents / resources. This work was further developed, resulting in the CoBASA architecture, presented in (Barata and Camarinha-Matos, 2003), focusing on a flexible approach to dynamic shop floor re-engineering. CoBASA was then applied in evolvable assembly systems (EAS), as presented in (Barata et al., 2005). Another initiative melding MAS and Manufacturing is presented in (Leitao and Restivo, 2008) aiming to increase the agility and re-configurability of production systems through the usage of Multi-Agent Systems. An extensive state of the art survey concerning this combination of MAS and Manufacturing can be found in (Leitão, 2009). Yet another study of the applications of MAS in Manufacturing, and particularly in the Supply Chain Management area, can be found in (Lee and Kim, 2007) which suggests that the MAS approach represents a feasible framework for designing and analyzing real-time manufacturing operations, since the approach is capable of modelling different levels of agent behaviour and dynamical interactions. A final reference goes to (Ghonaim et al., 2011), where the authors propose a model for smart manufacturing systems using distributed intelligence, rationality, collaboration and flow control.

Another interesting area where the MAS can be found is the e-government area, taken as an example of how diverse the MAS application areas can be. In this direction, an early specification of the requirements for the usage of agents in e-government are addressed in (Korhonen et al., 2003). These authors argue that e-government architectures must firstly be able to support workflow engines, transparent reliability and security; secondly, data needs to be presented in a format that might be understood by all parties; and thirdly it must be possible to define distributed workflows. This article concludes that Multi-Agent systems are adequate for the identified requirements. Later on, two examples can be found in (De Meo et al., 2008) and (Muhammad Anwar et al., 2006) that are particularly interesting because these are two examples that also gather web-services strength while tackling e-government issues.

The usage of MAS in Collaborative Networks, that is the case addressed in this dissertation, has also gained the attention of several research groups. Table 2.11 highlights some of these initiatives.

Table 2-11 – MAS usage in CN – some examples

Reference	Innovative Contribution
(Martinez et al., 2001)	A distributed and non-hierarchic control structure for a Consortium VE, allowing tasks distribution and product development management, is proposed with a multi-agent system based solution with self-organisation abilities.
(Aerts et al., 2002)	The support for co-ordination within a CN context is tackled in the area of networked electronic trading and mediation of negotiations. The authors argue that mobile agent-based ICT architecture will provide the required flexibility to support complex decision problems.
(Camarinha-Matos, 2002)	This author states that Multi-Agent Systems are considered as "a promising approach to both model and implement the complex supporting infra-structures required for virtual enterprises and related emerging organizations".
(Petrie and Bussler, 2003)	In this publication, the results of a survey show how the Software Agent's principles can be useful for the creation of web-service standards towards an application for Virtual Enterprises.
(Norman et al., 2004) (Patel et al., 2006)	These publications detail the CONOISE (www.conoise.org) project that uses agent-based models and techniques for the automated formation and maintenance of virtual organisations, tackling the need for robust, agile, flexible systems in that context.
(Ramirez and Brena, 2008)	In this initiative, the integration of the three research lines is considered: Software Agents, Service Oriented Architectures and Collaborative Networks.
(Brazier et al., 2009)	This paper recognizes the potential of the connection of the two research areas of MAS and SOA and draws a roadmap identifying research directions.

In fact, the autonomic characteristics of Software Agents, along with their pro-activity or potential self-initiative fits in the needs of professionals or enterprises in order to create software systems that are able to represent them. Concerning the integration of MAS and SOA in the CN context, a collection of research initiatives can be found in (Protogeros, 2007), pointing out how the two baseline approaches of MAS and SOA can be used in CN.

2.5. Other Key Research Initiatives

Some research initiatives tackle the usage of the Service Oriented Architectures or Multi-Agent systems to support collaborative networks. Three of these initiatives have been selected based on their connection to this dissertation and their contribution as an inspiration to this research work.

2.5.1. ICT-I Reference Framework

ICT-I is the approach used in the ECOLEAD project to help members of CNs in making businesses and collaborations more efficiently (Rabelo et al., 2006). ICT-I relies on the service oriented paradigm and is implemented with web-services.

ICT-I acts as a CN collaborative bus allowing different and distributed organizations to interact with another. More precisely, it has been designed with four major objectives:

- Collaboration and negotiation among people;
- Interoperability between ICT systems, as well as their ability to adapt to the surrounding environment;
- Support for knowledge and resources discover and share; and
- Synchronization and possible interconnection between processes.

ICT-I is created especially targeting a technological solution for SMEs, which are the major members of CNs. ICT-I is based on the ASP (Active Server Pages) model, and its services are accessed remotely, on-demand and in a pay-per-use model. An important feature of ICT-I is its capacity to evolve as new services are added and others are withdrawn from the Services Federation, a logical community of services providers.

Although ICT-I supports a major degree of auto-initiative ability for the base constructs to adapt themselves to the surrounding example, this solution also shares some of the identified limitations of web-services, namely their passiveness in what concerns pursuing business interests.

2.5.2. ManBree

ManBree is a VBE Management System based on Service Entities, from the research team from CIGIP - Research Centre on Production Management and Engineering, at the Polytechnic University of Valencia (Ferrario et al., 2011; Franco et al., 2009a; Franco et al., 2009b). This initiative addresses three main functionalities: VBE Management, VO Management, and Service Entities Management.

The most innovative aspect of ManBree is its base concept, the Service Entities, as well as the support of the lifecycle of this base concept that is integrated with the VO lifecycles. As mentioned before, the Service Entity concept embraces a finite set of business services, identifying the behaviour of the corresponding entities, and a finite set of attributes aiming the characterization of such entities towards distinguishing them.

ManBree supports the definition of Abstract Service Entities (ASE) in a first place, where a skeleton of attributes is included. This definition is abstract because it is not yet instantiated to specific values from any entity. Afterwards, the initiative supports the instantiation of such ASEs into Concrete Service Entities (CSEs), introducing the particular values of each entity that is joining the system. Finally, this CSE is registered in an open repository, where it can be searched, discovered and used to participate in a given VO.

As mentioned before, the ManBree is one of the inspiration initiatives, especially because of its first notion of aggregation, including distinct services from the same entity within a single construct – the Service Entity. The base construct of PASEF – the Pro-Active Service Entity – extends the Service Entity concept, mainly through the addition of pro-activeness.

This notion was borrowed for the base construct of PASEF – the Pro-Active Service Entity. Nevertheless, this approach also lacks on the introduction of pro-activeness or auto-initiative towards actively representing CN member's business interests instead of "delegating" all the initiative to the client side.

2.5.3. KIMM Framework

KIMM is an engineering framework based on service-oriented architecture and agent technologies. This framework was developed by the Korean Institute of Machinery and Materials (KIMM) aiming to provide an integrated environment to support collaboration among the elements participating in a product development process. The main features of this framework are the integration of distributed resources and the orchestration of engineering activities.

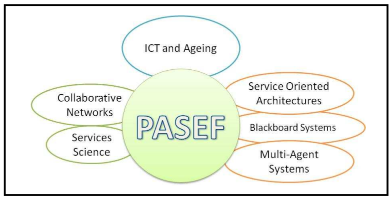
The framework follows the 3-tier software development approach, organized in: a presentation tier, responsible to provide distinct interfaces to the users; an "engineering process layer", responsible for the engineering processes; and an "engineering resources layer" (Kuk et al., 2008).

In this framework, the usage of Service Oriented Architectures is done based on the notion that this is a promising approach to supporting integration and collaboration of distributed resources. The reason for the usage of multi-agent systems is made in order to utilize agent's capabilities to negotiate in an autonomous manner. The framework includes 4 kinds of agents:

- Interface Agent (IA) is an agent responsible for the interface with the distinct kinds of users: designer, project builder, system administrator, etc.
- Engineering Server Agent (ESA) is the agent that is responsible to manage the workflow defined for an engineering process, controlling the starting and ending of tasks.
- Job Management Agent (JMA) is an agent responsible to support multiple jobs efficiently in the multi-user and multi-job environment.
- Monitoring Agent is specially designed to facilitate the monitoring of agents' behaviour in the system.

Although KIMM's initiative addresses the passiveness issue identified as a "bottleneck" of web-services, the pro-activeness of the proposed base elements are restricted to a negotiation between agents mainly concerning workflow issues. One limitation of this approach can be stated as a lack on the usage of the auto-initiative aspect for other business-oriented goals, like finding business opportunities or the ability to improve the chances a CN member has to see its services selected among competitors, based on QoS, for example.

2.6. Chapter Discussion and Conclusions



The creation of the Pro-Active Services Ecosystem Framework gathered inspiration from the three layers of contribution described in this chapter – the conceptual and the technological, along with the application domain contribution. Regarding the technological layer, as it will be shown in the next chapters, PASEF is positioned in the borderline between Service Oriented Architectures and Multi-Agent Systems, trying to gather relevant features of both areas, as highlighted in Figure 2-13.

In fact, the service paradigm orientation of PASEF leads to the adoption of Service Oriented Architectures. Nevertheless some of the identified limitations of Web-Services and SOA are the focus of this dissertation, namely: the passiveness of Web-Services, the limitations of the selection processes both for clients and providers, the possibility of catalogues becoming outdated in certain scenarios and the isolation / no aggregation of services. The adoption of Multi-Agent System's concepts and the inspiration on the Service Entities approach will try to overcome these issues in the following chapters.

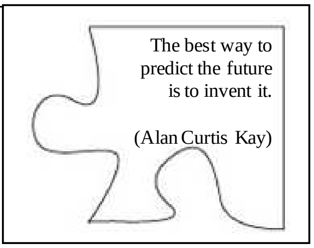
It is also interesting to notice that as the Cloud Computing is based on SOA, it inherits all the above-mentioned limitations of Web-Services. For that reason it would be interesting to study the possibility of implementing the Cloud Computing on top of computational elements that have auto-initiative and pursue business interests, as well. This exercise was postponed to future work challenges, as described in Section 6.2.

On the other hand, from a higher abstraction perspective, PASEF is a contribution to the newly created area of the Services Science, as it intends to contribute in the creation of a “bridge” between the ICT world and the Business world.

In what concerns the relation between PASEF and the research area of Collaborative Networks, as the focus of PASEF is on services provided by persons, rather than computational services, the CN branches that apply to PASEF are the Professional Virtual Communities and the Virtual Teams that are created from such groups. Moreover, in the example application scenario of consultancy services provided to entrepreneurs, the service providers are Senior Professionals.

Furthermore, as the two illustrative behavioural aspects addressed as proof of concept are finding Collaboration Opportunities and Improving Service Selection Chances, the CN lifecycle phases that apply are the creation and evolution of a CN. Nevertheless, the other phases of CN lifecycle will also be addressed in future work.

The following chapter introduces PASEF concepts aiming the mentioned contributions at the conceptual level. Chapters 4 and 5 introduce the proof of concept prototype design and the corresponding validation.



The best way to
predict the future
is to invent it.

(Alan Curtis Kay)

3. Pro-Active Services Ecosystem Framework

This Chapter introduces the Conceptual Framework created do model services offered by Collaborative Networks members within a collaborative Services Ecosystem, introducing service representatives. The self-initiative characteristic embedded in these modelling constructs has the aim of representing CN member's services in an ambassador like manner, towards pursuing the business success for their services. This goal is reached through the provision of the needed means to construct behaviours that can, for example, find new business opportunities or increase selection chances among competitors. The collaborative Services Ecosystem is also introduced as a space that induces and supports a smooth Collaborative environment for the elements that join that organizational structure – the service representatives. On the other hand, this ecosystem tracks all collaboration opportunities' lifecycle, as well as Client's Satisfaction towards Quality of Service assessment.

3.1. Re-Visiting the Problem

3.1.1. Current Situation

The area of Collaborative Networks (CN) counts already with a well defined conceptual baseline, namely in terms of Reference Modelling, as well as Methods and Tools. The involved research community identified distinct perspectives to study and model the collaboration between independent entities, as presented in (Camarinha-Matos et al., 2008a) and (Camarinha-Matos and Afsarmanesh, 2008c), as well as to offer new mechanisms and tools to foster such collaboration through the usage of Information and Communication Technologies. From a pragmatic perspective, the main objective of this recent scientific discipline is the provision of a conceptual framework and the corresponding artefacts to model such collaboration. The discipline itself embraces not only ICT, which is used to support the collaboration, but also other perspectives that have to be considered, like the legal constraints or socio-economic aspects, for example.

In terms of technological approaches used for the development of CN support tools, Service Orientation is one of the major paradigms used nowadays. This choice has been made for supporting the processes in distinct phases of a Virtual Organization or Virtual Team lifecycles, as well as the underlying Virtual Organization Breeding Environments or Professional Virtual Communities, respectively.

Nevertheless, as mentioned in the State of the Art Chapter, Web-Services, present some limitations. Two of these limitations are:

- Passiveness - Web-Services are passive constructs in the sense they stay still waiting for a third party initiative - the client's initiative. They do not perform any action aiming to attract more clients or to adapt to distinct market conditions.
- No aggregation - The existing mechanism used to find web-services is based on queries made to UDDI-like repositories, following a formalization specified in the Web Service Description Language (WSDL). If a given Business Opportunity requires the composition of 5 distinct Web-Services, for example, 5 queries are made to the registry, resulting in 5 independent answers. In this composition scenario, it could be desirable to consider an integrated approach fostering the possibility of having more than one service provided by the same entity. This reduction of the number of needed CN members for that case would naturally decrease the partnership agreement reaching efforts and other transactional costs.

Within a VBE or PVC context, as the network evolves, the number of members may increase. As a consequence, the number of potential providers for each service also increases. In this scenario, the chances each CN member has to see its services being selected among the competitors naturally decreases. To some extent, this fact is due to the nature of the base constructs (for example the Web-Services), namely because of their passiveness factor. In fact, the creation of constructs that benefit CN members’ expectations need to add elements of auto-initiative towards pursuing business success, instead of waiting for a client side initiative. On the other hand, one could argue that if all the service representatives have such auto-initiative elements, the expected advantage seems to disappear. Nevertheless, even in such scenario, the ones using best representation behaviours would still benefit against competitor representatives.

Another aspect that is a limitation of current approaches based on catalogues of services is the fact that such catalogues store data that does not reflect any dynamics of services, namely concerning their availability. If for example a given service provider becomes unavailable, even if that happens only in a short timeframe, the catalogues do not have the mechanisms to easily reflect that fact. This situation raises the possibility of an “erroneous” partner selection if a (temporarily) unavailable provider belongs to the result of some search query made to the catalogue. Table 3-1 summarizes the main bottlenecks of current approaches.

Table 3-1 – Some Limitations of Current Approaches

Limitation	Current Situation	Desirable Situation
Service Concept Understanding	Business and IT people have distinct understandings of the Service Concept.	Although distinct focuses may exist, they should complement each other and their integration should also be considered.
Technological Approach	Web-Services stay still waiting for a client-side initiative.	Instead of passiveness, behaving towards pursuing business success would be desirable. Finding new business opportunities or improving service selection chances are two examples of possible behaviours.
	Distinct services are treated independently.	An integrated approach for service composition potentially decreases the number of needed partners for a specific Business Opportunity.
Scalability	Large scale scenarios decrease service's selection chances.	High level QoS should be the element improving service selection chances.
Outdated data	Service Catalogue's data may become outdated.	Some mechanisms should exist to reflect dynamic service availability.

3.1.2. The Research Question and Hypothesis - Discussing Implications

Assuming the current situation, the research questions specified in the Introduction can be revisited and their implications detailed.

R.Q. – 1		Hyp. 1
Is it possible to create a collaborative services ecosystem in which the members of a collaborative network are modelled by computational elements that actively represent their business interests, inspired by an "ambassador-like" role?	→	*If the representation of services offered by Collaborative Network members is made using elements of Pro-Activeness, these enterprises, professionals or organizations can benefit in terms of the chances they have to see their abilities selected and a better fitness between them and the clients can be achieved. This representation can then be built upon an aggregation construct (including distinct services an entity can provide) and embedding behaviours towards finding new Business Opportunities and promoting the represented Services, all in an auto-initiative basis.*

The main elements from the Research Question 1 and the corresponding Hypothesis can be highlighted and further detailed. First, the creation of a collaborative services ecosystem leads to the need of a clarification of what is meant by this ecosystem. The idea behind this expression or concept is an environment where the base elements are services and the aim is collaboration among the corresponding providers towards sharing competences and risks. The word ecosystem induces that all the surrounding elements needed for that service provision made in a collaborative manner should be present. In fact, the creation of such environment will need to support a community management, in a first place, in order to engage the CN members in such environment, as well as the specification of what they are willing / able to provide. Furthermore, there has to exist the tools and mechanisms that provide the means to specify collaboration opportunities, corresponding to client needs. As the clients are not intended to deal with the complexity of the specification of documents detailing their needs into collaborative specifications, including the services provided within the ecosystem as well as the selection of the CN members that best fit each case specificities, the introduction of another actor that would play an intermediary / broker role might be useful. This intermediary would bridge the client perspective and needs through the corresponding models that express which services from the ecosystem have to be included in each case and engage specific members of the community in such CO. Finally, the runtime will also have to be supported by the ecosystem framework in order to launch each service provision at the right moment.

Concerning the computational elements that model each CN member’s services, as it is stated in the research question, they are intended to actively represent business interests. This auto-initiative characteristic, namely for finding new collaboration opportunities where the represented services may be included, introduces the need for the framework to provide the means for the definition and configuration of the behaviours of such constructs. As a detailed definition of behaviours may be too complex and / or time-consuming for all the providers to have to define / configure their service representatives, the framework also needs to find an easy way to perform such tasks. A possible solution is the definition of the most commonly used behaviours that could be made by specialists from the ecosystem. Therefore, the CN members would only need to select the ones that best fit their needs and slightly configure them. As a result, the computational elements representing each CN member’s services could behave in the “ambassador-like” manner mentioned in the hypothesis, towards representing services through the pre-defined behaviours.

R.Q. – 2		Hyp. 2
Is it possible to create a new Quality of Service (QoS) assessment mechanism that benefits from an active representation of the services from CN members, towards providing accurate and up-to-date data for clients to choose between competitor proposals?	→	*If a new Quality of Service Mechanism is created, based on distinct QoS characteristics, that can benefit from an active service representation, forming QoS Criteria it might be possible to feed up a collaborative Services Ecosystem with QoS data that may benefit final clients whenever a choice has to be made between two competing service provision proposals.*

The main elements of the Research Question 2 and the corresponding Hypothesis can also be highlighted and their implications further detailed. If one considers the active representation of the CN member’s services, as stated in Hypothesis 1, the mechanisms to assess quality of service might be updated / upgraded in order to consider / take advantage from such non-static characteristic of the computational elements that model the services a CN member provides.

On one hand, as these representatives are not waiting for a client initiative, they may be able to provide up-to-date data concerning the services they are representing. This fact overcomes the problem of catalogues becoming outdated, as mentioned in the previous section. On the other hand, the ecosystem itself might have the ability of assessing the QoS of the behaviour of such elements. This QoS data could then be stored within the ecosystem in order to benefit the client with the access to such information whenever he or she needs to select between two competing service provision proposals.

The proposal made in Hypothesis 2 for the creation of QoS Criteria based on distinct QoS Characteristics suggests that the historical data gathered by the ecosystem, along with characteristics from the proposals for each specific case can be used together. As a result, given the complexity factor that this might introduce, two levels of usage might be foreseen, similarly to the cases of the client needs specification and behaviour definition: 1 – the specialists / administrators level – where the distinct criterion is defined; and 2 – the CN members' level – where criterion is selected and slightly configured.

R.Q. – 3		Hyp. 3
Is it possible to create a mechanism, within a collaborative services ecosystem, for service composition processes relying part of these processes on the computational elements that actively represent such services?	→	*If a new framework is created modelling the services CN members are willing to provide through the usage of active computational elements, it might be possible to delegate on such elements part of the responsibilities related to service composition processes.*

If the representation of the services CN members are willing to provide within a collaborative services ecosystem is made in a pro-active manner, through behaviours performed by the service representation computational elements, it might be possible to take advantage of this behavioural aspect also in the services composition processes. In other words, if part of the configuration of such computational elements is the definition / configuration of their behaviours, it might be possible to create behaviours dedicated to part of the services compositions processes and include them built-in such computational elements.

One particular example of behaviour that will be used along this dissertation is finding new collaborative opportunities where the represented services might be included. This is an example of behaviour that will be included built-in the computational elements that represent CN services, meaning that they will contribute in this early task of the service composition processes.

From the collaborative services ecosystem side, there will be the need to provide the means for these mechanisms to be implemented through the behaviours of the CN members service's representatives.

3.2. Base Concepts

Based on these research questions and the corresponding hypotheses, the following sections introduce the proposed Pro-Active Services Ecosystem Framework (PASEF) - a conceptual framework which is organized in four groups of concepts:

1. Service Stereotyping related concepts (SS) - the concepts included in this first group support the construction of a Service Taxonomy for the CN members to follow in order to benefit from a common understanding concerning the services they provide within the ecosystem.
2. Membership Modelling related concepts (MM) - the concepts included in this group model the CN members and the corresponding services within a collaborative Services Ecosystem.
3. Quality of Service Mechanism related concepts (QoSM) - this group includes the concepts and mechanisms created to both benefit from the active service representation and include the contribution of clients in the QoS assessment through the manifestation of their satisfaction concerning services provided.
4. Business Process Modelling (BPM) - Finally, for each Collaboration Opportunity (CO) an associated business process will exist. This group of concepts include the elements needed to model this kind of processes, starting from their early stage of the specification of the services needed to achieve the goals of such CO, passing through the selection of the providers for each service, until the execution of the resulting model - provision of the included services by the selected providers.

Figure 3-1 represents the 4 conceptual groups in a graphical form, meaning that the Service Stereotyping and the Quality of Service conceptual groups constitute the base of the framework, on top of which the Membership Modelling related concepts can be defined. Based on these three conceptual groups, the Business Process Modelling related concepts are placed on top as the overall aim of the framework, to some extent.

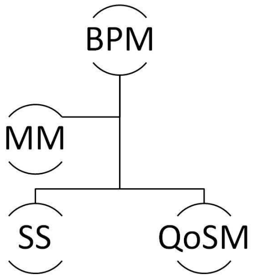


Figure 3-1 - PASEF Conceptual Groups

It is worth to list and slightly describe the actors / roles that will interact with PASEF:

- CN members – the service providers that will configure a computational element that will represent their services towards their business interests.
- Clients – the clients of the collaborative services ecosystem expressing their needs that will become collaboration opportunities.
- Intermediaries or brokers – one can say that these actors are part of the collaborative services ecosystem, like the CN members. They will be the ones that make the bridge between the clients and the providers, as mentioned before.
- Behaviour Modelling Specialists – also part of the services ecosystem. These will be the ones responsible for the definition of the most commonly used behaviours.

3.2.1. Service Stereotyping (SS) Related Concepts

The creation of a collaborative Services Ecosystem, including distinct service representatives needs a common understanding of the services that CN members provide. For this reason, the Service Stereotyping provides a set of concepts that the initiators of such ecosystem instantiate towards a smooth future work within this organizational structure.

If, for example, two distinct CN members provide a similar service, they should follow a common definition, instead of making their own definitions, towards avoiding misunderstandings or interoperability problems. Common definitions should be provided by the collaborative services ecosystem.

On the other hand, within a specific economic area, it can be possible to define, at an abstract level, a commonly used set of services that the entities from that area usually provide. These definitions should be made in a “meta” format in the sense that they would be higher-abstraction-level definitions of services. As a result, these meta-definitions should include not only standard terminology, but also a common interface of each service, identifying elements like for example the input information, needed by the service in order to pursue its objectives, and the expected results, both in terms of what information is considered and the corresponding format.

The Service Stereotyping related concepts is a group of three definitions that formalize the proposed solution for the described needs, as follows:

- **Meta-Service** – the Meta-Service concept corresponds to the interface of the service, identifying what the CN members that provide such service are expected to perform. The concept includes elements like a service description with the specific details from that service.
- **Service Category -** the Service Category concept groups distinct Meta-Services under a single set according to some common characteristics that are identified by the ecosystem initiator or administrator.
- **Service Taxonomy -** Finally, the Service Taxonomy concept may include distinct Service Categories and the corresponding Meta-Services. The definition of a Service Taxonomy is the first step taken by the collaborative Services Ecosystem initiator for future guidance of its members, who are willing to join such Ecosystem.

Figure 3-2 represents an example of Taxonomy of consultancy services from an association composed of senior professionals. In this particular case, several categories of services correspond to distinct expertise the SPs have attained in their life-long experience, for example working in plastic industry. As a result of that expertise, these SPs act as specialists that may help entrepreneurs when they are in the process of, or about to start a new business in this area.

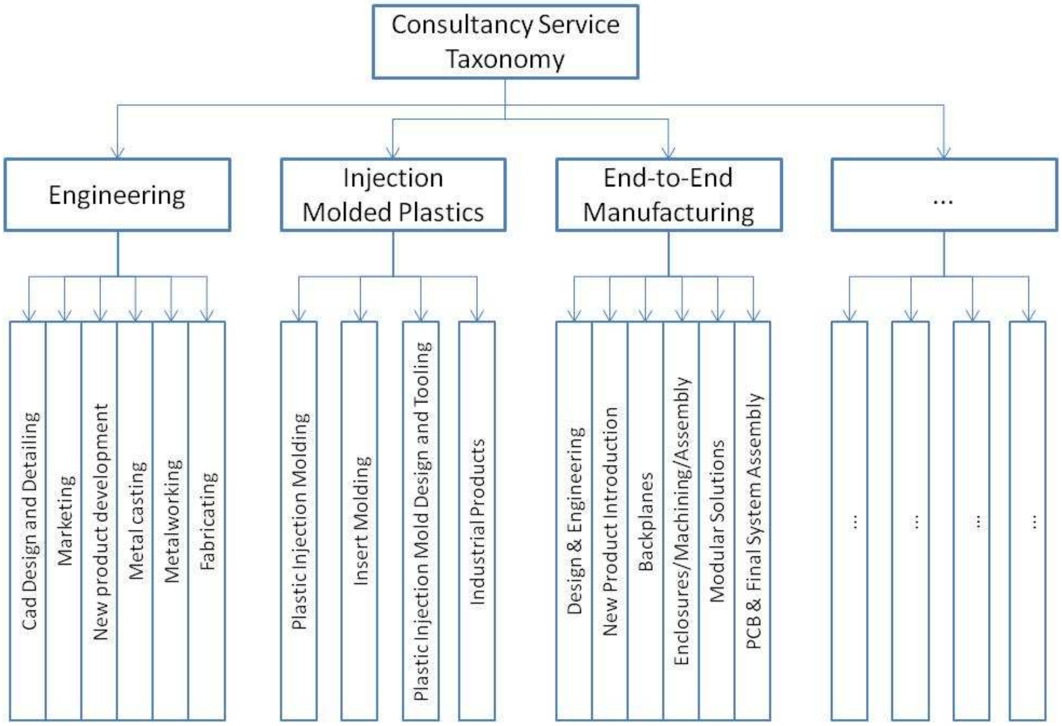


Figure 3-2 – Example of Senior Professional's Association Consultancy Service Taxonomy

Figure 3-3 represents the relation between the three concepts. A taxonomy is composed of several Service Categories, each having a set of Meta-Services. In the opposite direction, a Meta-Service belongs to a single Service Category that, itself, belongs to one Service Taxonomy. Usually, a collaborative Services Ecosystem will correspond to a particular economic activity area and a single Taxonomy will be defined in that area. A special case may happen when a collaborative Services Ecosystem covers more than one economic activity area. For that case, more than one Service Taxonomies may exist.

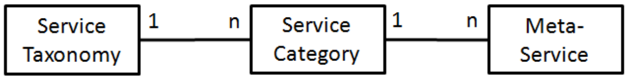


Figure 3-3 - Relation between the three Services Stereotyping related concepts

Naturally, a Service Taxonomy definition made by the Ecosystem initiator at an early stage of the Ecosystem may evolve through time. For example, whenever a member is editing his or her profile, expressing the intention to provide a new service, he or she selects and configures a pre-defined Meta-Service within that Ecosystem's Taxonomy. Nevertheless, there may be cases where the services CN members are willing to provide do not fit in any Meta-Service definition from the Ecosystem's Service Taxonomy. For that reason, the initiators act as moderators and may add a new Meta-Service definition and, starting from that point in time, this member may complete a profile definition and other members may also express that they are willing to provide a service implementation of the newly created Meta-Service, as well. A similar evolution may happen at the Service Category level. This happens when a new Meta-Service is being added to the taxonomy, but it does not fit in any existing Service Category. In that case, a new Service Category will be defined, in order to include the new Meta-Service. Finally, a third taxonomy evolution hypothesis exists, both at the meta-Service level and the Service Category level. That is the case where the existing definitions become obsolete and have to be updated. This may happen, for example, when the experience taken after several usage cases results on a know-how that invalidates previous definitions or simply shows the need to upgrade them.

Based on this taxonomy, it becomes possible to specify a workflow of services needed to be performed in response to a collaboration opportunity. In the example taxonomy of the figure, a workflow of consultancy services in the area of plastics can be built for the creation of a new business.

The formal definitions of the three concepts follow:

Definition SS 1: Meta-Service

A Meta-Service is an abstract definition of a service to which concrete services provided by CN members have to comply. A Meta-Service MS can be expressed as a tuple:

$$\mathbf{MS = < N, C, D >}$$

where:

- N – Meta-Service Name – the identification of the Meta-Service.
- C – Category – the category to which the Meta-Service belongs.
- D – Description – particular characteristics of MS, like the specification of needed input information and output result.

Definition SS 2: Service Category

A Service Category is a group of Meta-Services that share some common characteristics, within a given Taxonomy. A Service Category SC can be defined as a tuple:

$$\mathbf{SC = < N, D, T >}$$

where:

- N – Service Category Name – the identification of the category of services.
- D – Service Category Description – description information including common characteristics of the services from SC.
- T – Service Category Taxonomy – the Ecosystem's Services Taxonomy.

The following rule applies to a Service Category SC, stating that the elements of the Service Category have to be defined, *a priori*, as a service category needs an identification towards being referenced, it needs a description towards being understood and it belongs to a given taxonomy.

$$\forall \mathrm{SC}, \exists\ (\mathrm{N}, \mathrm{D}, \mathrm{T})\ \mid \mathrm{N} \neq \mathrm{null}, \mathrm{D} \neq \mathrm{null}, \mathrm{T} \neq \mathrm{null}$$

Definition SS 3: Ecosystem's Service Taxonomy

An Ecosystem's Services Taxonomy, Taxonomy for short, is the specification of a common understanding about services to be provided within that Ecosystem. A Taxonomy is composed of generalization / specialization hierarchical relationships among a super-type of services – the Service Categories - under which the Meta-Services are defined. The main goal of this taxonomy is to foster better communication among users, avoiding misunderstandings concerning the service definitions. A Taxonomy T may be defined as a tuple:

$$\mathbf{T = < N, D, SCS >}$$

Where:

- N – Ecosystem Taxonomy Name – the identification of the Taxonomy.
- D – Description of the Taxonomy – including the economic area to which it concerns.
- SCS – Service Category Set.

The following rules apply to every Taxonomy to guaranteeing it must have an identification and a description towards being referenced and understood; as well as a non-empty set of service categories. The 2nd and 3rd rules guarantee an hierarchical organization of the Taxonomy.

i. None of the values N or D, corresponding to the definition of a Taxonomy T, may be null nor the set of service categories SCS may be empty:

$$\forall\ \mathrm{T}, \exists\ (\mathrm{N}, \mathrm{D}, SCS)\ |\ \mathrm{N} \neq \mathrm{null}, \mathrm{D} \neq \mathrm{null}, SCS\ \neq \emptyset$$

ii. For each Meta-Service MS, there exists one and only one Service Category SC associated with it:

$$\forall\ MS, \exists^1 SC$$

iii. For each Service Category SC, there exists one and only one Taxonomy T associated with it:

$$\forall\ SC, \exists^1 T$$

3.2.2. Membership Modelling (MM) Related Concepts

After the definition of the collaborative Service Stereotyping related concepts, a set of concepts is needed to model CN members, what they are able to provide and the ecosystem itself. The Membership Modelling related concepts tackles this need through the introduction of 5 concepts. Four aspects introduced in this conceptual set are: 1) the elements that actively represent the services CN members provide; 2) the ability of such active service representatives to take the initiative of suggesting the inclusion of one or more of the services they represent in a BPM that is being built; 3) the introduction of an actor, that will be responsible to make the bridge between clients and CN members – the Intermediary or Broker; 4) the Services Ecosystem itself, working as a collaborative space where clients and providers find a set of functionality that fosters collaboration. In other words, the Services Ecosystem will be a space that brings together CN members through their service representatives, in order to pursue business success namely finding new business opportunities and improving the chances each CN member has to see his or her services being selected among competitors, based on QoS, for example.

The Membership Modelling conceptual set is composed of:

- **Service** – based on a specific meta-service that is an abstract definition, concrete services are modelled as instances of such meta-services. Whenever a CN member is willing to provide a new service, he or she selects the corresponding meta-service and instantiates it concerning its particular details. The concept also includes a set of Service Connections, defined by the CN member, as a specialist in that service area, identifying the relation among distinct Meta-Services. These Service Connections will support the posting of suggestions, other than proposals, whenever collaboration opportunities are found for connected services. If, for example, a CN member provides an implementation of the

Meta-Service MS1 and states that it is connected to another Meta-Service MS2, whenever the need for MS2 is found in a given collaboration opportunity, a suggestion can be made to include MS1 as well in the corresponding business process model (BPM).

If for example the service “Project Injection Molding” is provided by Mr. William, it might be possible that Mr William considers that every time he provides this service, the clients also ask for the “Insert Molding” service. Through this Service Connection mechanism, it becomes possible to express this know-how in the service area where his expertise reflects a life-long experience. As a result, if one considers a BPM that includes the first service, it is reasonable to consider suggesting the inclusion of the second service in the same BPM, improving the success for that service representation / promotion.

- **Service Entity (SE)** – the concept that models the entity (CN member), from the perspective of the services it is willing / able to provide, in an integrated manner. It includes all the services aggregated within this construct along with attributes from the CN member. This aggregation is of particular use, namely for the case where a particular collaboration opportunity requires two or more distinct services that may be provided by the same CN member. On the other hand, it also includes information from the service provider (the CN member attributes) that may be useful for a selection process undertaken by a client or a broker.
- **Pro-Active Service Entity (PSE)** – A PSE extends a Service Entity element with the ability to behave in a pro-active manner. As mentioned before, this auto-initiative behaviour can be configured towards finding new business opportunities or improving the chances that the represented services have to be selected in a given collaboration opportunity, through behaviours that try to make suggestions, other than proposals, for example.
- **Behaviour Definition** – The performance of a PSE towards pursuing the goals of the represented CN member is made through behaviours that the CN member may select and tune / configure. The concept of Behaviour Definition includes a triggering mechanism, identifying any periodicity or timing when the Behaviour will be launched; pre-conditions needed to assess if the behaviour can take place and post-conditions used to assess its success. Moreover, a Behaviour definition is specified as a workflow of actions that the PSE will perform in order to pursue the desired goals.
- **Services Ecosystem** – Finally, the collaborative Services Ecosystem can be defined as an environment, composed of services as the base element, created to provide the needed conditions to foster collaboration among CN members. This space brings together both the CN members, the Brokers and Clients in a single space. The Ecosystem tracks the

collaboration opportunities and the corresponding proposals and / or suggestions, storing such data in a pool. This pool of historical and performance data regarding service provision can be used afterwards in order to support the selection of potential partners for a given collaboration opportunity.

Figure 3-4 shows the relations among the 5 Membership Modeling concepts:

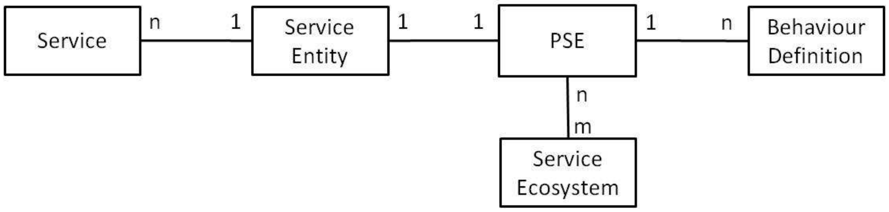


Figure 3-4 - Relation between Membership Modelling related concepts

As described before, a Service Entity represents the services provided by one CN member, as well as a set of attributes from the CN member itself. A PSE corresponds to one Service Entity and its configuration can be made of several behaviour definitions, whilst a single behaviour belongs to only one PSE. Finally, Services Ecosystems have many PSEs and one PSE may potentially be registered in more than one Ecosystem. The formal definitions of the 5 Membership Modelling concepts follow:

Definition MM 1: Service

Service is the concept that models what a CN member is willing to provide to the clients. In other words, a service is a concrete instance of a Meta-Service. The concept also includes two other elements defined by the CN member:

- Provision Conditions – specifying constraints for the service provision to be accepted.
- Service Connections – expressing know-how in what concerns other correlated services that usually are requested along with it. This relation is expressed connecting the Meta-Service implemented by the modelled service with a set of other Meta-Services, as detailed below.

A Service S can be expressed as a tuple:

$$\mathbf{S = < N, M, MS, SPC, SC >}$$

Where:

- N – Name – the identification of the Service.
- M – CN Member – the identification of the CN member that provides the specific service.
- MS – Meta-Service – the Meta-Service, defined in the Ecosystem's Service Taxonomy, of which S is an instance.
- SPC – Service Provision Condition set – $\{spc_i \mid i \in \mathbb{N}\}$
- MSC – Meta-Service Connection Set – $\{msc_i \mid i \in \mathbb{N}\}$ – identifying other Meta-Services to which the Meta-Service MS is connected to. A Service Connection msc_i can be represented as a tuple:

$$\mathbf{msc_i = < C\text{-}MS, R, D >}$$

Where:

- C-MS – The Meta-Services Connected to MS.
- R – The rating of the connection, indicating how often it happens.
- D – Directionality of the connection. The possible values are:
  - 0 – bidirectional connection
  - 1 – form MS to C-MS – a need for MS expressed in a BPM being built induces a need for C-MS. For that reason, the inclusion of C-MS in that BPM is suggested.
  - -1 – from C-MS to MS – a need for C-MS expressed in a BPM being built induces a need for MS. For that reason, the inclusion of MS in that BPM is suggested.

The diagram from Figure 3-5 represents a service connection between Meta-Service 1 (the Meta-Service MS that Service S implements) and Meta-Service 2 (the Meta-Service C-MS that might be implemented by some other Service X) to which MS is connected with 70% strength. The arrows in the diagram represent the three hypothesis of directionality of the relation. In this example, the directionality value of 1 (from MS to C-MS), meaning that when a Service implementing Meta-Service 1 is included in a BPM, usually a service implementing Meta-Service 2 will also be identified afterwards.

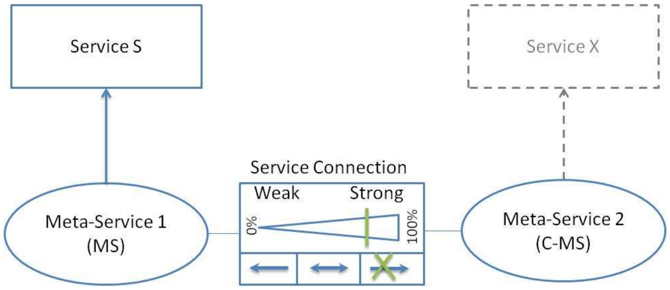


Figure 3-5 - Service Connection

Naturally, the knowledge manifestation made by a single service provider only influences the pro-activeness of the constructs that represent the services such enterprise or professional may provide. In other words, some other entity that also provides an implementation of the Meta-Service 1, from the above mentioned example, may connect it with some meta-service other than Meta-Service 2, if that is his or her understanding.

Definition MM 2: Service Entity

Service Entity is a construct that models CN members from the service provision perspective. It includes the Services a particular CN member is willing to provide and a set of other attributes modelling relevant characteristics of that CN member[1]. A Service Entity SE can be represented as a tuple:

SE = < M, ATS, SS >

Where:

- M – CN Member – the identification of the CN member.
- ATS – Attribute Set – $\{attr_i \mid i \in \mathbb{N}\}$ –set of relevant attributes of the corresponding CN member
- SS – Service Set – $\{ss_i \mid i \in \mathbb{N}\}$ – the set of services provided by the CN member.

After presenting the Service concept, a higher level concept is needed to aggregate distinct services, as mentioned before. This aggregation opens the possibility to create integrated bids or proposals for a given collaboration opportunity (CO). If, for example, a CO_1 is specified including the need for 10 services that implement the Meta-Services MS_1, MS_2 … MS_{10}, and if a given CN member provides services that implement MS_2, MS_7 and MS_{14}, the proposal from that CN

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[1] Notion similar to (Franco et al., 2009a, 2010)

member to CO_1 may include the services it provides implementing the Meta-Services MS_2 and MS_7.

Before the definition of the Pro-Active Service Entity, other than its Services and the Service Entity building blocks, a third definition is needed in order to model the pro-activeness of that construct. In other words, the Behaviour Definition is the concept that models the *how*, *when* and *what* of the behaviours from a PSE:

- How: the workflow of actions that the PSE will perform.
- When: the triggering rules and a set of pre-conditions that model when the behaviour will take place.
- What: a set of goals that the behaviour should achieve, used to assess its success.

With the Behaviour Definition concept, CN members can configure PSEs that represent their services as ambassadors in the ecosystem in the way that best fits their particular needs. As mentioned before, the definition of behaviours is intended to be used by specialists or administrators. In a specific system that might implement these concepts, the CN member might only need to select and slightly configure the behaviours that best fit his or her needs. Figure 3-6 represents the relation between distinct service providers and the corresponding PSEs, forming two distinct environments: the real (physical) world and the collaborative service ecosystem (cyberspace).

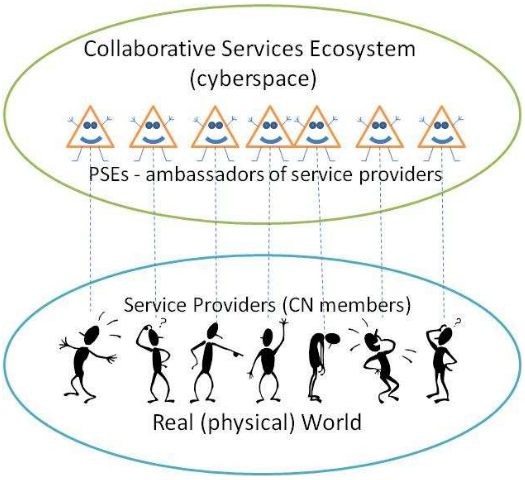

Figure 3-6 - Real (physical) world and Collaborative Services Ecosystem (cyberspace))

Definition MM 3: Behaviour Definition

A Behaviour Definition specifies the actions that a PSE will perform and the event that triggers such behaviour. A Behaviour Definition BD can be expressed as a tuple:

BD = < ID, D, TM, BWD, PREC, POSC >

Where:

- ID –Identifier – the Identifier of the behaviour.
- D – Description – a description of the behaviour.
- TM – Triggering Mechanism – timings, frequency and / or data-flow conditions specifying when the execution will be launched.
- BWD – Behaviour Workflow Definition – specification of the base functions that are used within the behaviour, their input information needs, output results and their execution flow graph.
- PREC – Pre-Condition Set – $\{prec_i \mid i \in \mathbb{N}\}$ – a set of conditions to be verified before the behavior is launched.
- POSC – Post-Condition Set – $\{postc_i \mid i \in \mathbb{N}\}$ – a set of conditions to be verified after the behaviour finishes, assessing its success.

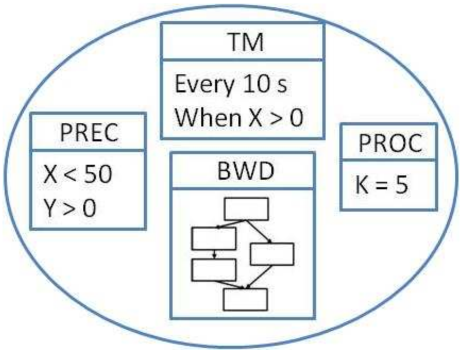

Figure 3-7 - Behaviour Definition Example

Figure 3-7 represents a Behaviour Definition example. It is worth to highlight the matching between the elements of this definition and the needs mentioned before: how, when and what:

- How – The Behaviour Workflow Definition dictates what the behaviour is intended to do when it is launched towards achieving the desired goals.

- When – the Triggering Mechanism dictates how often the behaviour should take place. In other words: when should the PSE "wake up" to perform this behaviour? Another aspect is a set of pre-conditions that might have to be verified before the workflow takes place. It might happen that the PSE has been "waken up" to perform a specific behaviour, but specific conditions do not allow it to start the workflow.
- What – the Post-Conditions to be verified towards assessing the behaviour success.

The Pro-Active Service Entity (PSE) is now introduced based on the above concepts. A PSE is a software component that will represent CN member's services, behaving towards promoting the represented services. This representation includes business opportunity procurement or service selection chances improvement, for example. The PSE also prepares proposals for any business opportunity that matches the services it represents and / or creates suggestions based on service connections specified by the CN member. It is also worth to notice that a CN member can choose / configure more than one behaviour in order to tackle distinct pre-condition scenarios. Figure 3-8 represents one PSE.

Definition MM 4: Pro-Active Service Entity (PSE)

The Pro-Active Service Entity is a concept that includes a CN members' Service Entity and a set of behaviours selected and configured by this CN member towards representation purposes. A Pro-Active Service Entity PSE can be expressed as a tuple:

PSE = < N, ID, SE, BD >

Where:

- N – Name – the identifier of the PSE
- SE – Service Entity – the Service Entity from the CN member including what this member is willing to provide.
- BD – Behaviour Definition set – $\{bd_i \mid i \in \mathbb{N}\}$ – a group of behaviour definitions, selected and configured by the CN member, which specify the pro-activeness of the construct.

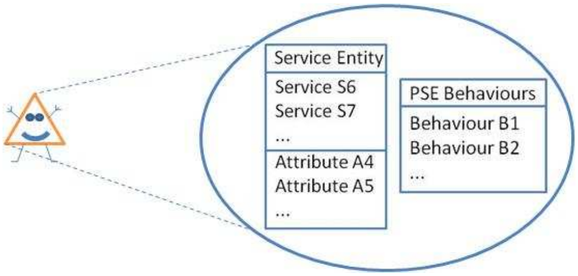

Figure 3-8 - PSE - Pro-Active Service Entity

Finally, the collaborative Services Ecosystem concept is introduced. This concept models the “space” where CN members register themselves and launch their PSEs, on one hand, expecting to find collaboration opportunities for which their services can be included / selected. On the other hand, this is the place where clients go and specify their needs, knowing it is a place where they can benefit both from a pool of providers and performance information mechanisms in order to support their choices. Finally, this space also interacts with an intermediary who is responsible to bridge between clients and providers. In a first stage, this intermediary is responsible to transform high-level need specifications made by clients into workflow documents, composed of Meta-Services defined in the Service Taxonomy. In a later stage, these intermediaries post a call for proposals in a blackboard like infrastructure to include in a system that implements these concepts, wait for the replies, and select the proposals and the corresponding CN members that best fit client’s needs. This process also corresponds implicitly to the creation of consortia composed of the selected CN members.

Furthermore, the collaborative Services Ecosystem has also the role to track all the service provisions, as well as all the corresponding calls for proposals. This monitoring task provides accurate performance information concerning all CN members, as mentioned. Based on this information, the collaborative Services Ecosystem may also provide Certification functionality upon request. Finally, it also gathers client’s satisfaction in order to add more data for Quality of Service assessment, as explained bellow, that is used for service selection purposes.

Definition MM 5: Services Ecosystem

A collaborative Services Ecosystem concept, Ecosystem for short, brings together CN members through their PSEs, final clients and intermediaries or brokers in a collaborative space fostering collaboration. This is a central place that manages information both concerning service providers and clients, as well as the Collaboration Opportunities offered by clients and performed by the providers. The Ecosystem also stores information concerning the Brokers that make the bridge between clients and providers, as well as Performance Measurement information used for QoS purposes. Finally, the Ecosystem provides a set of functionality groups towards fostering the collaboration between members, among which certification mechanisms attest PSEs performance on demand. A collaborative Services Ecosystem SEcoSys can be expressed as a tuple:

SEcoSys = < N, ST, PS, CS, BS, CO, CR, PM, BF >

Where:

- N – Name – the identifier of the collaborative Services Ecosystem.
- ST – Service Taxonomy – the base Service Taxonomy used in all interactions by the PSEs within the Ecosystem in order to guarantee a common understanding on service definitions.
- PS – PSE set – $\{pse_i \mid i \in \mathbb{N}\}$ – set of PSEs that represent CN members' services within the collaborative Services Ecosystem.
- CS – Client set – $\{clnt_i \mid i \in \mathbb{N}\}$.
- BS – Broker set – $\{brk_i \mid i \in \mathbb{N}\}$.
- CO – Collaboration Opportunity set – $\{co_i \mid i \in \mathbb{N}\}$ – set of client needs / business opportunities specified by the clients in the first place and further detailed by the intermediaries or brokers, within the Ecosystem.
- PM – set of Performance Measurement Information tracked within the ecosystem every time a PSE participates in a CO. This set can be expressed as:

  $$\{\mathrm{pm}_{i,j} \mid i, j \in \mathbb{N}, \forall\, \mathrm{pm}_{i,j}\ \exists\ \mathrm{pse}_i \in \mathrm{PS}, \exists\ \mathrm{co}_j \in \mathrm{CO}\}$$

  meaning that every performance measurement information element $\mathrm{pm}_{i,j}$ corresponds to a specific pse_i performance within a collaboration opportunity co_j.
- CR – set of Certification Information $\{\mathrm{cr}_i \mid i \in \mathbb{N}\}$ – the set containing all the certification requests received by the Ecosystem concerning specific PSEs.
- BF – Built-in Functionality – $\{f_{reg}, f_{post}, f_{perf}, f_{certify}, f_{other}\}$ – set of groups of functionality built-in the Ecosystem, based on which the PSE Behaviour Definitions are composed of. The 5 built in functionality groups identified are:
  - f_{reg} – Registration – enabling the CN members to register themselves and launch their PSEs.
  - f_{post} – CO Posting – enabling clients to post their needs in a blackboard-like infrastructure from the EcoSystem and PSEs to reply with their service provision proposals or service provision suggestions.

  - f_{perf} – Performance Measurement – providing PSE performance measurement mechanisms, as well as enabling brokers to grade performance, in order to increase the information on every PSE that is registered in the Ecosystem.
  - $f_{certify}$ – Certification – based on PM information, the Ecosystem may have a component responsible to certify some PSE's QoS upon request.
  - f_{other} – other than the 4 identified functionality groups, each particular Ecosystem may provide specific functionality under this group, that constitutes a possible extension point for the ecosystem.

3.2.3. Quality of Service Mechanism Related Concepts

The Quality of Service Mechanism (QoSM) is a pillar element of PASEF because it provides additional data for a smoother potential service provision's selection. The QoSM is the element that supports that data collection and is intended to be used by the PASEF system itself, through tracking all the service provisions and storing both data concerning QoS for each specific service provision, and performance data. The QoS Mechanism can also be used by clients to express their satisfaction concerning a service provision. All this information is stored in a pool of data that is included in the ecosystem, used afterwards in proposals / suggestions selection processes.

The mechanism is composed of three concepts: QoS Characteristics, QoS Criteria and Client Satisfaction. The QoS Characteristics model data that may be measured and define the way these data should be measured. These data are associated with one of the three possible service provision related information classes: 1) the service; 2) the service provider; 3) the service provision proposal. The QoS Characteristics also have a measurement unit associated with them and a category, useful to group distinct QoS Characteristics.

Definition QoSM 1 - Quality of Service Characteristic

A Quality of Service Characteristic (QoS Characteristic) is a property, either from the service itself, from the provider or the provision proposal, which may be measured and compared among distinct services. A QoS Characteristic can be defined as a tuple:

QoS_Characteristic = < N, IM, MU, C >

Where:

- N – Name – the identifier of the QoS Characteristic.

- IM – Information to Measure – the information that is to be measured.
- MU – Measurement Unit – the unit that will be used in the measurement.
- C – Category – the measurement category, used to group distinct QoS Characteristics.

QoS Characteristics may be created to measure both QoS data or service provision performance data stored in the collaborative Services Ecosystem. Some QoS Characteristics may even correspond to the success of the behaviour of the PSEs, also stored at the ecosystem. Some examples of QoS Characteristics grading Service Providers may include:

- N_COs **-** the number of COs where a specific CN member has been involved,
- BID_Success **-** the number of BIDs posted *vs*. the number of BIDs that really had a selection success,
- Satisfaction **-** the average satisfaction level posted by clients on services provided by a specific CN member,
- OnTimeDeliveryRate **-** percentage of services delivered within the pre-defined time-frame period,
- AverageDelayOnDelivery **-** The average delay time on service accomplishment delivery,
- ...

Based on the QoS Characteristics, it is possible to build the concept of QoS Criteria that is the combination of classification schemas for a set of QoS Characteristics identified as relevant for each specific case.

Definition QoSM 2 - Quality of Service Criterion

A Quality of Service Criterion (QoS Criterion) is the collection of QoS Characteristics and a corresponding evaluation schema, used to grade distinct service proposals and compare the results. A QoS Criterion can be defined as a tuple:

QoS_Criterion = < N, CS, ES, RC, RF >

Where:

- N – Name – the identification of the QoS Criterion.
- CC – QoS Characteristic Set – the set of QoS Characteristics used in this QoS Criterion.

- ES – Evaluation Schema – the mechanism defined to make a classification based on the QoS Characteristics Set. An Evaluation Schema ES is a set that can also be defined as a tuple:

  $$\mathbf{ES = < (CLN, CLD) >}$$

  Where:

  - CLN –Classification Level Name – the identification of the Classification Level.
  - CLD – Classification Level Definition – the identification of the set / range of values and the conditions that evaluate the corresponding QoS Characteristic value in order to assess what Classification Level a given service belongs to.
- RC **-** Restriction Conditions used to exclude proposals that are out of scope.
- RF **-** the overall Rating Formula.

A QoS Criterion may be defined through the following sequence of steps:

1. Selection of a relevant QoS Characteristic set;
2. Selection / definition of an evaluation schema, e.g., 3 classification levels: Level 1 (best), Level 2, and Level 3 (worst).
3. Definition of how each selected QoS Characteristic fits into the specified schema. For example, if we consider for a given business opportunity where the meaningful QoS characteristics are the number of COs in which CN members have been involved (N_COs), and the Average Satisfaction level of previous clients regarding such CN members, it would be possible to define a QoS Criterion organized in three levels and following the rules:
   - N_BOs **-** Level 3 (values <= 5); Level 1 (values >= 15); Level 2 (otherwise)
   - Satisfaction **-** Level 3 (values <= 5); Level 1 (values >= 8); Level 2 (otherwise)
4. Definition of restrictions, e.g., no proposals should be considered from providers with Level 3 concerning N_COs QoS Characteristic classification.
5. Definition of the overall rating formula for provision proposals, based on the QoS Characteristics selected in 1.

It is interesting to notice that a QoS Characteristic may benefit from the pro-activeness of the PSEs. For example, a scenario can be considered where the fastest PSEs becomes rewarded. In this case, the period of time between the post of a CfP and the corresponding Bids / Proposals is measured and used as a QoS Characteristic that may be used afterwards within a QoS Criterion.

After these 5 steps, the final overall rating formula is used to classify all received proposals and sort them, in order to help the selection task, made by the broker.

The Client Satisfaction assessment is a particular use case of the QoS Criteria concept, which should be expressed every time a service provision takes place. This satisfaction expression is useful to feed PASEF QoS Mechanism with data from the client's perspective. The ecosystem element responsible for gathering these data is the workflow engine, as explained in Section 3.2.5, and based on the concept of Client Satisfaction introduced bellow.

Definition QoSM 3 - Client Satisfaction

Client Satisfaction (CliSat) is a classification, made by the client, on a given service provision under a specific QoS Criterion. A Client Satisfaction CliSat can be defined as a tuple:

CliSat = < QoS_Criterion, (QoSCharacteristic, EV) >

Where:

- QoS_Criterion – the selected Quality of Service Criterion for the evaluation of the Client Satisfaction
- (QoS_Characteristic, EV) – the set of pairs including the QoS Characteristics from the selected QoS Criterion and the Evaluation Value given by the client to that characteristic.

One Example of QoS_Criterion used to gather Client Satisfaction might be composed of the following QoS_Characteristics and the corresponding Evaluation Values:

{(OnTimeDelivery, True), (DelayOnDeliver, 0), (Satisfaction, 10)}

Figure 3-9 shows the relation between the Quality of Service Mechanism related concepts, as well as the corresponding cardinality. It is important to notice that a QoS Criterion may include one or more QoS Characteristics, as expected; and a QoS Characteristic may be used in distinct QoS Criterion, naturally. On the other hand, many Client Satisfaction instances may be expressed using the same QoS Criterion, whilst a single Client Satisfaction refers to only one QoS Criterion.

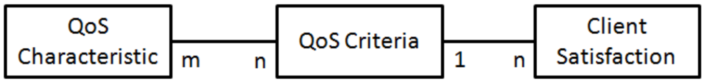

Figure 3-9 - Relation between the Quality of Service Mechanism related concepts

3.2.4. Business Process Modelling Related Concepts

The Business Process Modelling (BPM) related concepts are particularly important, especially in the creation phase of these documents and potentially in the edition at runtime.

In a first stage, the Client specifies its needs in a high-level form in the Services Ecosystem, through an interaction with intermediaries. Then, such intermediaries or brokers have to make a Workflow Model, potentially in interaction with the client. At this first stage, no providers or performers of the services are considered and the objective is the selection of the Meta-Services defined in the Ecosystem Services Taxonomy, towards the achievement of the Client goals. The resulting document is called an abstract Business Process Model (absBPM), since it has no performers yet.

The process needed to create an absBPM specification can be summarized as: identification of needed Activities and Selection of a Meta-Service from the Taxonomy for each Activity; specification of the activity / service flow through the introduction of Transitions; identification of input and result information for the services and potentially introducing conditions in the transitions based on these data; and finally specification of the Start and End points in the graph.

The creation of an absBPM can also be initiated by the Intermediary itself, without any client involvement. In this case, the resulting model is created as a Template for future use by the CN members, based on the notion that many clients may have similar needs.

Definition BPM 1 - Abstract Business Process Model

An Abstract Business Process Model (absBPM) is the definition of the Activities composing a process, as well as a Meta-Service for each activity, identifying what should be provided for each one at runtime. This abstract Model also identifies the Data involved in the Process and the flow of activities that should take place. An Abstract Business Process Model absBPM can be defined as a tuple:

$$\mathbf{absBPM = < CO, AMS, TS >}$$

Where:

- CO – Collaboration Opportunity – the identifier of the CO to which absBPM corresponds, or null for the case of template definitions.

- AMS – Activity and Meta-Service set – the set of activities and the corresponding Meta-Services that can also be defined as a set of tuples:

  AMS = < {A, MS, RD}>

  Where:
  - A – Activity – identifier of an activity.
  - MS – Meta-Service – identifier of a Meta-Service.
  - RD – Relevant Data Set – the information used as input and gathered from the results of the services.
- TS is the Transition set that defines the activity flow at runtime.

The definition of an absBPM follows the rules[2]:

i. For every activity A of the Activity and Meta-Service Set AMS of an absBPM, there exists one and only one associated Meta-Service MS from the Services Ecosystem's Taxonomy T.

$$\forall\ A = \Pi_1(AMS),$$

$$AMS \in\ \Pi_2(absBPM)$$

$$\exists^1\ \mathrm{MS} \in \mathrm{T}$$

ii. For every activity A of the Activity and Meta-Service Set AMS of an absBPM there exists, at least, one transition Tr of absBPM from a Predecessor element P, that may be another activity or the starting point of the model, to A – Figure 3-10 and Figure 3-11.

$$\forall\ A = \Pi_1(AMS),$$

$$AMS \in\ \Pi_2(absBPM)$$

$$\exists\ \mathrm{Tr}(\mathrm{P},\mathrm{A}) \in \Pi_3\mathrm{absBPM}$$

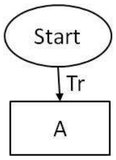

Figure 3-10 - Activity A is preceded by the start element of the graph

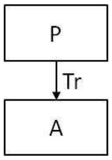

Figure 3-11 - Activity A is preceded by another activity P

iii. For every activity A of the Activity and Meta-Service Set AMS of an absBPM, there exists, at least, one transition Tr from A to some Following element F, that may be another activity or the end point of the model - Figure 3-12 and Figure 3-13.

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[2] The operator $\Pi_N(T)$ corresponds to the isolation of the element of order N form tupple T. Example: if T=(A, B, C), then $\Pi_2(T)$ equals B, because B is the 2nd element within T.

$$\forall\ A = \Pi_1(AMS),$$

$$AMS \in \Pi_2(absBPM)$$

$$\exists\ \mathrm{Tr}(\mathrm{A}, \mathrm{F}) \in \Pi_3(\mathrm{absBPM})$$

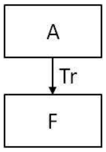


Figure 3-12 - Activity A is followed by another activity F.

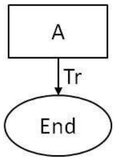


Figure 3-13 - Activity A is followed by the end element of the graph.

iv. For each Meta-Service MS with a parameter set P, there exists a relevant data variable set RD, associating a specific variable rd_j to each particular parameter p_i.

$$\forall\ MS(P) = \Pi_2(AMS), AMS \in \Pi_2(absBPM)$$

$$\exists\ \mathrm{RD} \in \Pi_3(AMS) |\ \exists\ \{p_i, \mathrm{i} \in \mathbb{N}\}, \{rd_j, j\ \in \mathbb{N}\}$$

$$\forall\ p_i \in\ \mathrm{P}\ \exists\ \mathrm{rd}_j \in \mathrm{RD}$$

v. For each Meta-Service MS with an output result set OR, there exists a relevant data set RD, associating a specific variable rd_j, to each particular result or_i.

$$\forall\ MS(OR) = \Pi_2(AMS), AMS \in \Pi_2(absBPM)$$

$$\exists\ \mathrm{RD} \in \Pi_3(AMS)\ |\ \exists\ \left\{or_i, \mathrm{i} \in \mathbb{N}\right\}, \{rd_j, j\ \in \mathbb{N}\}\ \Big|$$

$$\forall or_i \in \mathrm{OR}\ \exists\ \mathrm{rd}_j \in \mathrm{RD}$$

After the specification of an absBPM is complete, the client has to commit to that absBPM in order to go to the next stage that is the selection of CN members who are willing to perform each of the included services. Figure 3-14 illustrates an example of an abstract Business Process Model composed of 4 Activities.

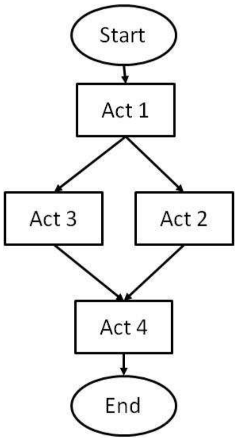


Figure 3-14 – Example Abstract BPM

The transformation of an absBPM into a BPM ready to be executed is the point where the main advantages of the pro-activeness from the PSEs take place, as well as the QoS Mechanism feedback. There, a call for proposals is made and the PSEs, which frequently check for new business opportunities, have their chance to make proposals or suggestions. After a pre-defined time-frame, the potential performers' selection process starts. First, PASEF excludes the proposals that do not fit the pre-defined conditions' set. Next the Broker selects the best proposals and includes the corresponding CN members as performers in the BPM, based on parameters like price or delivery time, depending on the specificities of the particular case, but also taking benefit from their QoS ratings.

There are two possibilities for an absBPM to become executable:

1. All the services have at least one selected performer.
2. At least the services from the starting activities in the absBPM have a selected performer.

This second possibility is the minimal case under which the execution can start, leaving some performers' selection task to a later time during the BPM execution.

From the client's perspective, one of the main advantages of the PASEF approach is that instead of asking for proposals from a limited set of potential providers that he or she may know *a priori*, posting calls for proposals within a Services Ecosystem potentially opens the possibility to receive proposals from unknown potential providers. This fact introduces an advantage and a drawback. The advantage is that the number of proposals potentially increases through the inclusion of proposals of potential providers that are unknown by the client. The drawback is that because of being unknown, an uncertainty factor is introduced. This drawback is tackled by the

QoS mechanism introduced in the previous section, which gives the client the needed QoS information concerning all the providers.

Definition BPM 2 - Call for Proposals

A Call for Proposals is the first step for the transition of an abstract BPM into an executable specification. A Call for Proposals CfP can be expressed as a tuple:

CfP = < BPM, NSS, GPC >

Where:

- BPM – Business Process Model – the model to which the call corresponds. This is the link to the abstract BPM that is about to become an executable BPM.
- NSS – Needed Services Set – the services that are in need and for which the proposals are expected. A Needed Services Set can also be expressed as a set of tuples:

  NSS = {(MS, SC, PC)}

  Where:
  - MS – Meta-Service – the identifier the Meta-Service requested. Proposals of Services implementing MS are expected.
  - SC – the Meta-Service Category.
  - PC – Service Provision Conditions – the conditions to which the proposals should comply.
- GPC – General Proposal Conditions – general conditions to which the proposals also have to comply.

As mentioned, the CN members' pro-active service representative - the PSE - checks for service needs in a pre-defined frequency-rate. Whenever a Call for Proposals is posted in the blackboard-like element from the collaborative Services Ecosystem, in a short time-frame period all PSEs become aware of the needs expressed in that CfP. If a PSE finds out a direct match, which happens in the case it represents a subset of the needed services; it becomes possible to post a proposal. In other words, when a CN member provides service Sx and a CfP is posted expressing the need for Sx, the PSE that represents such CN member’s services becomes aware of that match and may prepare a proposal or Bid for that case.

Definition BPM 3 – Service Provision Proposal

A Service Provision Proposal (SPP) is the provision intention expression made by the PSE, trying to be selected for a given client's need. A Service Provision Proposal SPP can be expressed by a tuple:

$$\mathbf{SPP = < SP, GPC >}$$

where:

- SP – Service Proposals – a set of services the CN may provide. The Service Proposals SP can be expressed by a set of tuples:

  $$\mathbf{SP = \{(S, SC, PC)\}}$$

  Where:
    - S – Service – the identifier of the Service;
    - SC – Service Category – the category of the proposed service; and
    - PC – Provision Conditions – a set of service provision conditions for that service.
- GPC – General Proposal Conditions – general conditions concerning the whole service provision proposal SPP.

It is interesting to notice that one service provision proposal may target more than one single service need. This corresponds to the situation where a CN member has the provision ability for more than one of the service needs expressed in the CfP. In this special case, promotional Service Provision Conditions may be expressed in the proposal applied if the Client and the Intermediary select more than one service included in the proposal, for instance. These promotional conditions are included in the General Proposal Conditions. For example, if a proposal includes three services, a promotional condition of 10% discount in the price can be considered for the case where the three services become selected.

It is also interesting to notice the similarity between the two definitions: Call for Proposals and Service Provision Proposals, because of their complementarities. In the first case, service needs are expressed, including the conditions to which the proposals have to comply, whilst in the second case, a subset of the needed services is included and provision conditions are expressed, this time from the providers' perspective. The Provision Conditions expressed in the proposal made by the PSE should comply with the Provision Conditions expressed in the Call, naturally.

Based on the Service Connections defined by the CN members, the PSEs will be looking also for indirect matches. That is the case when a CN member connects service Sx with service Sy, expressing his know-how in that specific service area and saying that 70% of the times Sx is requested, Sy is also in need, for example. In this case, if there is a call for proposals that includes Sx and if the PSE of that CN member represents Sy, it will prepare a Suggestion.

Definition BPM 4 – Service Provision Suggestion

A Service Provision Suggestion (SPS) is similar to a proposal and is a provision intention expression made by a PSE, this time trying to be included in a BPM definition from a given client. A suggestion can be expressed as a tuple:

SPS = < SS, GSC >

where:

- SS – Services Suggestion – is the set of services that a CN member suggests to be included. The Service Suggestions can be expressed as a set of tuples:

  SS = {(S, SC, BS, BSC, PC)}

  Where:
    - S and SC are the Suggested Service and the corresponding Service Category
    - BS and BSC are the Base Service need and the corresponding category, based on which this suggestion takes place
    - PC Provision Conditions, corresponding to that service provision conditions
- GSC is a set of General Suggestion Conditions from S.

The definition of a Service Provision Suggestion is similar to the definition of a Service Provision Proposal, since it also expresses a provision intention. The only additional information is the service based on which the suggestion took place.

The selection of more than one service to be provided by the same CN member naturally reduces the final number of CN members that are needed to form the consortium for that Collaboration Opportunity. As a consequence, all the overhead taken with the agreement reaching process is reduced, namely in the contracts that have to be celebrated. Although consortia formation cost analysis is out of the scope of this work, this consortium reduction is a clear advantage of the PASEF usage.

Figure 3-15 shows graphically an executable BPM based on the abstract BPM from Figure 3-14, where only 3 performers were selected for the services of the activities. In this example Participant 2 has suggested the inclusion of another service and the corresponding activity (Act 5) was added to the model. The representation follows the Business Process Modelling Notation (BPMN) standard and thus each line corresponds to a performer and the services themselves are not represented.

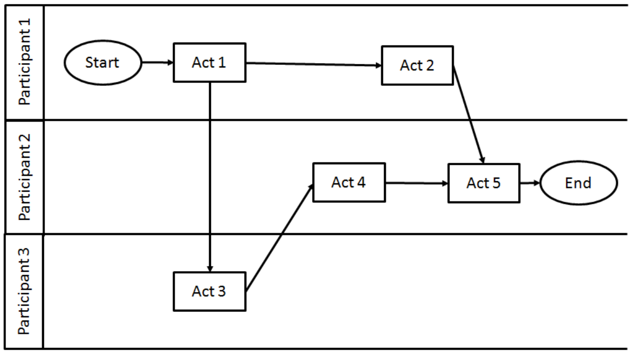


Figure 3-15 – Example of Executable BPM

Definition BPM 5 - Executable Business Process Model

An Executable Business Process Model (eBPM) is the completion of an absBPM, through the selection of service provision proposals and maybe following some suggestions and including new activities and the suggested services. An Executable Business Process Model eBPM can be defined as a tuple:

$$\mathbf{eBPM = < CO, AMP, RD, TS >}$$

Where:

- CO – Collaborative Opportunity – the CO to which eBPM corresponds.
- AMP – Activity, Meta-Service and Proposals set - is the set of Activities, the corresponding Meta-Services, as well as a Set of Provision Proposals, that can also be expressed as a set of tuples

$$\mathbf{AMP = \{(A, MS, SPP, RD)\}}$$

Where:

  - A – Activity – the activities composing the BPM.

  - MS – Meta-Service – the Meta-Service assiciated with the activity.
  - SPP – Service Provision Proposal set – the set of proposals that have been selected to perform the corresponding service. This set is sorted according to the selection made by the broker or intermediary. If nothing goes wrong at runtime, only the first element of the set will be used. Otherwise, if for example the first selected provider becomes unavailable, there is the pre-defined possibility to resort to one of the other selected providers.
  - RD – Relevant Data Set – the data variables used as input parameters and output results of the services.
- TS is the Transition Set that defines the activity flow at runtime.

The definition of an eBPM follows the rules of an absBPM plus a sixth rule created to guarantee that the services within the model have at least one performer associated with them. This rule is mandatory only for the initial services of the model. The rule is defined as follows:

vi. For every Activity A associated with a Meta-Service MS, if there is a transition Tr from the Start point in the workflow to A, there must exist a not-empty set of provision proposals SPP identifying potential performer of services implementing MS.

$$\forall\ (A, MS) \in\ \Pi_2(\mathrm{absBPM}),$$

$$\mathrm{Tr(Start, A)} \in\ \Pi_4(absBPM)$$

$$\mathrm{SPP} \neq \emptyset$$

Finally, the executable Business Process Model is similar to the abstract definition, but also including performers in the Service Provision Proposals and their concrete services, rather than abstract service definitions – the Meta-Services. It is interesting to notice that this model includes a subset of the received proposals, rather than a single proposal, as mentioned, in order to cope with the potential need of changing a performer at runtime. Naturally, the proposals included in this list are the only ones that were selected, according to the first validation made by PASEF and the broker selection, made afterwards. They are sorted starting on the one that best fits the needs. This first proposal will be the only one launched, if nothing goes wrong at runtime, as mentioned before.

3.3. Chapter Discussion and Conclusions

This chapter presented the specification of the main concepts composing PASEF - the Pro-Active Services Ecosystem Framework. The main objective was to define a set of base concepts towards an active representation of the services CN members' are willing to provide, following the service orientation paradigm evolution. This goal was achieved through the introduction of pro-activeness elements along with a Quality of Service Mechanism that benefits from such auto-initiative, on one hand, and considers the client's perspective, on the other hand.

The Conceptual Framework is divided into 4 conceptual groups: Service Stereotyping related concepts, Membership Modelling related concepts, Quality of Service Mechanism related concepts and Business Process Modelling related concepts. Together, these concepts open the possibility of creating a collaborative Services Ecosystem composed of CN member's services through representative entities – the PSEs. In other words, such CN members benefit from active constructs they can configure to better represent and promote their services, in an auto-initiative basis, instead of the passiveness of current approaches. Furthermore, the presented Quality of Service Mechanism provides the possibility to improve service selection processes towards rewarding the best providers in terms of QoS and Performance indicators, as well as the possibility to consider previous clients' perspective.

In the next chapter a Logical Architecture and the *proof of concept* PASEF prototype design are introduced.

The shortest
answer is
doing the
thing.

(Ernest Hemingway)

4. Logical Architecture

This Chapter presents the Logical Architecture of the proof of concept support prototype, based on the Pro-Active Services Ecosystem Framework concepts introduced in the previous chapter. The Chapter starts with the description of the adopted software lifecycle phases, followed by a description of an intended usage perspective, gathering the stakeholders understanding of PASEF. It then proceeds with the software Requirements Engineering phase, which is done using the i framework. The analysis and design using UML diagrams conclude the logical architecture of PASEF.*

4.1. Introduction

The design and development of a *proof of concept* support prototype follows an adaptation of the traditional software development processes. This chapter covers the modelling phases of this process, following a top-down approach, in the sense that higher level descriptions and diagrams are progressively turned into software specification models. Figure 4-1 represents the lifecycle of the prototype.

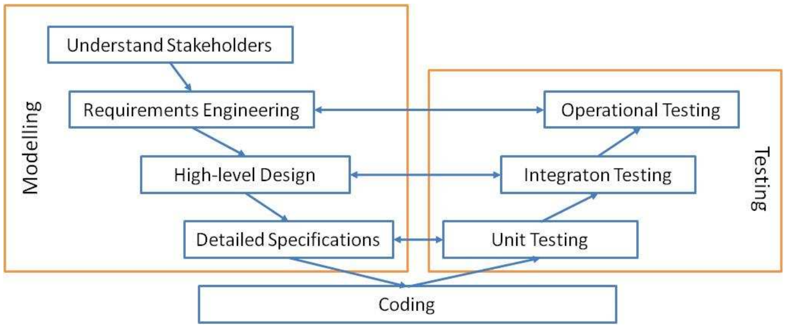


Figure 4-1 – Adopted Software Development Life Cycle

The phases illustrated in Figure 4-1, used in the development of the prototype, are summarized as follows:

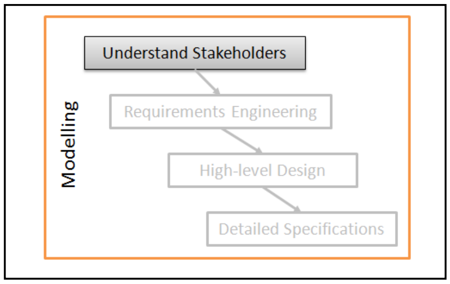
- Understanding Stakeholders' needs and expectations – This is the highest-level definition of the systems to-be developed, mainly from a usage perspective. This phase is added to the typical software lifecycle in order to include documentation from that perspective. Moreover, towards providing a better comprehensive model, the PASEF architecture is defined in three abstraction layers or spaces: the Actors Space, the Service Market Space and the Integrated Service Space. Next, the identification of the main actors is made, as well as their roles and the corresponding mechanisms. Finally, a BPMN-like diagram is presented representing the service composition process, which shows the overall PASEF intended usage phases.
- Requirements Engineering (RE) – The early stage requirements specification is made using i* framework ("i-star"), through the specification of a global "Strategic Dependency Model" (SD) in a former stage, and "Strategic Rationale Models" (SR), in a later stage.
- PASEF Analysis and Design – The pre-coding process is completed with the classical UML mechanisms: first the Use Cases' specification, identifying the interactions or triggers from the actors and the systems, followed by the Class Diagrams of the prototype systems, identifying the main classes and their relations. These two diagram sets constitute the High-Level Design. The Detailed Specification is carried out afterwards using collaboration diagrams that show how the systems will behave whenever each identified Use Case is triggered. In this stage, Sequence Diagrams are selected because of their chronological layout. In specific cases, where iterative processes had to be modelled, state transition diagrams complement these Sequence Diagrams.

This division of the software lifecycle into independent tasks or phases has an organizational advantage concerning major decisions. The correct moments to make such decisions are exactly between each two subsequent stages from the lifecycle. In other words, the documentation produced in the concluding phase is analysed and decisions are made towards a smoother execution of the phase that is about to start. Furthermore, after the modelling phase ends, the coding phase starts and feedback comes from the distinct levels of testing. As a result the overall models are changed accordingly.

In terms of functionality and structure, the framework is composed of a central PASEF system – the Services Ecosystem, as the main software component; and several instances of Pro-Active Service Entities – the PSEs; corresponding to each CN member's services, as another software system from the framework. The framework is intended to be used by: 1) the clients that will be able to specify high-level needs – the collaboration opportunities; 2) brokers that will be able to detail such opportunities into workflow models composed of the services existing in the ecosystem; and 3) the CN members that are the ones providing the services. The mechanism of selecting the best provider(s) for each case will be based on the CO_Board (a blackboard-like infrastructure) that must exist within the Services Ecosystem, where the broker posts the needs, and the Pro-Active Service Entities, that represent CN members and will be checking the CO_Board for business opportunities from time to time, and post Bids or Suggestions. The ecosystem itself will monitor the processes and guarantee Quality of Service measurement and Performance Certification.

The sequence of the detailed modelling process (left side of Figure 4-1) is also the outline of this chapter.

4.2. Understanding Stakeholders' Needs and Expectations



As mentioned in (Ranganathan and Magel, 2010), "successful RE requires understanding the needs of users, customers, other stakeholders and understanding the contexts in which the to-be-developed software will be used". For this purpose, the following section defines the example application scenario where the concepts presented in the previous chapter will be used. Although PASEF is intended as a general framework, applicable to different contexts, the adoption of a particular application scenario helps guiding the understanding of requirements and focusing the validation process.

4.2.1. Example Application Scenario

In this particular case, the base motivation scenario is a PVC of Senior Professionals (SPs), which represents a group to which the "service representation" and the "pro-activeness" elements provided in PASEF can enhance networked operation. As mentioned earlier, Senior Professionals have the ability to add value and contribute to the society, but they have few opportunities / support in order to perform such contribution. The creation of collaborative networks of SPs is important and constitutes a challenge nowadays because of the increase of life expectation, as well as the need for sustainable economies, as foreseen in (Camarinha-Matos et al., 2004). The purpose of such networks is to "support active ageing and facilitating better use of the talents and potential of retired or retiring senior professionals”, as mentioned in (Camarinha-Matos and Afsarmanesh, 2010).

Considering the PASEF assumptions, it would be desirable that in the mentioned scenario Senior Professionals abilities could be represented by active constructs that would find collaboration opportunities for them and improve the chances their services have to be selected. In fact, these constructs are the Pro-Active Service Entities that do not intend to perform the services in substitution of the Senior Professionals, but rather represent them and improve their business success chances.

4.2.2. Multi-Level Modelling

The Pro-Active Services Ecosystem Framework architecture is modelled into three abstraction layers, as represented in Figure 4-2:

- Actors Space – In the lowest layer, we can find free-lancers, enterprises or other organizations that are members of the CN. In the presented motivation scenario, we can find the senior professionals that are willing to continue their working life after retirement.
- Service Market Space – At the middle layer, there are the services the CN members are able / willing to provide – the PSE layer.
- Integrated Service Space – At the top layer, there is the Integrated Services Space, which holds a “higher level” of services that are built from the composition of simpler services and, implicitly, may correspond to consortia created in response to Collaboration Opportunities. As mentioned before, this is also the space for templates of these higher-level services, created by brokers whenever they perceive that several clients share similar needs.

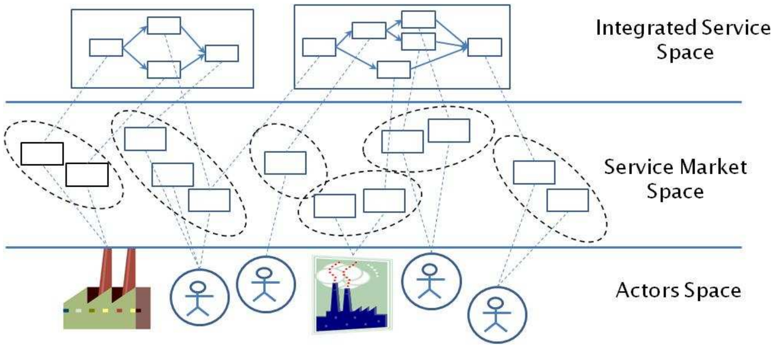


Figure 4-2 - PASEF's 3 abstraction spaces

An example of an integrated service provided by senior professionals is a composed consultancy service created to help entrepreneurs in the creation phase of a new business. In such example, the experience attained by the senior professionals during their life-time is quite valuable for the success of the new business. This Integrated Service could include the following services (inspired in www.secot.org):

- Activity Start Consultancy – helping the entrepreneurs to identify the needed steps in order to create the desired business.
- Quality Management Consultancy – helping the entrepreneurs to identify the quality standards and procedures that should be followed in the intended business.
- Financing Consultancy – helping the entrepreneurs to find the best funding solutions.
- Communication Consultancy – helping the entrepreneurs to decide the best communication infrastructures.
- Accounting Consultancy – helping the entrepreneurs to organize all the accounting issues.
- Strategic Consultancy – helping the entrepreneurs to make their strategic choices both in terms of market opportunities and marketing strategies.
- Legal Consultancy – helping the entrepreneurs to be aware of all the legal constraints involved in the desired business.
- Human Resources – helping the entrepreneurs to make the best decisions in terms of selection of employees and recruiting calendar.

Naturally, these consultancy services have distinct priorities and some may depend on the results of others. As a result, a workflow graph has to be defined, in order to create the mentioned Integrated Service, as detailed later in this Chapter.

The idea behind the creation of PASEF is that CN members, at the Actors Space, register their services and launch a system that represents them – the PSE, that “lives” in the middle layer – the Service Market Space. The PSEs behave towards finding collaboration opportunities and pursuing the creation of consortia, that is the formation of elements of the Integrated Service Space. To some extent, they constitute a bridge between the actors’ space and the integrated service space, in the sense they represent the actors towards taking part of Collaborative Opportunities (COs).

It is important to mention that the actors configure their PSEs, namely in what concerns their autonomy. In the limit scenario, it is possible to consider that the actors configure their PSEs with full autonomy, meaning that the PSE finds the business opportunities, prepare and submit the proposals and suggestions all by their own initiative. In this case, the Senior Professionals see their collaboration preparation tasks “shifted” to PSE monitoring. The opposite case, very limited autonomy, corresponds to the case in which PSEs are simple representatives of SPs, but all the decision-making is on the human side.

This multi-layered modelling spaces diagram also highlights one particular advantage of PASEF approach:

- **Aggregation** – distinct Services from a CN member are aggregated within a single construct – the PSEs at the Service Market Space. This can be useful in a composition process, in order to decrease consortia size, based on the inclusion of partners that can provide more than one needed service.

4.2.3. Actors, Mechanisms and Roles

Taking into account the foreseen usage of PASEF, five Actors are identified:

- CN members – the providers of the services (Senior Professionals, in the considered scenario),
- Clients – making high – level specifications of the needs - the Collaboration Opportunities (COs),
- Brokers – responsible to prepare proposals for clients' needs, select the Services that best fit these needs, as well as the corresponding performers – the CN members,
- Services Ecosystem Administrator, and
- Pro-Active Service Entity – although not a human actor, given their pro-activeness, PSEs are considered actors.

Still from a high-level perspective, the identified roles and the corresponding mechanisms are:

- Services Ecosystem Administration – providing Monitoring function and Managing Performance Information, as well as QoS assessment and certification, both concerning services and consortia, as well as managing client’s satisfaction.
- Service Integration – providing Service composition mechanisms.
- Workflow Engine – providing Service execution mechanisms, needed to launch the correct service at the right moment.
- Assistants to both CN member, Clients and Brokers, which help them interact with the system.
- Service Entity Representation – the PSE role, including mechanisms like:
    - registration in the Services Ecosystem;

  - check for new existing collaboration opportunities;
  - whenever new collaboration opportunities appear, match the expressed service needs with represented services, both directly and indirectly, corresponding to the services provided or to pre-defined service connections;
  - prepare and submit proposals or suggestions for the case of matching success.

4.2.4. Logical Architecture

The Logical Architecture of the Pro-Active Services Ecosystem Framework follows a star-like structure, as shown in Figure 4-3, as the central system – the Services Ecosystem Platform - is surrounded by the CN member representative systems – the PSEs.

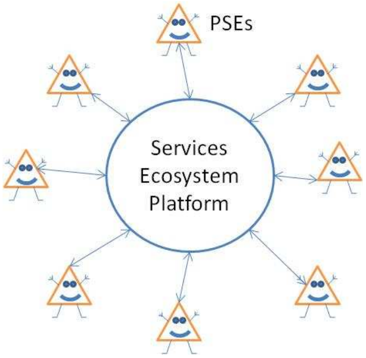


Figure 4-3 - PASEF Star-like platform concept

In other words, the Services Ecosystem is a space composed of a Services Ecosystem Platform as the central system, and the Pro-Active Service Entities, which represent the CN members' services, checking the CO_Board from time to time, trying to participate in Collaboration Opportunities.

The Logical Architecture of the Services Ecosystem Platform is presented in Figure 4-4.

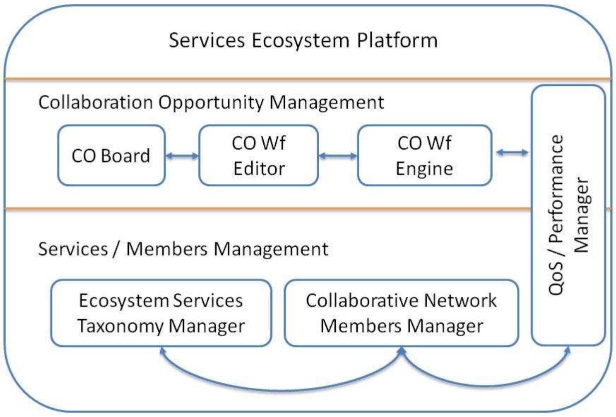


Figure 4-4 - Services Ecosystem Platform Architecture

The Architecture is divided into two layers:

1. Services / Members Management – This layer is responsible for the management of the services provided within the Services Ecosystem, as well as the CN Members that register themselves and the services they are able / willing to provide. This Layer is composed of two modules:
   a. Ecosystem Services Taxonomy Manager – Responsible for the creation and edition of the Meta-Services and the corresponding Service Categories that will be instantiated and provided within the Services Ecosystem,
   b. Collaborative Network Members Manager – The module responsible for the registration / management of the members of the CN. This is also the module responsible for the configuration and launch of the Pro-Active Service Representatives.
2. Collaboration Opportunity Management – This layer is responsible for all the interactions towards supporting Collaboration Opportunities. The modules composing this layer are:
   a. CO Workflow Editor – used by the brokers to create workflow specifications towards tackling specific COs,
   b. CO_Board – blackboard-like infrastructure where brokers post the service needs or opportunities for the PSEs to check, try to match the services they represent and post Bids or Suggestions,
   c. CO Workflow Engine – responsible for the execution of workflow models, launching each service at the right moment, through the corresponding PSE.

The Architecture has a transversal module – the QoS / Performance Manager – that is responsible to track COs' related QoS information, including the proposals or suggestions made by the PSEs. The information stored by this module is used afterwards for selection purposes.

The Pro-Active Service Entity Logical Architecture is shown in Figure 4-5.

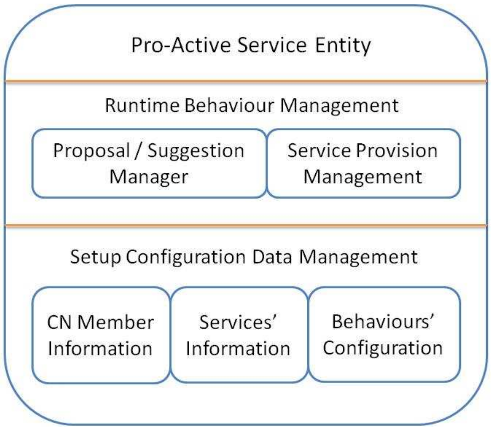


Figure 4-5 - PSE Architecture

The PSE is also divided into two layers:

1. Setup Configuration Data Management - storing information about the configuration given by the corresponding CN member, concerning the CN member itself, the communication mechanisms between the PSE and the CN member; the Services to be represented and the behaviours that the PSE should perform in such representation.
2. Runtime Behaviour Management – this layer is responsible for the performance of the previously selected and configured behaviours, such as checking the CO-Board from the Services Ecosystem Platform, and making the match between the existing open COs and the services that the PSE represents, as well as preparing (and potentially submitting) proposals or suggestions. This layer is also responsible to manage the service provisions, receiving notifications from the Ecosystem Workflow Engine, forwarding them to the CN member and receiving notifications back from the CN member and informing the Engine, when the service provision gets completed.

4.2.5. Service Composition Process

The framework usage process is divided into a chronological sequence of phases (phase I … phase V), as illustrated in Figure 4-6, towards service composition and the corresponding consortia establishment, whenever new collaboration opportunities arise.

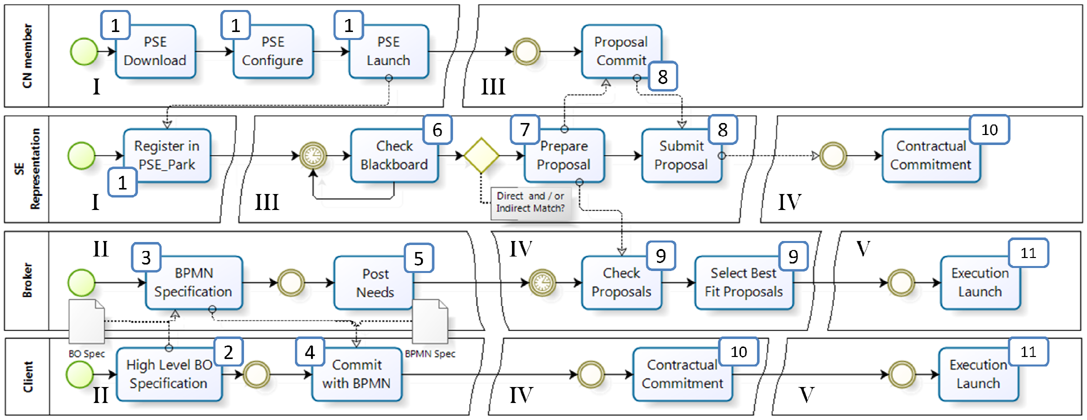


Figure 4-6 - PASEF usage overview in a BPMN-like diagram

I. Configuration Phase

1. PSE Configuration - first each CN member downloads a PSE software component and configures it. This includes setting up the Services to be represented by such PSE and filling in information concerning the provider – the CN member. Afterwards, the PSE has to be launched so it registers itself in the pre-defined Services Ecosystem Platform and starts looking for new Collaboration Opportunities where the represented services may be included, as well as performing other pre-defined behaviours.

II. Collaboration Opportunity Specification Phase

2. Clients' Need Specification - Through the Client's Assistant, that is a system that interfaces with the client, a high level specification can be made starting a new Collaboration Opportunity.
3. Broker details Business Needs - Based on the high level model of the Collaboration Opportunity specified by the client, the Broker creates a Business Process Model (BPM), using the Workflow Editor from the Ecosystem Platform, detailing the Services required to accomplish the specified needs. The BPM does not have to be complete at this stage, but the

Core Services (defined as the first services to be executed at runtime) have to be defined in order for that BPM to be able to start an execution.

4. Client BPM Commit - When the BPM specification is ready for execution (not necessarily complete), the Client is requested to commit to that BPM.
5. Broker writes needs on the CO_Board - After the Client Commits to the specified BPM, the Broker announces the specific Service needs in the CO_Board from the Services Ecosystem.

III. PSE Proposals / Bidding Phase

6. PSE checks for Business Needs - Each PSE looks for Collaboration Opportunities on the Services Ecosystem's CO_Board, according to a pre-defined frequency rate, towards two possibilities of matching:
    a. Direct - a Business Need matches exactly one of the Services that the PSE represents;
    b. Indirect – following the notion that the need for a service A may also indirectly represent a need for some other Service B, expressed through service connections made by the CN member, the PSE checks if any of the represented Services indirectly matches the specified needs. In other words, if the clients that request service A usually also need the provision of Service B, the PSE may propose the provision of B, in an auto-initiative basis, whenever a need for A is specified.
7. PSE prepares Proposal - both in the direct and indirect matching cases, the PSE is responsible to prepare a first version of a proposal / suggestion that it will post afterwards towards the participation on a given consortium.
8. Provider Commits to the Proposal – a PSE can be configured to send the proposals automatically or to ask the provider to complete / review them before submission.

IV. Service Selection / Negotiation Phase

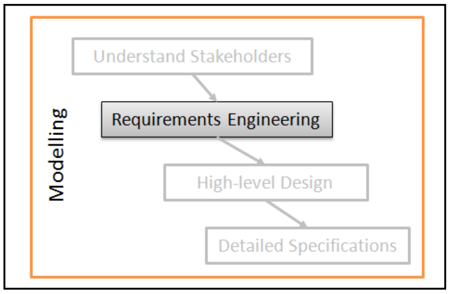
9. Broker checks Proposals – after a pre-defined time-frame, the Broker checks the received proposals and selects the ones that best fit the needs. Alternatively, a negotiation process may take place in order to change some details of the existing proposals or bids, namely decreasing the provision conditions in order to attract more bids.
10. Contractual Commitment - Both the Client and all the Providers have to commit to each other through a contract generated for that purpose.

V. Execution Phase

11. BPM Launch - After the BPM has all the providers selected, at least for the Core Services, it is possible to launch it, through a trigger made by the Client, in a first stage. After that, the broker launches the execution in the workflow engine that is responsible for "triggering" each Service at the right moment.

- Edition at Runtime - at anytime during the execution phase, the Broker can complete or change the BPM. If that occurs, the process may go back to:
    - Phase II - when the BPM did not get complete before starting execution. This case may happen when there is not enough information at an early stage and that information becomes available afterwards. In this case, the Broker has to complete the workflow definition, potentially changing some Services.
    - Phase III / IV - when some providers have not been selected yet or there is some ongoing negotiation process. If the workflow model became executable although partially complete, it means that the performers for the first services were selected, but there may be services without a performer selection made yet. This process has to be complete during runtime, repeating phases III and IV for these services.

4.3. Requirements Engineering Specification Using i*



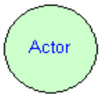
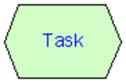
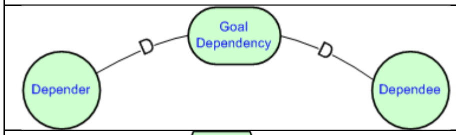
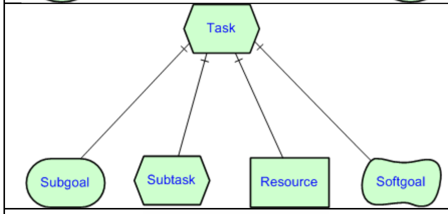
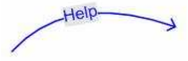
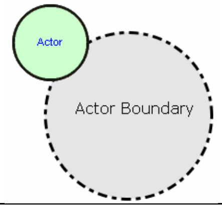
After the identification of the actors, their roles and the mechanisms that will be supported by the framework, as well as the global usage description, the next step is to go down into a more detailed descriptive level, through a systematic requirements engineering (RE) specification.

The option of selecting the i* framework for this RE phase was based on two main factors: 1) i* is goal-oriented, resulting in more intuitive diagrams, which helps the connection of this modelling framework with the previous specification of stakeholders needs and expectations; 2) the bridge between i* framework models and the tools used in later stages of software analysis and design phases is also extensively addressed in the literature, namely for the case of UML, as mentioned in (Aldewereld et al., 2010).

In a first stage, the overview described in Figure 4-6 is used as input for the creation of a global "Strategic Dependency" model (SD), that "focuses on intentional relationships among organizational actors" (Santander and Castro, 2002). Next, a sort of "zoom in" is made through the "Strategic Rationale" model (SR), applied to the two identified systems: Services Ecosystem Platform and PSE.

Table 4-1 presents a brief description of some elements from the i* framework (Aachen, 2008). It is important to notice that the table only contains the subset of i* formalization elements that are used during the PASEF RE specification.

Table 4-1 – i* partial elements' description

i* Element	Short Description
	Actor - Active entities that carry out actions to achieve goals by exercising their know-how. The term actor generically refers to any unit to which intentional dependencies can be ascribed.
	Goal (Hard Goal) – Represents and intentional desire of an actor, the specifics of how the goal is to be satisfied is not described by the goal itself.
	Soft Goal – Soft goals are similar to (hard) goals except that the criteria for the goal's satisfaction are not clear-cut.
	Task – One of the ways for the elements to achieve the goals is through the execution of specific tasks. A goal may be detailed / decomposed in a set of tasks.
	Dependency links – In a dependency link, the *depender* depends on the *dependee* to bring about a certain state of affairs in the world. The same dependency links can be established between tasks.
	Decomposition Links – A task can be decomposed into several other elements like a sub-goal, a sub-task, a resource or a soft-goal.
	Contribution Links (Help) – A partial positive contribution, not sufficient by itself.
	Actor Boundaries – Actor boundaries indicate intentional boundaries of a particular actor. All of the elements within a boundary of an actor are explicitly desired by that actor.

4.3.1. "Strategic Dependency" Model

The Strategic Dependency Model (SD) is a global specification composed of a set of nodes representing actors and dependency links connecting such actors, indicating that one actor depends on another actor in order to attain a specific goal. This is the first i* diagram, and models the main interactions between the distinct actors and the systems: the Services Ecosystem Platform and the PSEs. It is important to notice that this is neither complete nor a final diagram, given the fact that it is produced in an early stage of the software lifecycle. As a result of this fact, it only models the most important interactions. In later stages, more detailed diagrams will be focused on further modelling the interaction between actors.

Figure 4-7 represents the described overview of PASEF. The main "Soft-Goal" of the framework is the "service provision" from the CN member (at the right-bottom "corner" of the diagram) to the Client (at the left-bottom "corner" of the diagram). It is reasonable to say that all the goals (Hard and Soft) and the Tasks in the diagram, between these two actors, "positively contribute" to this higher level soft-goal.

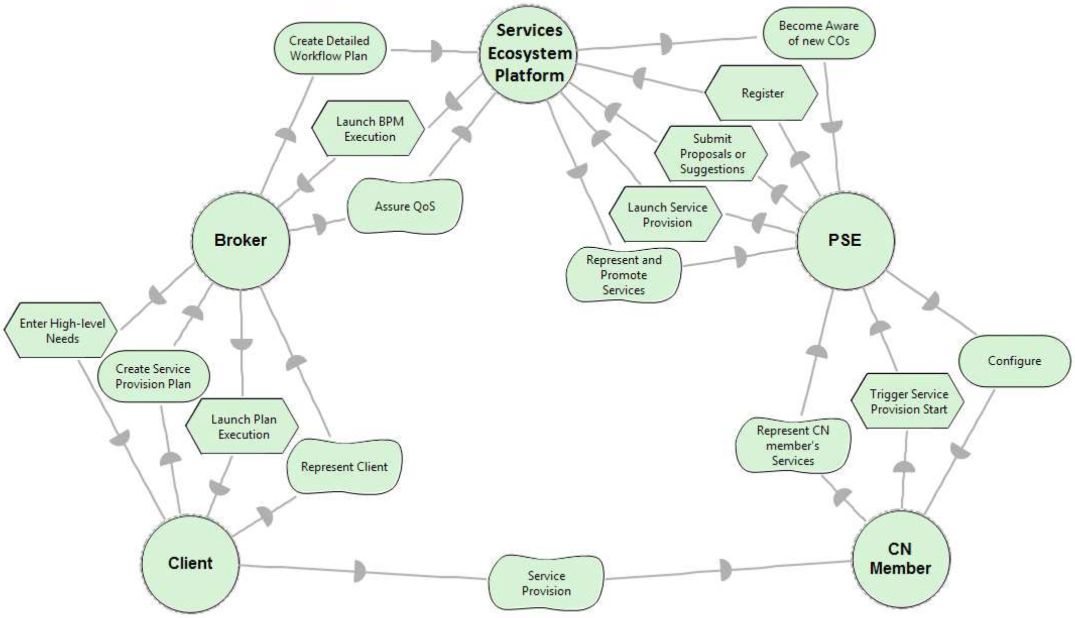


Figure 4-7 - Strategic Dependency Model (simplified)

It is also interesting to notice that this diagram corresponds to the elements from the BPMN-like diagram defined in the previous stage of the software lifecycle in Figure 4-6. Furthermore, in the next two sub-sections, the Services Ecosystem and PSE systems will be detailed with SR models that zoom in the systems, further highlighting details on how each interaction is performed.

Finally, it should also be mentioned that a soft goal between each pair of actors, represents the high-level goals that are not detailed in this early stage of the requirements engineering phase, but are already clearly identified. Each of these soft goal dependencies includes a set of tasks or goal dependencies that are less important than the ones represented in this diagram, but that also need to be addressed. These goals are:

- Represent the Client – this soft goal dependency is defined between Client and the Broker, stating that the client depends on the broker for this purpose.
- Assure Quality of Service – this soft goal is defined between the Broker and the Services Ecosystem software system and maps the conceptual QoS assessment mechanism defined in Section 3.2.3. As a result, the Services Ecosystem will track all the collaboration opportunities, proposals or suggestions, workflow model execution, as well as the client's satisfaction in order to assess QoS.
- Represent CN member's services – this soft goal is defined between the CN member and the PSE software system, mapping the high level aim of PSE. Although there are two other main dependency links, the PSE should also be able to perform negotiations or promotions, if the corresponding CN member configures it in that direction. These are two example extensions of this framework. In particular the negotiation functionality was not addressed in this research work because several sound results already exist in the literature.
- Promote Services – this soft goal is defined between the PSE and the Services Ecosystem software systems and maps the soft goal of representation of CN members' services, this time between the two main software systems – the Services Ecosystem and the PSE, stating that the Services Ecosystem depends on PSEs for this service representation purpose.

4.3.2. Services Ecosystem Platform – "Strategic Rationale" Model

The SR model is a graph with several types of nodes and links that work together to provide a representational structure for expressing the details behind dependencies. In other words, a "Zoom In" is made to the actors from the SD model in order to show their specific details or how they will pursue the desired goals.

In the case of the Services Ecosystem Platform, the actors that interact with it are the Broker, from the Client side; and the PSEs, from the CN members side. Figure 4-8 shows the internal structure of Services Ecosystem Platform and how the dependencies "propagate" into its internal goals and tasks.

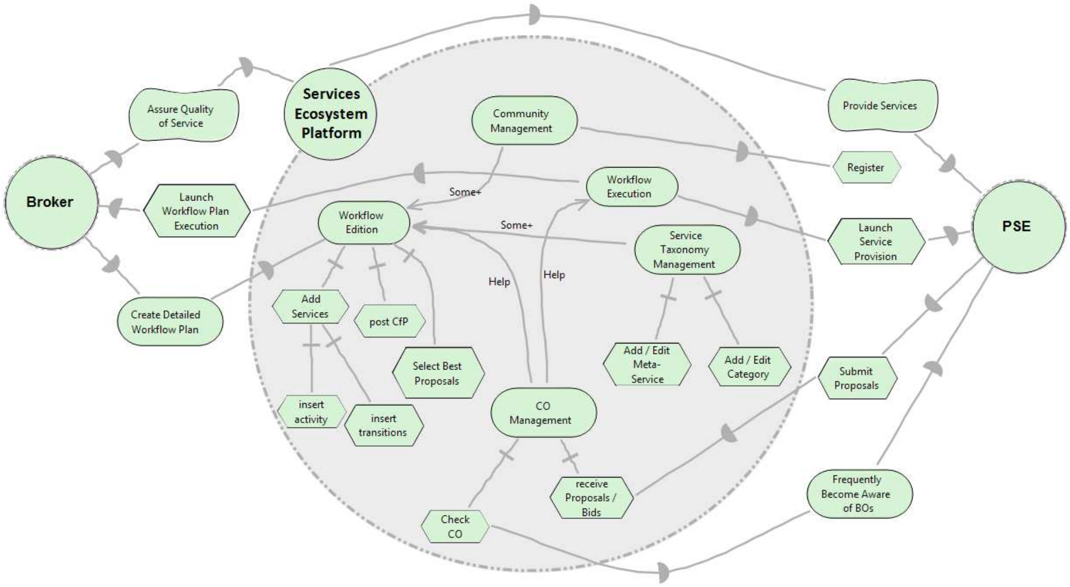


Figure 4-8 – Services Ecosystem Platform – Strategic Rational Model

The following list describes the four main internal goals of the Services Ecosystem Platform:

- Service Taxonomy Management – this goal provides a common understanding within the Ecosystem. All providers (PSEs and the corresponding CN members) and all the consumers (Brokers and Clients) have to comply with the definitions made by this goal.
- Collaboration Opportunity Management – this goal is responsible to manage all the COs and the corresponding proposals or suggestions made by PSEs.
- Workflow Edition – this goal is the one upon which the creation of the detailed workflow plans depends. This goal is decomposed into the tasks “Addition of Services”, “Post Calls for Proposals” and “Select the Best Proposals”. The addition of services itself is decomposed into two tasks: the insertion of activities and transitions. This group of tasks create the skeleton of a workflow plan. Afterwards, there is the need to post Calls for Proposals in the Services Ecosystem CO_Board, so that PSEs become aware of the needed services. Finally, the selection of the best proposals concludes the creation of executable workflow models.
- Workflow Execution – this goal is responsible for using the executable Workflow Models created and launch each service at the right moment.

In this SR model, there are also positive contributions between goals. For example, the Community Management goal, the Taxonomy Management goal and the CO Management goal all contribute positively to the Workflow Edition goal. The Community Management provides a pool of CN members who are willing to provide services. The Taxonomy Management guarantees a common understanding of what each service is intended to perform and how it can be included in a workflow model, both in terms of needed information and produced results. Finally, the CO Management tracks the phases of each CO, starting at the client's need specification and ending at runtime.

4.3.3. PSE – "Strategic Rationale" Model

The PSE SR follows the same approach as the Services Ecosystem Platform SR. The main goals are mapped and decomposed into their main tasks. As identified in the global SD model, the PSE interacts with the Services Ecosystem Platform and the CN member. As the main aim of this software system is to represent the services from the CN member in the Ecosystem following an auto-initiative approach, the CN member needs to configure it not only concerning some profile data and the services he or she is willing to provide to the Ecosystem, but also how autonomous the PSE should be, as well as how should it behave.

On the other side of the diagram, the main dependencies between the PSE and the Services Ecosystem Platform are mapped as the goal of collaboration opportunity management. This goal is then divided in two main tasks:

- Check existing collaboration opportunities – this task is performed by the PSE in a pre-defined frequency rate, allowing the PSE to become aware of new COs in a reasonable time-frame, after such COs have been posted by a broker.
- Prepare / Submit Proposals or Suggestions – in a later stage, whenever a CO is found, matching the represented services, the PSE is responsible to prepare a proposal and ask the represented CN member to edit and commit to such proposal, so it can be submitted.

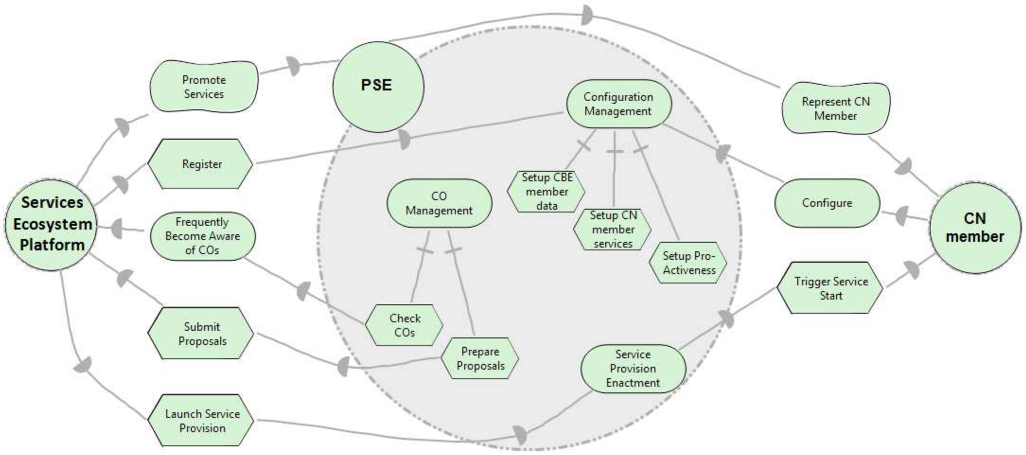


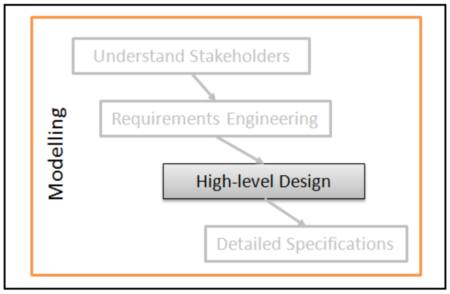
Figure 4-9 - PSE – Strategic Rational Model

As mentioned before, major decisions concerning the software specification should be made between each pair of stages identified in that software lifecycle. After the requirements engineering phase, two decisions are presented below:

1) All the interactions involving human actors should be made through a portal system. The drawback of this approach is the centralized nature of the solution. Nevertheless, since PASEF is a prototype system with non-commercial purposes, this bottleneck is not considered relevant.
2) Based on the fact that the PSE should behave in an auto-initiative basis for its representative purposes, the system should be developed within an existing Multi-Agent-System Integrated Development Environment. The platform selected for the prototype system development is JADE, because it is supported by an active research community and it offers an easy development approach. Furthermore two general MAS design characteristics, also followed by JADE, are aligned with the Pro-Active Services Ecosystem Framework concepts (Bellifemine et al., 2007): 1 - an agent is autonomous and pro-active; 2 - agents are loosely coupled, meaning that the communication is asynchronous and no temporal dependency exists between message senders and receivers. As a result, the development target is the *proof of concept* support prototype through a Web-based prototype infrastructure built on top of the JADE platform.

These two decisions are especially important at this stage for the next phases to benefit from them, because all the analysis and design made afterwards take these facts into account.

4.4. UML - High-level Design



The "high-level design" and the "detailed specifications" phases are made using UML formalisms because of their intuitive look, on one hand, and because of the mapping with the RE phase diagrams, facilitating the specification process, on the other hand. Furthermore, a literature review shows that UML is still one of the most suitable techniques for these two phases of Object Oriented (OO) software construction. Actually, UML is also a *de facto* standard in other OO based paradigms, like the Aspect Oriented Programming, as illustrated in (Khan and Nadeem, 2010; Zohreh, 2010).

The UML tools used are:

- Use Cases Diagrams – representing the main system entrance points;
- Class Diagrams – identifying the main classes composing the Services Ecosystem Platform and the PSE, as well as how they are related to each other.
- Sequence Diagrams – identifying how the various systems should behave whenever each Use Case is triggered.
- State Transition Diagrams – used whenever iterative mechanisms have to be modelled, because they better describe this kind of behaviour when compared to sequence diagrams.

4.4.1. Use Case Diagrams

The definition of the Use Case diagram from a software system identifies the actions that the actors can trigger. The black box metaphor can be used for the description of these design elements as they represent the usage of the system without detailing yet how the system should process such requests. In other words, from the usage perspective, a request is made and, despite the way the results are reached, a response is expected.

The utilization of i* on the previous phase helps the process of identifying the Use Cases of the Services Ecosystem and the PSE. Each identified goal leads to a potential Use Case. Figure 4-10 shows the main Use Cases of Services Ecosystem Platform, both concerning the interaction with the Broker representing the Client; and the PSE, representing the CN member.

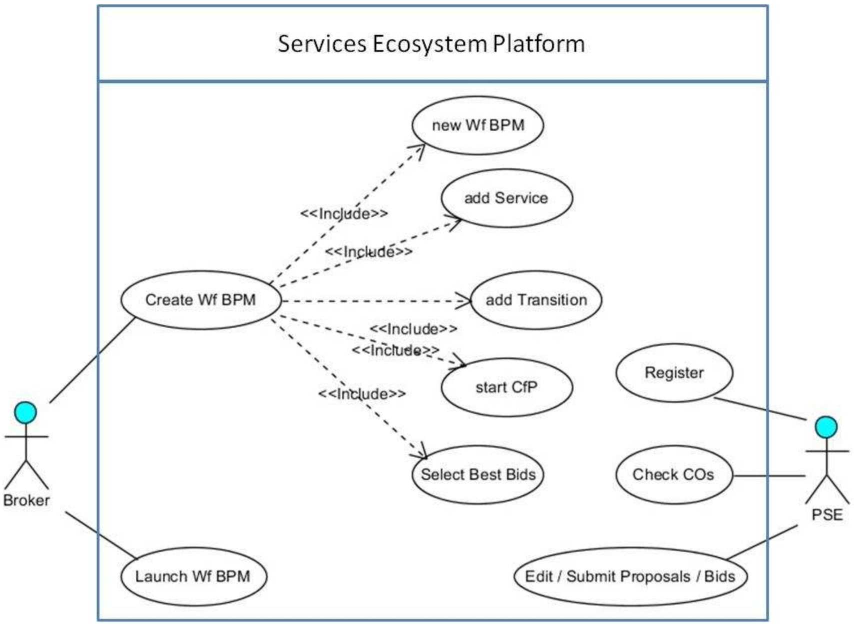


Figure 4-10 - Main Services Ecosystem Platform Use Cases

Only three main Use Cases were identified for the Pro-Active Service Entities, as mentioned in the RE phase: 1) configuration of the PSE (CN member), 2) launch service provision (PASEF), 3) notification of service provision completion (CN member) - Figure 4-11.

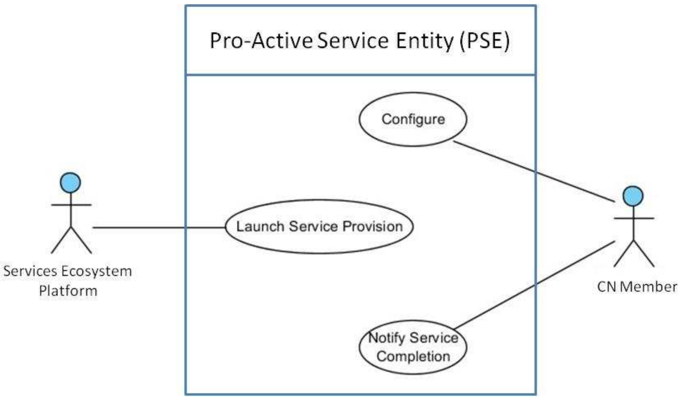


Figure 4-11 - Main PSE Use Cases

In the selected application scenario, described in Section 4.2.1, these are the two main Use Cases where the Senior Professionals interact with PASEF. First, with the help of specialists from the Senior Association they belong to, a setup is made configuring the PSE that will represent the services they are able / willing to provide. In a second stage they receive the notification whenever a service provision should be about to start and they notify back the PSE when such provision gets complete.

4.4.2. General Services Ecosystem Platform Class Package ICE Diagram

The specification of the classes composing the system to be developed followed the ICE methodology dividing the classes into three groups:

- Interface – the classes from this group are dedicated to interface with other information systems or final users. The main objective of this group is to prepare the meaningful information in both directions: from the control classes to the users or other systems, as well as the reverse order, towards releasing control classes from mechanisms like parsing, translating or validating.
- Control – all the logic of the system is developed at the control classes. These classes receive the requests corresponding to each Use Case; they use or update the information of the classes from the Entity level and produce the response results from that Use Case.
- Entity – the classes that represent data objects, as a direct image of database information.

Figure 4-12 represents the main packages of classes from the Services Ecosystem Platform within an ICE diagram.

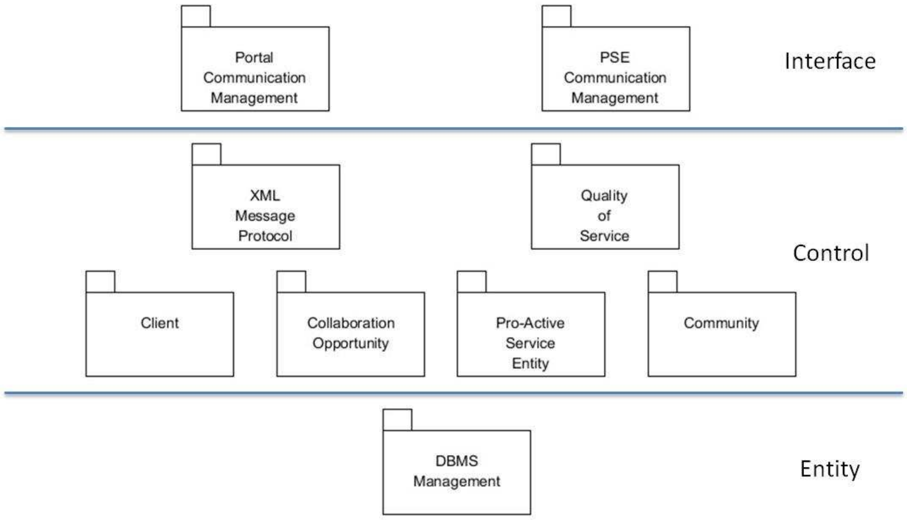


Figure 4-12 – Services Ecosystem Platform packages ICE diagram

For each package of classes, one Class Diagram is defined afterwards, identifying the included classes, their attributes, constructors and methods, as well as the relations between distinct classes. Figure 4-13 shows the Class Diagram from the XML Message Protocol from PASEF, for illustrative purposes. In this diagram, a main class called PASEF_XML_Msg is defined as a general class below which the other particular classes, corresponding to specific messages, are defined.

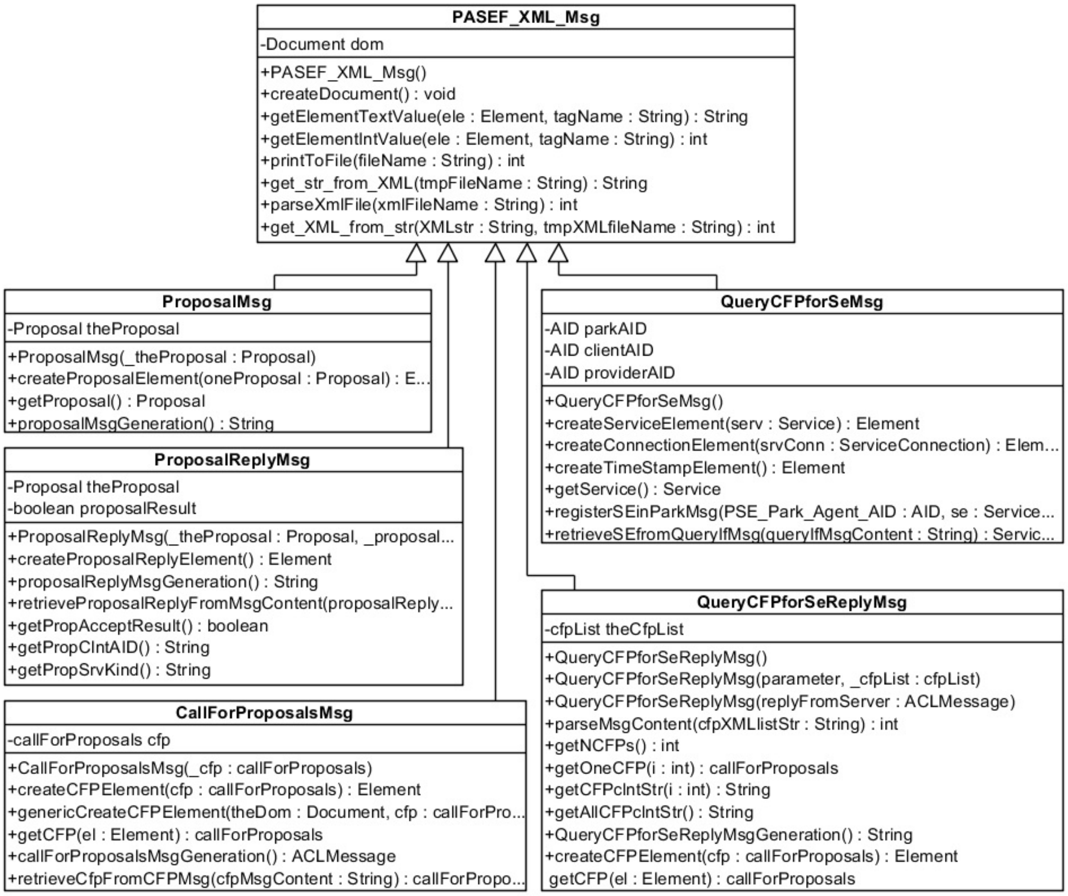
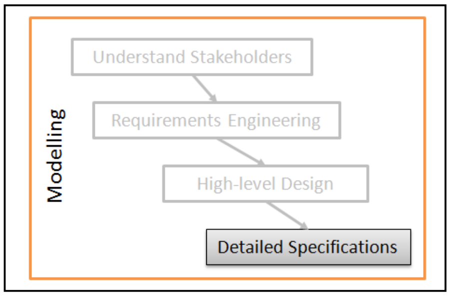


Figure 4-13 - PASEF XML Message Protocol Class Diagram

4.5. UML - Detailed Specification



Finally, the following collaboration diagrams have the aim to model how PASEF Portal and PSE behave whenever the corresponding Use Cases are triggered. UML Sequence Diagrams are selected to show a chronological perspective of such behaviour and State Transition diagrams are used in the cases where iterative processes had to be modelled. It is important to notice that the following diagrams do not strictly follow the standards. An adaptation is made to the sequence diagrams in order to merge distinct diagrams into a single one, providing higher-level / wider perspective.

Only the two main processes are included, again for illustrative purposes: the “creation of a Business Process Model”, as illustrated in Figure 4-14 and Figure 4-15; and the “execution of a Business Process Model”, as illustrated in Figure 4-16 and Figure 4-17.

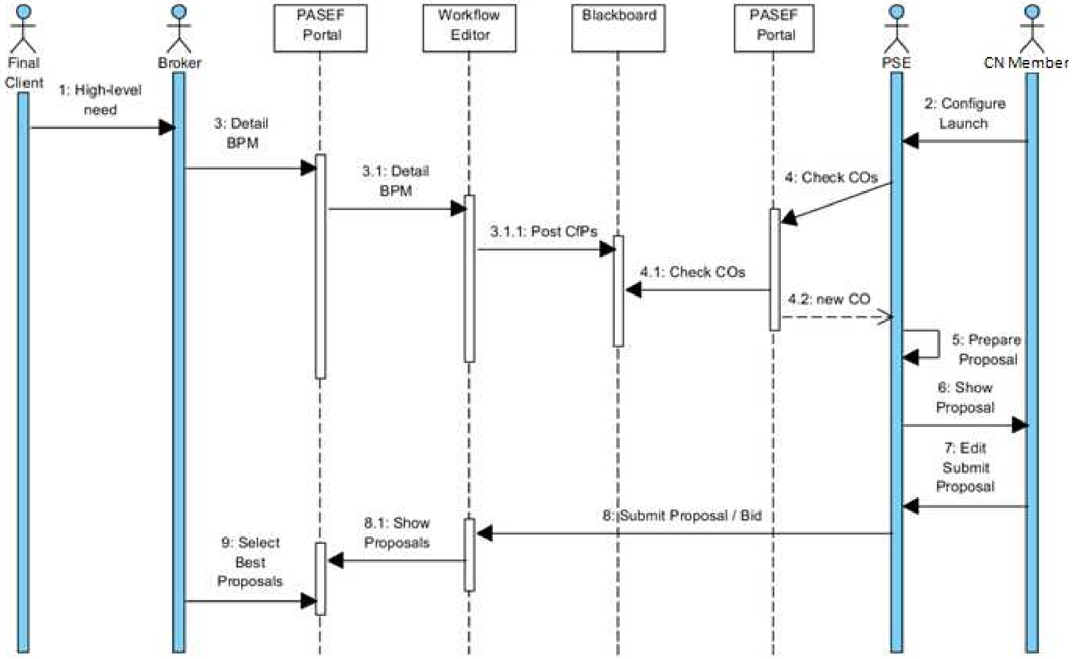


Figure 4-14 - BPM Creation Sequence Diagram

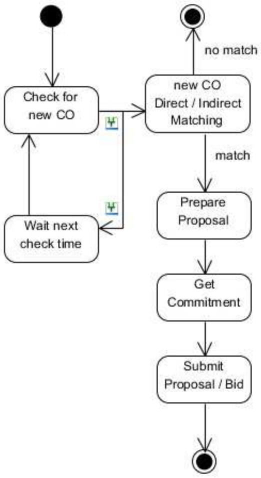


Figure 4-15 - PSE Check CO State Transition Diagram

The processes represented in the two figures above can be described by the following sequence of steps:

- High-level need – Everything starts on the Client side, expressing a high-level need.
- Detail BPM – the next step is taken by the Broker that uses a Workflow Editor from the Services Ecosystem Platform to decompose the expressed high-level need into a concrete workflow business process model that is composed of meta-services from the Ecosystem Taxonomy. After this model is complete, calls for proposals are posted in the CO_Board component of Services Ecosystem Platform.
- Configure Launch - On the other side of the diagram, all the CN members configure and launch their PSEs.

Figure 4-15 shows the details of the PSE process in a state transition diagram.

- Check for new COs – the PSEs check for new collaborative opportunities in a pre-defined frequency rate.
- After the first state, there are two possibilities for the next state:
    1. Wait the pre-defined time before checking again for new COs again.
    2. Whenever a new call for proposals is found, a matching assessment state is reached. There are two possibilities of matching: direct matching and indirect matching; as detailed in section 3.2.4 (concerning Business Process Modelling). Either way, whenever a matching success happens, three steps follow:
        - Prepare a proposal / suggestion,
        - Ask the CN member to edit and commit to the proposal,
        - Submit the proposal / suggestion.

Back to the Sequence Diagram, after a pre-defined time-frame (the period for the entrance of proposals / suggestion), the edition process ends with the following tasks:

- Show the Proposals to the Broker.
- Let the Broker select the best ones for each service. This is the spot where some iterative negotiation could take place, as mentioned before.

It is important to notice that in this last task, the broker may select more than one proposal for each service, if he has that possibility, in order to cope with the potential need to change the service provider at runtime, as detailed also in the BPM section of Chapter 3. It is also important to notice that the model does not need to be complete in order to be ready to start the execution. The only constraint for starting an execution is that the first services in the model need to have a selected provider / performer.

Concerning the selected example application scenario described in Section 4.2.1, the two diagrams from Figure 4-14 and Figure 4-15 detail a bit more the interaction between the PSE and the Senior Professionals, as they constitute the CN members in this scenario. In fact, after the above mentioned configuration phase, their PSEs are launched and start looking for collaboration opportunities where the expertise of the represented SP can be used. Whenever an opportunity is found, depending on the initial configuration of the PSE, the SP may be requested to review the proposals the PSE has prepared before they become submitted and afterwards he is notified of their success.

The BPM execution process within the ecosystem is summarized in the overall Sequence Diagram of Figure 4-16, and the workflow engine mechanism is represented in Figure 4-17. Basically, the Client launches the BPM execution and the workflow engine is in turn responsible to launch each service provision at the right moment, according to the BPM definition, until the end of that BPM execution.

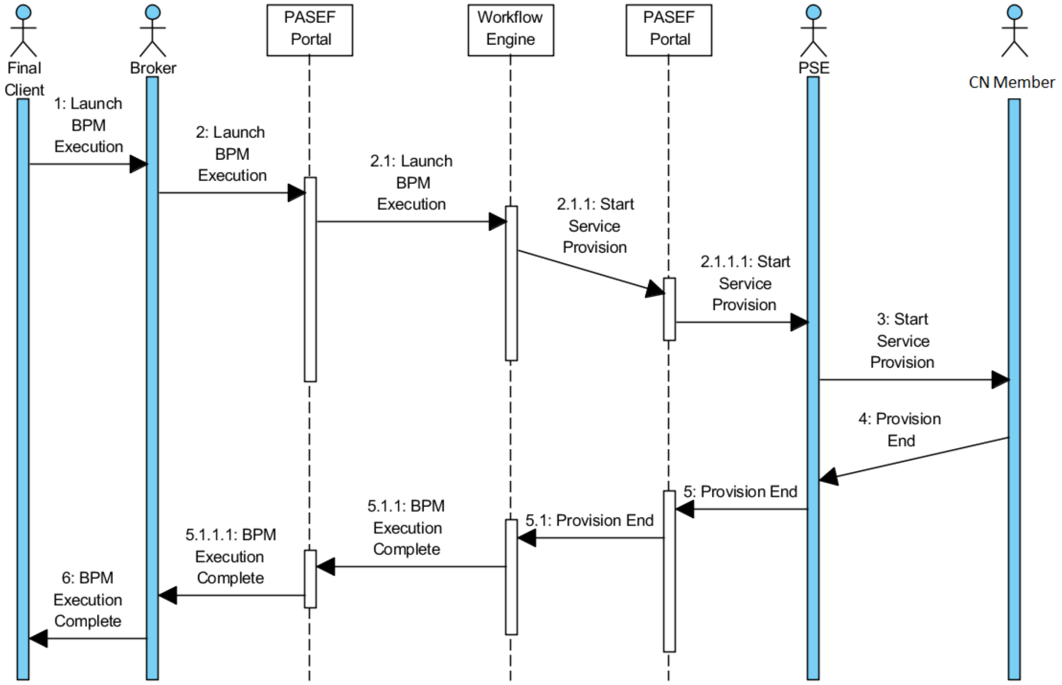


Figure 4-16 - BPM Execution Sequence Diagram

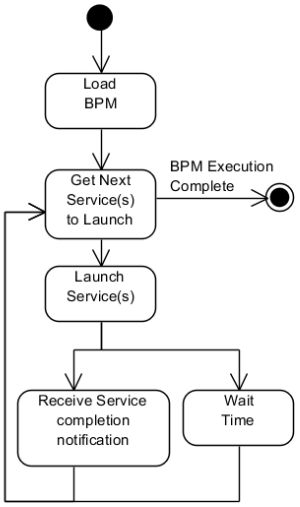


Figure 4-17 - BPM Execution State Transition Diagram

Considering again the application scenario, changing the “CN member” designation in the diagrams from Figure 4-16 by “Senior Professional” corresponds to a diagram representing the consultancy service provision mechanism from such SP, interacting with their PSE that in turn interacts with the workflow engine through the PASEF portal. This is where such SPs put to work their expertise within a wider workflow of consultancy services from other SPs with whom they form a Virtual Team towards pursuing the success of the corresponding Collaboration Opportunity.

4.6. Chapter Discussion and Conclusions

This chapter described the Logical Architecture of the Pro-Active Services Ecosystem Framework (PASEF), as well as the design phases of the *proof of concept* support prototype. In a first place, the chapter covered a clarification understanding stakeholders’ needs and expectations towards defining the logical architecture of PASEF. This was made through the specification of an example application scenario focusing the support for Senior Professionals to continue their active life after retirement as a particular case where PASEF can be applied. The chapter proceeded with a multi-level modelling definition that helped to clarify the aim of the intended Logical Architecture. Next the actors, mechanisms and roles were identified and the Logical Architecture of PASEF was presented. This higher-level description of PASEF ended with a description of the service composition process through a BPMN-like diagram. The chapter went down into more detailed specification of PASEF through the usage of i-star framework and UML.

In the next chapter the experimental development is described, as well as the selected validation process, which is composed of five validation elements, including the experimental prototype itself, two benchmarking exercises and two validation elements based on the peer community.

The logic of validation
allows to move between the limits
of dogmatism
and skepticism.
(Paul Ricoeur)

5. Experimental Development and Validation

This chapter presents the validation of PASEF. This validation is composed of five elements: the proof of concept support prototype, two benchmarking exercises and the peer community validation. The chapter presents these validation elements and ends with an assessment of their contribution to the hypothesis stated in this dissertation.

5.1. Validation Methodology

Validation is a key process in scientific research. It is a necessary step for two main reasons: 1 - the results need to be valid in order to be accepted; 2 - further research can be built upon such results. In other words, for a research initiative to be accepted among the scientific community, two implicit questions have to be considered: 1 - “Was it validated?” and 2 - “How was it validated?” If the answer to the first question is negative, the research initiative is not even considered by the peer community. This consequence is quite fair because research results are always intermediate in the sense that further research may be based on them, naturally referencing the initiatives upon which they are built. If these results have not been validated, there is no motivation to build something upon them. Furthermore, another base scientific assumption is that if the experimental processes of a research initiative are repeated, under similar circumstances, the results should be the same or, at least, comparable to the original ones. The answer to the second question is meaningful exactly when such experimentation is about to be repeated.

The experimentation mechanisms are thus quite important as the most commonly used approach to validate research work. Nevertheless, several cases find barriers when trying to cope with a direct experimentation in real world scenarios, even though the research may be a valid contribution to science. In such cases, it is necessary to find alternative mechanisms to assess the formulated hypothesis. Mechanisms like simulation can be used in such cases.

The case of PASEF is an example where direct and full real world experimentation is not possible with the time limits and resources of a PhD work. As a result, alternative validation mechanisms were carried out towards: 1) prove that the presented research effort is a valid one, 2) the proposed models and mechanisms are worth to consider as scientific base for future works. The adopted validation mechanism is thus composed of 5 Validation Elements:

1. Prototype Development (VE_1) – As mentioned along the document, a generic *proof of concept* support prototype is developed. The mapping between the base problems identified for the creation of PASEF and the problems that Senior Professionals face concerning ICT solutions to support their active life after retirement is the base for the selection of this motivation scenario for the application of this prototype. Nevertheless, it turned out not to be possible to test the prototype with SPs in a real professional environment. The necessary robustness of the prototype, its integration with existing working environments, as well as the needed training actions, which would be required for a practical use, are out of the scope of this work. The solution was reached through the simulation of real usage.
2. Benchmarking – two benchmarking exercises are made, in order to assess PASEF value "against" other approaches or solutions tackling similar concerns. This work is performed using an adaptation of the TOPSIS benchmarking mechanism, detailed in (Hwang et al., 1993). This process is based on a classification of a set of elements concerning a set of comparison parameters, as described below. The two benchmarking exercises are:
    a. Approach Benchmark (VE_2) – A comparison between PASEF and other approaches tackling similar problems, namely the application of the service paradigm and Service Oriented Architectures to the Collaborative Networks context, as well as the adoption of multi-agent systems in the same context. In this benchmarking exercise the architectures of such approaches are classified in what concerns current limitations, as well as a business perspective from the service providers – the CN members.
    b. Solution Benchmark (VE_3) – Another benchmark exercise is made between the *proof of concept* support prototype and other solutions that exist on the Internet tackling consultancy services. In a similar way as the approach benchmark, the comparison parameters used in this case are based on the limitations of the current situation from the service providers and their business interests - this time the focus is put on the usage perspective.
3. Peer Validation – This element is a key validation of PASEF, made along the research period, as usual in a scientific research work. This Validation Element is of particular importance, namely to get extra-motivation and, especially, to get other inputs based on a

broader perspectives from the peer community. The peer validation is divided into two validation elements:

a. Refereed Publications (VE_4) – This validation element was made along PASEF research work through publication of partial aspects of the specification and implementation, made in refereed international conferences and journals. All the publications are included in the ISI Web of Science and a journal publication is also indexed in the Science Citation Index.
b. Specialists' Perspective (VE_5) – Specialists opinion was gathered along PASEF creation especially in the discussions that took place in conferences where publications covering partial PASEF results took place. A complete PASEF specification and the prototype demonstration were also introducerd to an audience of specialists in the CN area, at a later stage, towards gathering feedback on the modelling perspective. After this presentation a survey was conducted in order to collect opinions and insight information concerning the proposed approach.

Figure 5-1 shows these five validation elements in a timeline.

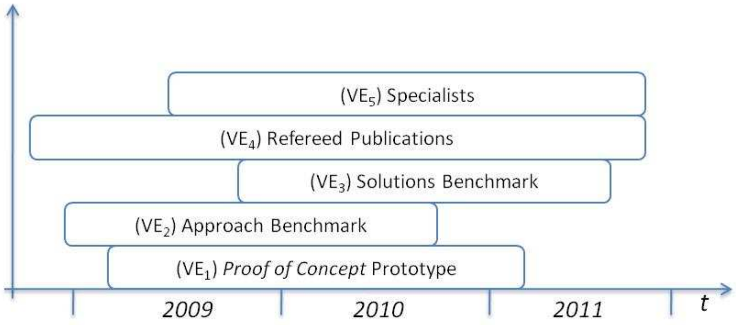


Figure 5-1 - Five Validation Elements carried out during the research period

The following sections describe each of these Validation Elements. Finally, a contribution mapping between the hypothesis that conducted this research and the validation elements is made, as shown in section 5.5.

5.2. *Proof of Concept* Support Prototype Development

The implementation of a *proof of concept* support prototype is presented in this Section, in line with the logical architecture defined in Chapter 4. As mentioned before, the example application scenario is a consultancy Professional Virtual Community (PVC) of Senior Professionals (SPs), as detailed in section 4.2.1. The result framework is composed of 6 modules:

1. PASEF Toolbox – The main objective of this module is to have a central control and monitoring point, which provides a straightforward mechanism for the creation of testing scenarios, as well as launch, test, and monitor all the modules from the Pro-Active Services Ecosystem Framework prototype - Figure 5-2. This module automates tasks like the process of creating a PVC composed of a configurable number of Senior Professionals and launching the corresponding PSEs, namely:
    - The creation and registration of the senior professionals.
    - The definition of a set of services each senior professional can provide – a selection of meta-services from the service's taxonomy and the corresponding instantiation.
    - The definition of a set of service connections, representing the know-how / service expertise from each senior professional.
    - The launch of the PSEs, which represent each Senior Professional and the corresponding services, towards finding collaboration opportunities and improving the selection chances of the represented services.

N 10

30% Services connected
90% same category / kind
10% Bi-Directional

● DB @ Local Host ○ DB @ Titanic
PSE Park location: pc-tomfc
PSE Park Framework: PSE_Framework
☐ Auto Post BOs
found PSE_Parks: pse_park@pc-tomfc:1099/JADE 12

Figure 5-2 - PASEF Toolbox

2. Service Taxonomy Management – as identified in the Service Stereotyping related concepts group, a module for the specification of a Service Taxonomy, to which the SPs should comply, is presented in Figure 5-3 (lower side). This module provides the

possibility for the Services Ecosystem administrator to create new service categories and include new meta-services in each category, as defined in Section 3.2.1. This data is stored in the Taxonomy of the Services Ecosystem and is used by the CN members to select the services they are willing to provide. The taxonomy is also used by the PASEF toolbox for the creation of pseudo-random data for testing purposes. Furthermore, it is possible, through the PASEF toolbox, to import taxonomy information from an XML file, as well.

1:Carlos Luis Oliveira Sousa Sousa Correia;
2:Joana Alves Figueira de Figueira Correia;
3:Ana Silva Correia Sousa Alves;
4:Luis Abel Figueira Silva Figueira Santos;
5:Joana Sousa Figueira Figueira Correia;
6:Ana Figueira Santos Reis Correia;
7:Joaquim Carlos Alves Reis Figueira Cardoso;

Selected Senior
ID: SeniorID
Name: SeniorName

1:Babyminding;
2:Leisure;
3:Housekeeping;
4:Animals and plants;
5:Bricolage (do-it-yourself);
6:Accompany (accompanying);

Selected Service Kind
ID: ServiceKindID
Name: ServiceKindName

1:Babysitting;
2:Taking/looking for children to the school;
3:Bicycling (bicycle);
4:Walking;

Selected Service
ID: ServiceID
Name: ServiceName

Figure 5-3 - Service Taxonomy Management & Service Community Management

3. Senior Professionals' Community Management – This module is responsible for the management of the CN members. In this particular case, the CN members are the Senior Professionals who are willing to provide consultancy services, taking benefit from their life-time experience, towards remaining in an active life. This module provides the functionality of service and service connection’s specification. After the SP profile is complete, the PSE launch takes place, in order to represent the corresponding SP, in an ambassador-like manner – Figure 5-3 (upper side). Figure 5-4 illustrates the user interface where senior professionals express their know-how concerning service connections. This manifestation consists on selecting the two meta-services from the taxonomy that will be connected to each other, and deciding the strength and the directionality of the connection. This information will be used afterwards by the PSEs to make service

provision suggestions, towards the inclusion of the represented services in business process models being built, according to the concepts defined in Section 3.2.4.

4:First Service: 8:Insert Molding:Second Service:9:Plastic Injection Mold Design and Tooling

First Service – Service Kinds / Category:
1:Engineering
2:Injection Molded Plastics
3:End-to-End Manufacturing

First Service – Services:
11:Design & Engineering:
12:New Product Introduction:
13:Backplanes:

New Connection Strength: 70%

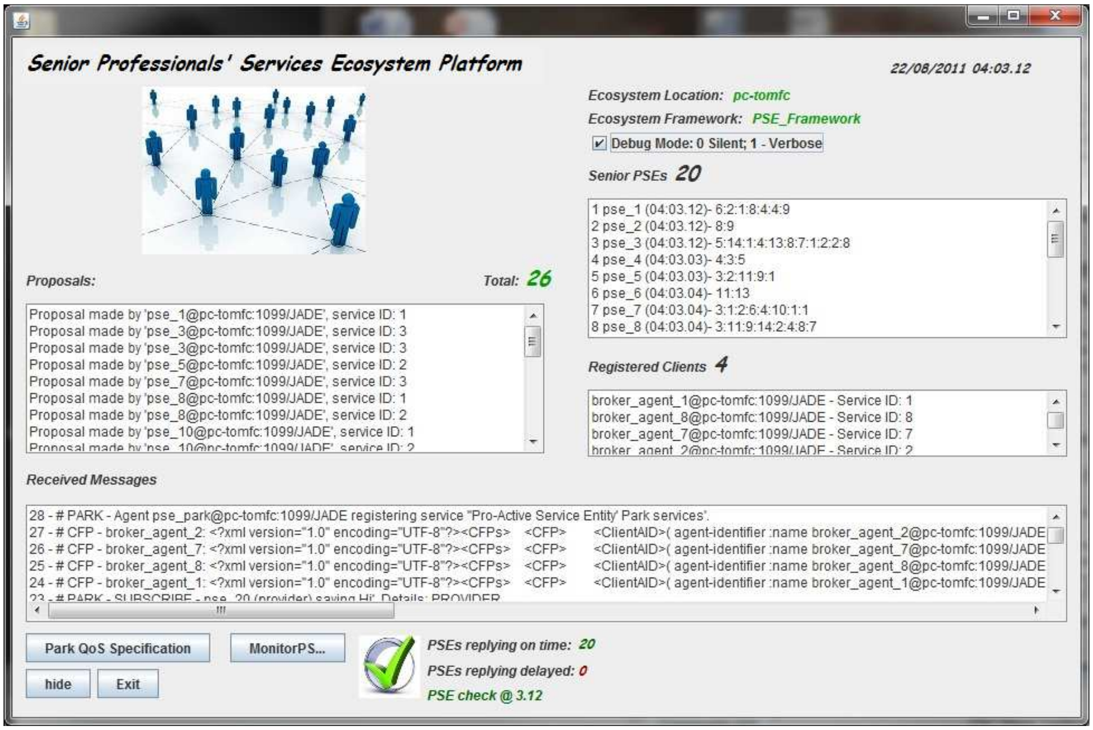
☑ BiDirectional Connection

Second Service – Service Kinds / Category:
1:Engineering
2:Injection Molded Plastics
3:End-to-End Manufacturing

Second Service – Services:
11:Design & Engineering:
12:New Product Introduction:
13:Backplanes:
14:Enclosures/Machining/Assembly:

Figure 5-4 - Service Connection Definition

4. Senior Professionals’ Services Ecosystem Platform – This module is the central element, which provides functionality to allow the PSEs to find collaboration opportunities, as well as potential partners. The module also monitors the activity of the Ecosystem, showing everything that is happening “behind the scenes”: active PSEs (upper-right box), clients or brokers waiting for proposals (middle right box), proposals submitted (upper-left box) and all the messages exchanged among distinct actors (lower box) - Figure 5-5.
   This module also includes a monitoring system with “watchdog-like” functionality, which frequently “pings” the PSEs, perceiving if they remain “alive”. Whenever a given PSE does not reply within a reasonable timeframe, the monitoring module has the ability to launch it again in an automated manner (a functionality that is useful during testing phases).



Senior Professionals' Services Ecosystem Platform

22/08/2011 04:03.12

Ecosystem Location: pc-tomfc

Ecosystem Framework: PSE_Framework

☑ Debug Mode: 0 Silent; 1 - Verbose

Senior PSEs 20

```
1 pse_1 (04:03.12)- 6:2:1:8:4:4:9
2 pse_2 (04:03.12)- 8:9
3 pse_3 (04:03.12)- 5:14:1:4:13:8:7:1:2:2:8
4 pse_4 (04:03.03)- 4:3:5
5 pse_5 (04:03.03)- 3:2:11:9:1
6 pse_6 (04:03.04)- 11:13
7 pse_7 (04:03.04)- 3:1:2:6:4:10:1:1
8 pse_8 (04:03.04)- 3:11:9:14:2:4:8:7
```

Proposals: Total: 26

```
Proposal made by 'pse_1@pc-tomfc:1099/JADE', service ID: 1
Proposal made by 'pse_3@pc-tomfc:1099/JADE', service ID: 3
Proposal made by 'pse_3@pc-tomfc:1099/JADE', service ID: 3
Proposal made by 'pse_5@pc-tomfc:1099/JADE', service ID: 2
Proposal made by 'pse_7@pc-tomfc:1099/JADE', service ID: 3
Proposal made by 'pse_8@pc-tomfc:1099/JADE', service ID: 1
Proposal made by 'pse_8@pc-tomfc:1099/JADE', service ID: 2
Proposal made by 'pse_10@pc-tomfc:1099/JADE', service ID: 1
Proposal made by 'pse_10@pc-tomfc:1099/JADE', service ID: 2
```

Registered Clients 4

```
broker_agent_1@pc-tomfc:1099/JADE - Service ID: 1
broker_agent_8@pc-tomfc:1099/JADE - Service ID: 8
broker_agent_7@pc-tomfc:1099/JADE - Service ID: 7
broker_agent_2@pc-tomfc:1099/JADE - Service ID: 2
```

Received Messages

```
28 - # PARK - Agent pse_park@pc-tomfc:1099/JADE registering service "Pro-Active Service Entity' Park services'.
27 - # CFP - broker_agent_2: <?xml version="1.0" encoding="UTF-8"?><CFPs>   <CFP>      <ClientAID>( agent-identifier :name broker_agent_2@pc-tomfc:1099/JADE
26 - # CFP - broker_agent_7: <?xml version="1.0" encoding="UTF-8"?><CFPs>   <CFP>      <ClientAID>( agent-identifier :name broker_agent_7@pc-tomfc:1099/JADE
25 - # CFP - broker_agent_8: <?xml version="1.0" encoding="UTF-8"?><CFPs>   <CFP>      <ClientAID>( agent-identifier :name broker_agent_8@pc-tomfc:1099/JADE
24 - # CFP - broker_agent_1: <?xml version="1.0" encoding="UTF-8"?><CFPs>   <CFP>      <ClientAID>( agent-identifier :name broker_agent_1@pc-tomfc:1099/JADE
23 - # PARK - SUBSCRIBE - pse_20 (provider) saying Hi'. Details: PROVIDER
```

PSEs replying on time: 20

PSEs replying delayed: 0

PSE check @ 3.12

Figure 5-5 - Senior Professionals’ Services Ecosystem Platform

5. Workflow Editor – The module responsible for the specification of absBPMs and the corresponding eBPM, as defined in section 3.2.4: first the workflow skeleton definition – the absBPM; second the selection of the best performers for each service resulting on the eBPM. Figure 5-6 represents an example absBPM, without performers, as explained above. The specification of an abstract business process model starts by the inclusion of as many activities as the needed services for a given collaboration opportunity. The second step is the selection of specific Meta-Services, from the Service’s Taxonomy, and their association to the activities in the workflow definition. Next, the flow is specified through the inclusion of transitions between distinct activities. The final step corresponds to the specification of the start and end points of the model. As mentioned before, these steps should be carried out by a broker, or intermediary. This actor receives a high-level specification of a need from a client and details such need in these abstract business process models, in a first stage. In a second stage and the corresponding executable models are created. Template absBPMs can also be defined by such brokers in order to tackle the needs that repeatedly become expressed by clients.

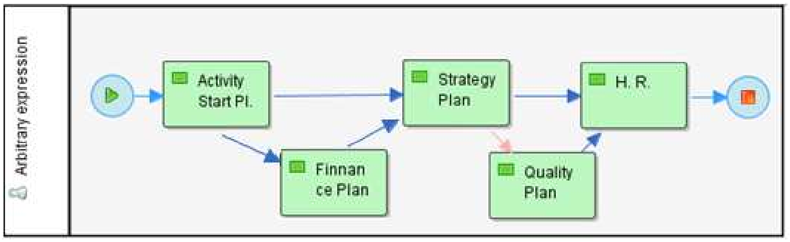


Figure 5-6 - Example absBPM

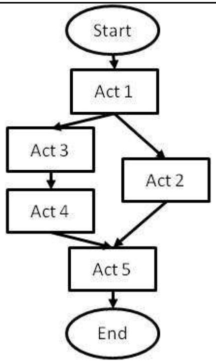
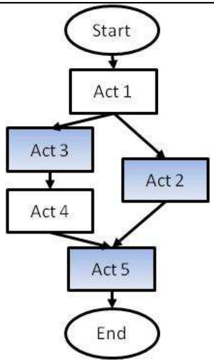
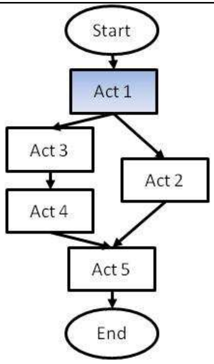
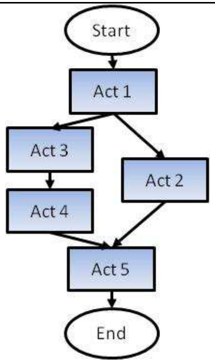
The second stage of these models is achieved through a call for proposals made within the Services Ecosystem. This call for proposals is announced in the CO_Board (blackboard-like infrastructure that the Services Ecosystem Platform provides), including the services from the abstract business process model. The PSEs, checking for collaboration opportunities, find these calls and try to make a matching with the services they are representing and able to provide under the required conditions, as explained before. Whenever a match is found, either in the case of a direct match or an indirect one, the PSE creates a *service provision proposal* or a *service provision suggestion*, which is sent back to the broker through the Services Ecosystem, as defined in section 3.2.4. After a pre-defined timeframe, the broker selects the proposals that best fit the needs and potentially includes some suggestions in the abstract BPM. The selection of performers for the services included in an absBPM is what transforms it in an executable document – an eBPM. There are two possibilities under which an abstract workflow model may become executable:

- Minimum execution possibility - The services attached with the starting activities have at least one performer selected. The start activities are the ones that have a transition from a starting point in the workflow model to such activities. In this case, the selection of performers for the remaining services is postponed.
- Complete model – All activities have performers selected for the provision of the attached services, meaning that if nothing goes wrong at runtime, the model will be executed straightforward and the performers of each service will be notified to start their provision at the right moment.

It is worth to notice that more than one service provider can be selected for a single service in an absBPM. This fact leaves an open possibility of requesting a service provision from the second or third selected provider when the first one becomes unavailable at runtime. Naturally, all the providers included in the eBPM have also to commit themselves, even if that is a “second choice” commitment.

Table 5-1 represents 4 distinct possible completion states of a BPM, between an absBPM, at the left hand side, and a complete eBPM, at the right hand side.

Table 5-1 – Possible BPM completion states

<table>
<tr><td colspan="2">☐ Act — Activity WITHOUT performers associated</td><td colspan="2">▨ Act — Activity WITH performers associated</td></tr>
<tr>
<td>
</td>
<td>
</td>
<td>
</td>
<td>
</td>
</tr>
<tr><td>absBPM, ready to start execution - NO</td><td>ready to start execution - NO</td><td>eBPM, ready to start execution - YES</td><td>Complete eBPM, ready to start execution - YES</td></tr>
</table>

6. Workflow Engine – Finally, a workflow engine provides functionality for the execution of the eBPMs. For instance, Figure 5-7 represents an eBPM that is being executed. The execution of an eBPM is started by the client and / or the broker and performed by the workflow engine. It consists on launching each service provision, through the corresponding PSE, at the right moment. Afterwards, the engine waits to receive a completion message from the PSE and repeats the process with the subsequent activities and services, as defined in the workflow model. The PSE itself has an interface with the Senior Professional to inform him or her that it is time to start the service or to receive the notification that the service provision is finished. In the snapshot from Figure 5-7, the “strategic plan” activity indicates a service that is being performed. In this case, three previous services have already been completed, namely: the Activity Start Planning, the Financial Planning and the Fiscal Planning services. In terms of interaction with the Senior Professionals, this means that three distinct SPs have been already notified that their service provision should start. This notification was made by the corresponding PSEs: pse_1, pse_6 and pse_3, respectively and the SPs themselves have already finished such services and notified the corresponding PSEs, which forward such notifications to the workflow engine. At the current moment, pse_1 has already notified the corresponding SP as well, and he or she is performing the “Strategy Planning”

consultancy service, the second service provision for that specific senior professional in this eBPM.

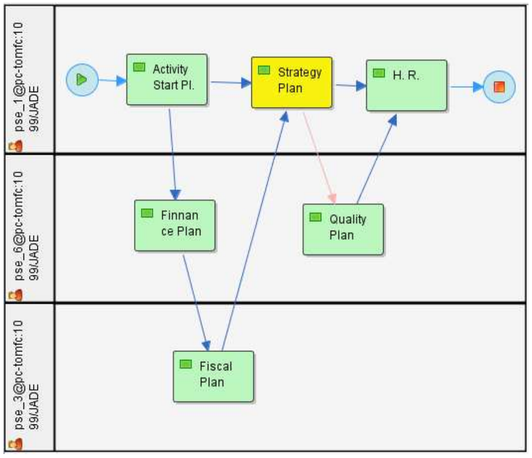


Figure 5-7 - Example eBPM being executed

In fact, the model of Figure 5-7 corresponds to the absBPM of Figure 5-6, to which 3 SPs were selected as performers. In this case a suggestion was also made by pse_3 towards including a "Fiscal Plan" service that was not identified in the absBPM.

The selection of the SPs for each service is supported by the QoS data stored at PASEF. It is worth to notice that the performer lines in the model of Figure 5-7 correspond to the PSEs representing the selected seniors, following the BPMN standard notation. The corresponding proposals are made by the PSEs themselves, reacting to the call for proposals. In this particular example, three PSEs have made successful proposals, among which two are composed of more than one service:

- pse_1 – represented in the first line, has successfully proposed the following services:
    - Activity Start Planning,
    - Strategy Planning (the service that is being executed), and
    - Human Resources Planning.
- pse_6 – represented in the middle line, has successfully proposed the following services:
    - Finance Planning, and
    - Quality Planning

Still concerning Figure 5-7, the service that is being executed is the "Strategic Planning" consultancy service, provided by the SP that is represented by pse_1. The interaction between the workflow engine and the PSE made towards launching this service might somehow go wrong. Some possible reasons may be a network connection break or some unexpected unavailability from the SP. For that reason “second chance” providers were included in the BPM and if this fault happens during execution, the workflow engine should contact the pse from the second choice towards asking the corresponding SP to execute this “Strategic Planning” consultancy service.

Besides supporting the professional life of seniors, the example application area selected for PASEF, collaborative networks can also play a relevant role in other life settings, namely independent living, healthy living, and recreation in life, as identified in the BRAID roadmap on ICT and Ageing (Camarinha-Matos and Afsarmanesh, 2011). In all these areas there is a trend to evolve towards more integrated services, involving multiple stakeholders through well coordinated collaborative ecosystems. PASEF, as a configurable and extensible framework, can be applied in such contexts, especially based on the pro-activeness factor of the base constructs – the PSEs. In fact, the behavioural aspect of these constructs can be defined for distinct circumstances. Nevertheless some future work functionalities for the framework are identified in section 6.2.

In what concerns the specific technologies selected for the development of this prototype, three approaches were considered:

1. Develop the whole system from scratch, including all the multi-threaded mechanisms in order to create independent and autonomous PSEs, as well as all the message exchange mechanisms.
2. Build the framework on top of an existing MAS middleware solution.
3. Build the framework on top of an existing Web-Services middleware solution.

The followed strategy was to combine approaches 2 and 3, through the usage of the Web Service Integration Gateway (WSIG), defined by FIPA, because it is a user-friendly bridge already providing combination / integration between the two worlds – MAS and SOA (JADE-Board, 2008). This gateway is extended in order to cope with the defined conceptual framework, namely for the automation of the notifications made to, and received from the PSEs.

The specific platform on top of which the prototype system is developed is JADE both because it is supported by an active research community and because it offers an easy development approach. JADE also follows the general MAS development frameworks’ design characteristics aligned with the Pro-Active Service Entity Framework concepts (Bellifemine et al., 2007):

1. An agent is autonomous and pro-active;
2. Agents are loosely coupled, meaning that the communication is asynchronous and no temporal dependency exists between message senders and receivers;
3. The system is peer-to-peer, meaning that each agent is uniquely identified by the Agent Identifier, as defined by FIPA.

Some of the technologies selected for the development of the prototype, described in this section, are listed in Table 5-2.

Table 5-2 - Technologies used in proof of concept support prototype

Technology	Role in PASEF and key factors for the selection
NetBeans Java IDE	IDE for Java development with fast user interface development.
Eclipse Java IDE	Java Development IDE used to extend the workflow editor and engine.
JADE	Provide a Multi-Agent System towards the creation of the pro-active constructs of the framework .
WSIG	Integration between PSEs services and other PASEF modules.

Although these technologies are selected as the most adequate ones, the future work elements identified in the concluding Chapter may result in changing some of these technologies if some other ones become more adequate for other application scenarios or for any other compatibility reasons.

5.3. Benchmarking

As mentioned before, VE_2 and VE_3, the Benchmark validation elements, were carried out following a process inspired in the TOPSIS method (Hwang et al., 1993). The aim of this mechanism is the assessment of a distance between distinct “elements to compare” to an ideal approach or solution. This distance is based on the classification of such elements under several classification parameters that have also to be identified. In this method, the ideal value is selected the best value attained in each classification parameter. The classification is then normalized and the distinct elements are sorted according to the attained distance values. The defined process is composed of the steps detailed in Table 5-3.

Table 5-3 - TOPSIS method

1. Selection of comparison parameters (CP_1, …, CP_n) – find out what meaningful characteristics to evaluate the elements being compared, quantitatively or qualitatively.
    - For every quantitative classification parameter, define the scale for the classification values.
    - For every qualitative classification parameter, define the possible values and a corresponding quantitative matching towards using the classification afterwards. This case is not used in the two benchmark exercises presented bellow.

2. Identify the elements to compare (EC_1, …, EC_m) – in each benchmark validation exercise, a set of existing elements are selected in order to pursue the benchmarking. These are the elements that will be compared to PASEF.

3. Classify each EC_j ($1 \leq j \leq m$) – make the classification of all elements being compared in the benchmark exercise for each comparison parameter CP_i, ($1 \leq i \leq n$). In this case all classifications are made in a scale from 1 (lowest classification) up to 5 (highest classification).

4. Normalization of the classification – use vector normalization in order to be able to use classification values from distinct comparison parameters in the same formulas. For each classification value x_{ij}, a corresponding normalized classification value r_{ij} is calculated according to the formula:

$$\boxed{r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{k=1}^{n} x_{kj}^2}}}$$

5. Relative weight of comparison parameters w_i, ($1 \leq i \leq n$) – identify the most meaningful classification parameters and the less important ones, giving a relative value to each one, with the guarantee that the sum of all these weight values equals 1.
    - Weighted classifications – after each classification parameter has a specific weight w_i, apply such weight to the normalized classifications made in the 4th step of the benchmarking process. For each normalized classification value r_{ij} a corresponding weighed classification value v_{ij} is calculated using the formula:

$$\boxed{v_{ij} = w_j \times r_{ij}}$$

6. Identify ideal / anti-ideal values $(a_{\mathrm{i}}^{+}, a_{i}^{-})$, (1 ≤ i ≤ n) – the two extreme values, the best and the worst case, for each classification parameter $\mathrm{CP_j}$, where:

$$a^{+} = \begin{cases} \max\limits_{1\le j<m} v_j, & if\ CP_i\ is\ a\ benefitial\ parameter \\ \min\limits_{1\le j<m} v_j, & if\ CP_i\ is\ a\ cost\ parameter \end{cases}$$

$$a^{-} = \begin{cases} \min\limits_{1\le j<m} v_j, & if\ CP_i\ is\ a\ benefitial\ parameter \\ \max\limits_{1\le j<m} v_j, & if\ CP_i\ is\ a\ cost\ parameter \end{cases}$$

In the two benchmarking exercises carried out, all the classification parameters are beneficial parameters, meaning that higher values correspond to a better classification on that comparison parameter.

7. Calculate distance to ideal and anti-ideal values – after the ideal and anti-ideal extreme values selection, the distance of each classification to such extreme values is calculated.

$$\boxed{D^{+}(A_i) = \sqrt{\sum_{k=1}^{n} (v_{ik} - a_k^{+})^2}}$$

$$\boxed{D^{-}(A_i) = \sqrt{\sum_{k=1}^{n} (v_{ik} - a_k^{-})^2}}$$

8. Relative proximity calculation – after the absolute distance calculation, a relative distance calculation is made for each classification parameter.

$$\boxed{C_i = \frac{D^{-}(A_i)}{D^{+}(A_i) + D^{-}(A_i)}}$$

This $\mathrm{C_i}$ value, corresponding to the relative distance to ideal values, is the final result of this TOPSIS-based mechanism for each element being compared. The final step of the mechanism is sorting the elements being compared according to the corresponding $\mathrm{C_i}$ value

5.3.1. Benchmark of Approaches

The Benchmark of Approaches validation element aims at comparing PASEF with related or similar approaches. As mentioned in Section 2.4.1, several initiatives took place already, applying the service paradigm and Service Oriented Architectures to the Collaborative Networks context. Furthermore, the multi-agent systems' approach has also attracted the attention of several other research groups in this area. In order to cover the two approaches and, at the same time, avoid a too long benchmarking exercise, three initiatives were selected as the mentioned elements to evaluate through the TOPSIS-based method described above. The selected initiatives are: ICT-I

(Rabelo et al., 2006), ManBree (Franco et al., 2009a) and KIMM's framework (Kuk et al., 2008). These are the Elements to Compare (EC$_j$) mentioned in the previous section. The first two are selected because both of them use Service Oriented Approaches in Collaborative Networks. KIMM's framework is selected because it considers the usage of multi-agent systems, together with service orientation in a collaborative context. These three initiatives are briefly described in Section 2.5. Table 5-4 shows the Classification Parameters identified for this comparison exercise.

Table 5-4 - Benchmark of Approaches - Classification Parameters

#	Name	Description
CP$_1$	Pro-Activeness	How pro-actively do the constructs representing Business Services behave towards business success?
CP$_2$	Aggregation	Does the approach aggregate distinct services provided by the same entity, taking benefit from that?
CP$_3$	QoS Assessment	Does the approach include and take benefit from Quality of Service assessment?
CP$_4$	Service Suggestions	Does the approach somehow considers the suggestion of services, other than a traditional bidding mechanism?
CP$_5$	Self-Optimization	Does the approach benefits from usage, meaning that it may evolve to adapt to the environment.

Classification

After the identification of the Elements to Compare (EC$_j$) and the definition of the Comparison Parameters (CP$_i$), the classification was performed, as shown in Table 5-5 and Table 5-6. For each classification value, a list of the key reasons for that classification is presented.

Table 5-5 - Benchmark of Approaches - Classification (i)

		CP$_1$		CP$_2$		CP$_3$	
		Pro-Active Constructs		Aggregation		QoS assessment	
EC$_1$	ICT-I	* Although behavioral aspects are out of the scope at base constructs, they are carried out at higher levels.	3	* Services in the base constructs.	3	* QoS considered in security services, fault-tolerance, real-time supporting services, etc.	5
EC$_2$	ManBree	* Although behavioral aspects are out of the scope at base constructs, they are carried out at higher levels.	3	* Services + Attributes in the base construct * Aggregation is a keyword.	5	* not considered.	1
EC$_3$	KIMM's framework	* Negotiation behaviour considered.	4	* not considered.	1	* QoS Considered at a higher level.	3
EC$_4$	PASEF	* One of the key factors for PSEs.	4	* Services + Attributes in the base construct.	3	* QoS assessed in all service provisions.	3

Table 5-6 – Benchmark of Approaches - Classification (ii)

		CP_4		CP_5	
		Suggestions		Adaptability	
EC1	ICT-I	* not considered	1	* key design goal	5
EC2	ManBree	* not considered	1	* service entities wrap interoperability constrains	4
EC3	KIMM's framework	* not considered	1	* Engineering Service Server hides interoperability constraints	5
EC4	PASEF	* indirect match * PSEs suggest service inclusion	3	* PSEs wrap interoperability constrains	2

The two classification tables – Table 5-5 and Table 5-6 – are key elements of this TOPSIS method as this is the point where the concrete classification values are given to the Elements being compared (EC_j) under the selected Comparison Parameters (CP_i). On the other hand, this is one limitation of the method as it embodies a case of "judgement of the own cause". Nevertheless, an effort was made in order to minimize this factor and avoid falling in the temptation of over-grading PASEF. For that reason, a short classification scale was selected, from 1 up to 5, in order to swallow up, to some extent, the subjectivity of the values. Moreover, the systematic nature of the process contributes as a positive factor as it works straightforward. It is also worth to notice the classifications attained in the CP_5 – "Adaptability", where PASEF took the worst classification. In fact the adaptability is a key factor and an improvement of PASEF will have to be made in the near future, as mentioned in the future work section.

Normalization

As mentioned before, the normalization process can follow a typical vectorial approach. Table 5-7 shows the normalized classification values.

Table 5-7 – Benchmark of Approaches - Normalized Classification

		CP_1	CP_2	CP_3	CP_4	CP_5
		Pro-Active Constructs	Aggregation	QoS assessment	Suggestions	adaptability
EC_1	ICT-I	0.4243	0.4523	0.7538	0.2887	0.5774
EC_2	ManBree	0.4243	0.7538	0.1508	0.2887	0.4619
EC_3	KIMM's framework	0.5657	0.1508	0.4523	0.2887	0.5774
EC_4	PASEF	0.5657	0.4523	0.4523	0.8660	0.3464

Relative weight for Comparison Parameters

Deciding the relative weight for each comparison parameter is not a linear exercise as each one tackles a distinct perspective that complements the other CPs. A simplistic solution would be to equally weight all parameters. Nevertheless, a distinct approach is selected and the weight given to each parameter is based on two factors:

1. How effectively does that comparison parameter reflect a solution to the limitations identified for current approaches?
2. How effectively does each parameter influence the service providers in a business perspective?

Table 5-8 shows a classification in the scale from 1 (lowest) up to 5 (highest) to these two questions for each comparison parameter. The weight of each comparison parameter is calculated based on this classification.

Table 5-8 – Benchmark of Approaches - Relative weight of Comparison Parameters

	CP_1	CP_2	CP_3	CP_4	CP_5
	Pro-Active Constructs	Aggregation	QoS assessment	Suggestions	Adaptability
1	5	4	4	3	2
2	5	5	4	4	3
sum	10	9	8	7	5
weight	26%	23%	21%	18%	13%

Weighted classifications

Table 5-9 shows a “weighted normalized classification”, resulting from the relative weight of the classification parameters.

Table 5-9 – Benchmark of Approaches – Weighted classifications

		CP_1	CP_2	CP_3	CP_4	CP_5
		Pro-Active Constructs	Aggregation	QoS assessment	Suggestions	adaptability
EC_1	ICT-I	0.1088	0.1044	0.1546	0.0518	0.0740
EC_2	ManBree	0.1088	0.1739	0.0309	0.0518	0.0592
EC_3	KIMM’s framework	0.1450	0.0348	0.0928	0.0518	0.0740
EC_4	PASEF	0.1450	0.1044	0.0928	0.1554	0.0444

Ideal and anti-ideal values

The ideal and anti-ideal values are gathered selecting the highest and lowest classification for each comparison parameter. Table 5-10 shows these values for this approach benchmarking.

Table 5-10 – Benchmark of Approaches – ideal and anti-ideal values

	CP_1	CP_2	CP_3	CP_4	CP_5
	Pro-Active Constructs	Aggregation	QoS assessment	Suggestions	adaptability
Ideal	0.1450	0.1739	0.1546	0.1554	0.0740
Anti-ideal	0.1088	0.0348	0.0309	0.0518	0.0444

Distance to ideal and anti-ideal values and relative closeness to ideal values

The fourth step of the TOPSIS-based mechanism calculates the distance of all classifications to the ideal and anti-ideal values. The fifth step gathers these distance values to calculate the final relative closeness to the ideal values. The final step is sorting the approaches based on the benchmarking result – the C value. Table 5-11 shows these distances, as well as the relative proximity C, already sorted.

Table 5-11 – Benchmark of Approaches – distance to ideal values and relative proximity

	Approach	D+	D-	C
EC_4	PASEF	0.0977	0.1439	0.5957
EC_1	ICT-I	0.1300	0.1450	0.5273
EC_2	ManBree	0.1661	0.1399	0.4573
EC_3	KIMM’s framework	0.1842	0.0776	0.2963

The final results of the TOPSIS-based mechanism applied to this benchmark exercise put PASEF in the first place. This fact was expected, to some extent, because the selection of the classification parameters was centred on the main limitations of current approaches, which were indeed taken as the base for PASEF specification. The classification of the other approaches was also expected. On one hand, KIMM’s framework is close to PASEF in what concerns the multi-agent systems characteristics. On the other hand, the ManBree approach is also close to PASEF, this time in what concerns the aggregation factor. Nevertheless, despite these two intermediate classifications, the “second place” goes to the ICT-I approach because, although it does not gather a “closest” classification in any specific factor, it has a relatively strong classification in several classification parameters. This fact has a particular magnitude in the adaptability perspective, which is a classification factor where ICT-I had the best classification. After ICT-I, the classification of Manbree is very close because it benefits from the aggregation classification parameter where it gets the higher classification. Finally, although the KIMM's framework comes in the last place far from Manbree, it gains in the pro-activeness factor along with PASEF.

As mentioned before, this benchmarking exercise suffers from a limitation as "*one cannot do a thing that he is a proper judge of it*" (Oscar Wilde). In fact, the selection of the classification parameters and the classification marks attained in the Elements being Compared (EC_j) for each Comparison Parameter (CP_i), was based on a personal opinion or understanding. This fact introduces subjectivity and one can argue that distinct persons would reach different results.

In what concerns the selection of the comparison parameters, this limitation is somehow diluted because the option taken was the selection of such parameters based on the limitations identified in the beginning of the work. Although this choice benefits PASEF, as these limitations were also the base inspiration for the creation of this framework, it still is quite fair because these parameters are exactly the elements intended to improve in comparison with existing approaches.

In what concerns the values attained for the EC_j on each PC_i, although they were based on personal understanding or opinion, an effort was made towards producing a fair classification. For that reason, a small scale was selected, from 1 up to 5, in order to dilute the main advantages of PASEF against the other approaches.

In fact, whenever a benchmark exercise has to be made, either through TOPSIS method or some other mechanism, there is a point where quantitative classifications have to be given to the elements being benchmarked. At this point of the process, there are two possibilities: 1) the values result from absolute measurements, like the time in seconds that a system takes to perform some task, or 2) the values result from an evaluation of the elements being benchmarked, following some criteria, and this evaluation is always made by humans, meaning that distinct persons can reach distinct results. Nevertheless, an effort was made towards finding out the reasons and arguments based on which each value was selected, as presented in Table 5-5 and Table 5-6 – the classification tables.

Moreover, the fact of using a transparent and straightforward mechanism in this benchmarking, like the TOPSIS method, works as an advantage, as other than the selection of the classification parameters and the classification itself, all the process is defined *a priori* and goes straightforward.

5.3.2. Benchmark of Solutions

The Benchmark of Solutions validation is made through the comparison of PASEF prototype with existing solutions found on the Internet that also tackle consultancy services. This validation element follows a usage perspective. The first step is the identification of the factors that will be compared between the PASEF prototype and the existing solutions. Next, these mentioned solutions are selected and each one is classified on the identified comparison parameters, including PASEF. The identified comparison parameters are described in Table 5-12.

Table 5-12 – Benchmark of Solutions – Comparison Parameters

#	Name	Description
CP_1	Specificity	How specific is the solution? Can it be applied to distinct economical areas? Can it be applied to other kinds of services, distinct from consultancy?
CP_2	Effectiveness	How effectively does the solution achieve the desired goals?
CP_3	QoS reward	Does the solution consider Quality of Service rewarding?
CP_4	Collaboration	Does the solution consider the collaboration between distinct consultants?

In what concerns the selection of existing solutions, it was difficult to find the right ones for this benchmarking. For that reason, the target was restricted to general consultancy solutions, where freelancers and clients / customers can get connected. Even though some websites provide mechanisms for free-lancers to register and provide their services, collaboration mechanisms for the free-lancers to work with each other were practically not found – a key comparison parameter. The only interaction found was always between clients and the freelancers. Two solutions were selected for this benchmark exercise: liveperson.com/experts and freelancer.com, briefly described below.

EC_1 – lifeperson.com/experts - http://www.liveperson.com/experts/

Lifeperson is an online solution targeting the establishment of a connection between enterprises and their clients or costumers. The solution is web-based and relies on communication channels like video-conferencing, chat or document exchange for the consultancy interactions. The solution lets members that need consultancy services to find experts on a specific field and provide them the mentioned communication channels. Afterwards, Lifeperson receives the payment due to the consultancy services from the client and forwards the payment to the service provider in a pay-per-time basis. In this case, the focus of the service is on the experts – the freelancers. Table 5-13 shows a sample browsing snapshot of the expertise available at liveperson.com, in distinct areas. Table 5-14 zooms in the Computers & Programming expertise area.

Table 5-13 – Browsing liveperson.com available expertise

Expertise Area	Available Experts
Arts & Creative Services	845
Business & Finance	2303
Coaching & Personal Development	940
Computers & Programming	2305
Education & Tutoring	1425
Health & Medicine	1348
Home & Leisure	155
Legal Services	310
Spirituality & Religion	5672
Professional Counselling	564
Shopping & Style	469
Social Media	145
Other Expertise	0
Total	**16481**

Table 5-14 – Computers & Programming Expertise

Expertise	Available Experts
Applications	61
Computer & Video Games	12
Computer Repair	188
Databases	136
Handhelds/PDAs	10
Hardware	49
Help For Beginners	158
Internet Searches	227
Networking	106
Office Software	96
Open Platform Development	6
Operating Systems	59
Other Computers & Programming	120
Programming and Computing	4
Programming	286
Security & Encryption	70
System Administration	152
Telecommunication	133
Web Development	290
Website Partners	3
Wireless Technology	26
Total	**2305**

These categories are further detailed in some cases and each professional shows his or her expertise in a short text as well as price per minute. The system also shows the classifications given by previous clients in a 5 star scale. Figure 5-8 highlights a snapshot of the website in the Firewall expertise area from the networking expertise group, highlighting the expert “Dan007” that has already received 1392 reviews. It is also possible to zoom in the reviews and see how previous clients graded a given expert and any comments they left.

Have issues with your firewall or need help installing modem or router? Contact me and I will fix your problem quickly. I also provide remote...

Figure 5-8 - liveperson.com snapshot

EC$_2$ – freelancer.com – http://www.freelancer.com/

Freelancer.com is another online service that works as a marketplace providing the means for employers and freelancers to collaborate. The mechanism is similar to liveperson.com/expert.

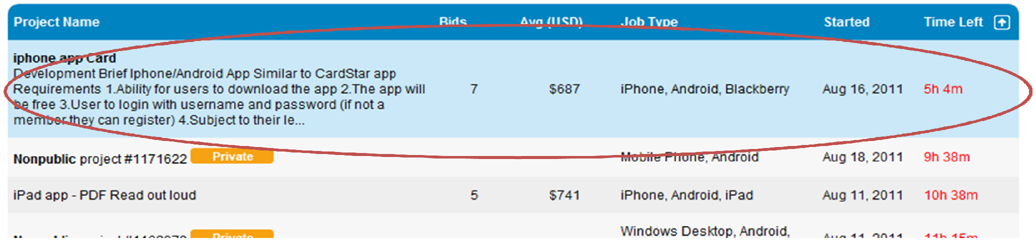
Projects are described in free text for freelancers to post bids. The service also includes mechanisms for providers and consumers to grade each other. Freelancer.com provides a message board system for private communication and the payment is made in a milestone base, meaning that milestones are defined and the payment is made upon their completion. Freelancer.com highlights two innovation aspects, although only the first one is partially new: 1 – an API that allows retrieval of freelancer.com information in order to be used by members' own applications; 2 – dedicated interface for members to earn money from their websites by including text links, banners, etc. In this case, the focus of the service is on the projects – the business opportunities. Table 5-15 shows a sample browsing snapshot of the project areas and the number of available projects waiting for bids, in each area. Zooming in "Mobile Phones & Computing", for example, specific project areas are shown with the corresponding number of available projects waiting for bids Table 5-16. Finally, zooming in the Android project area, a table shows each project in a row, including details like a project name, a description, the number of bids already submitted and the average price requested in the bids. Figure 5-9 shows a snapshot of the site, highlighting a project from this area that already had 7 bids.

Table 5-15 – Browsing freelancer.com projects waiting for bids

Project Area	Number of Projects
Websites, IT & Software	9668
Mobile Phones & Computing	1105
Writing & Content	2340
Design, Media & Architecture	4434
Data Entry & Admin	1017
Engineering & Science	315
Product Sourcing & Manufacturing	95
Sales & Marketing	2819
Business, Accounting, Human Resources & Legal	186
Other	219
Total	**22198**

Table 5-16 – "Android Jobs" available Projects

Project Area	Number of Projects
Amazon Kindle	2
Android	214
Android Honeycomb	10
Appcelerator Titanium	4
Blackberry	56
Geolocation	8
iPad	162
iPhone	327
J2ME	12
Mobile Phone	311
Nokia	4
Palm	1
Samsung	0
Symbian	12
Windows CE	1
Windows Mobile	13
Total	**1105**



Project Name	Bids	Avg (USD)	Job Type	Started	Time Left
iphone app Card Development Brief Iphone/Android App Similar to CardStar app Requirements 1.Ability for users to download the app 2.The app will be free 3.User to login with username and password (if not a member they can register) 4.Subject to their le...	7	$687	iPhone, Android, Blackberry	Aug 16, 2011	5h 4m
Nonpublic project #1171622 Private			Mobile Phone, Android	Aug 18, 2011	9h 38m
iPad app - PDF Read out loud	5	$741	iPhone, Android, iPad	Aug 11, 2011	10h 38m
			Windows Desktop, Android,		

Figure 5-9 - freelancer.com snapshot

The members of the community can post bids on the projects through private messages and it is possible to see the members who made the bids, how much money they did request and their rating. This rating is attained through a review system similar to the one from liveperson.com.

It is worth to mention that these two Elements to Compare (EC$_1$ and EC$_2$) are quite distinct from PASEF in the sense that they embody the concept of Service Markets instead of Service Ecosystems. In fact, in the two cases clients can go and find providers or performers for the services they need. In the PASEF case, the proposal embodies a wider concept or space where providers, clients and brokers share an environment created to pursue collaboration. As a result, naturally the benchmarking of solutions shall reflect that fact.

Classification

After the selection of the solutions to benchmark, the classification concerning the identified comparison parameters is made. A similar approach to the one taken in the benchmark of approaches was conducted. A scale from 1 up to 5 was selected and a personal understanding was the base for the classification values, always finding out the reasons for them. Table 5-17 and Table 5-18 show the mentioned classifications, including the reasons for each value.

Table 5-17 - Benchmark of Solutions – Classification (i)

		CP$_1$		CP$_2$	
		Why?	Specificity	Why?	Effectiveness
EC$_1$	lifeperson.com	* applied to many activity areas * 13 main activity categories	5	* provides distinct communication channels * 1641 available expertise	4
EC$_2$	freelancer.com	* applied to many activity areas * 10 main activity categories	4	* provides private message board communication channel * 425 average open projects	4
EC$_3$	PASEF	* general, but especially used for senior professionals (in current implementation)	3	* Support bidding * Direct / Indirect Matching between projects and provided services.	5

Table 5-18 - Benchmark of Solutions – Classification (ii)

		CP$_3$		CP$_4$	
		Why?	QoS reward	Why?	Collaboration
EC$_1$	lifeperson.com	* Clients and providers grade each other's performance	4	* No collaboration between providers is considered	1
EC$_2$	freelancer.com	* Clients and providers grade each other's performance	4	* No collaboration between providers is considered	1
EC$_3$	PASEF	* Clients and providers grade each other's performance	4	* BPM support. * High-level client needs detailed in workflow BPMs by brokers	5

Normalization

As explained before, after the classification values are achieved, a vector normalization takes place. This step is needed in order to guarantee that the values from distinct comparison parameters' classification can be used together in the benchmarking. Table 5-19 shows the normalized values.

Table 5-19 - Benchmark of Solutions – Normalized Classification

		CP_1	CP_2	CP_3	CP_4
		Specificity	Effectiveness	QoS reward	Collaboration
EC_1	lifeperson.com	0.7071	0.5298	0.5774	0.1925
EC_2	freelancer.com	0.5657	0.5298	0.5774	0.1925
EC_3	PASEF	0.4243	0.6623	0.5774	0.9623

Relative weight for Comparison Parameters

The definition of the Comparison Parameters' weight in the benchmark of solutions is similar to the one used in the benchmark of approaches. Each comparison parameter is classified on the factors:

1. How does that comparison parameter reflect a solution to the limitations identified for current approaches?
2. How effectively does each parameter influence the service provider's business interests?

Table 5-20 shows the classification of each comparison parameter according to the mentioned factors and the resulting weight values.

Table 5-20 - Solution Benchmark - Relative weight of Comparison Parameters

	CP_1	CP_2	CP_3	CP_4
	Specificity	Effectiveness	QoS reward	Collaboration
1	2	3	3	4
2	3	4	5	5
Sum	5	7	8	9
Weight	17%	24%	28%	31%

Weighted classifications

Table 5-21 shows the classification of each comparison parameter on the mentioned factors and the resulting weight values.

Table 5-21 – Solution Benchmark – Weighted classifications

		CP_1	CP_2	CP_3	CP_4
		Specificity	Effectiveness	QoS reward	Collaboration
EC_1	lifeperson.com	0.1219	0.1279	0.1593	0.0597
EC_2	freelancer.com	0.0975	0.1279	0.1593	0.0597
EC_3	PASEF	0.0731	0.1599	0.1593	0.2986

Ideal and anti-ideal values

Table 5-22 shows highest and lowest values from each comparison parameter – the ideal and anti-ideal values. These are the values used to assess the distance of each solution from the best classification.

Table 5-22 – Solution Benchmark – ideal and anti-ideal values

	CP_1	CP_2	CP_3	CP_4
	Specificity	Effectiveness	QoS reward	Collaboration
Ideal	0.1219	0.1599	0.1593	0.2986
Anti-ideal	0.0731	0.1279	0.1593	0.0597

Distance to ideal and anti-ideal values and relative closeness to ideal values

Table 5-23 shows the final values from this benchmarking exercise: the distance to the ideal value, the distance to the anti-ideal value and the final relative closeness to ideal values – the C value.

Table 5-23 – Solution Benchmark result

	Solution	D+	D-	C
EC_3	PASEF	0.0488	0.2410	0.8317
EC_1	lifeperson.com	0.2410	0.0488	0.1683
EC_2	freelancer.com	0.2423	0.0244	0.0914

In this Benchmark exercise the final results put PASEF in the first position, far from the other two solutions. Actually these results were somehow already expected because of two reasons: 1 – the selected comparison parameters were the base problems that originated PASEF; 2 – PASEF is the only solution considering a collaboration factor among the members of the community using the solution.

As mentioned in the Benchmark of Approaches, the main limitation of this exercise is the fact that it embodies a case of judging own work. Nevertheless, an effort was made to overcome this issue and the fact that the process was conducted through a transparent and straightforward method like the TOPSIS, dilutes this limitation.

5.4. Peer's Validation

5.4.1. Specialist's Opinion

The specialist's opinion concerning PASEF was obtained along the creation of the framework, especially through discussions in conferences, where it was possible to collect sound and valuable contributions. In fact, these discussions strongly helped the process of creation of the PASEF framework, both gathering the opinion of specialists in the areas of Collaborative Networks and Computer Science in general. As mentioned before, another strong input and validation contribution came from the two Portuguese Senior Professional associations.

A final peer validation element was made through a survey conducted with a set of specialists that also participated in ECOLEAD and / or the ePAL projects[3]; from which a subset of 20% volunteered to participate. This group included specialists in the areas of computer science, collaborative networks, industrial engineering, ICT and ageing, etc. The exercise itself included a presentation of the complete PASEF framework description a demonstration of the prototype. Afterwards, a small survey was conducted. The questions used in this survey are organized around the most innovative topics addressed by PASEF – Table 5-24.

Table 5-24 - Specialists survey question topics

Topic
Introduction of Pro-Activeness in service constructs.
Aggregation of distinct services provided by the same provider within a single construct.
Creation of an Ecosystem instead of an open market over the Internet.
Shorten the distance between business and software worlds, through the possibility of defining distinct behaviours for the PSEs.
Application to Senior Professionals.

Three classification factors are introduced in order to provide a systematic classification schema towards the assessment of how innovative these topics are, how useful and finally how effectively PASEF addresses them:

A. How innovative is PASEF approach to the topic? (distinct from current approaches)

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[3] ECOLEAD involved 29 partners from 15 countries and ePAL involved 6 partners from 4 countries. On average each partner involved a team of 3-4 researchers in the project.

B. How useful is PASEF in the topic? (addressing real usage needs)
C. How effectively does PASEF address the topic? (solving the identified needs)

The classification is made in a scale from 1 (worst) up to 10 (best). The statistical data from this survey points out the Introduction of the Pro-activeness in the service representative constructs as the leading aspect, exception made to the usefulness classification factor where the aggregation of distinct services provided by the same provider within a single construct gets the best average classification of 8.8. The pro-activeness gathers 8.4 average classification value in this classification factor. Figure 5-10 shows the average classifications made by the specialists group concerning the five addressed questions.

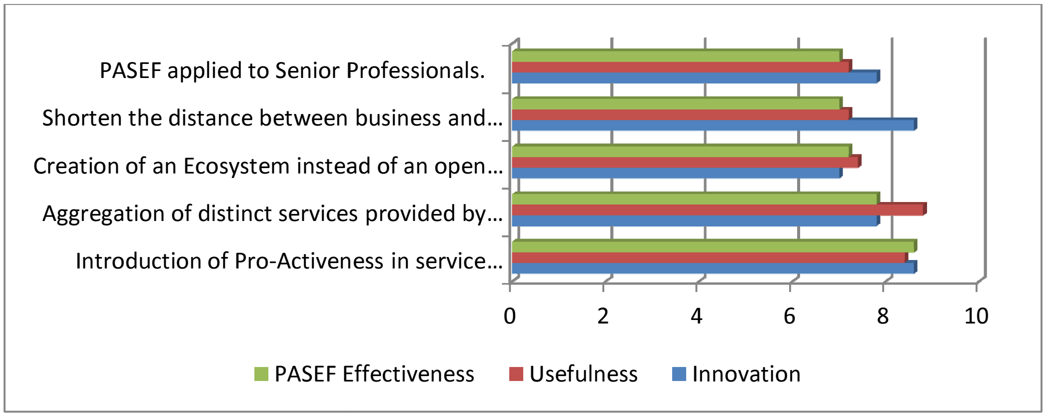


Figure 5-10 - Average Specialists Opinion / Classification of PASEF innovation

5.4.2. Publications

Along the research towards the creation of PASEF, a peer validation has been carried out through the publication of articles in refereed international conferences and journals, as shown in Table 5-25. Two other publications are included in the table, given their early contribution to this work.

Table 5-25- List of Publications

#	Title	Where	When	Reference / Authors	Index
P_5	Pro-Active Services Ecosystem Framework	Journal: International Journal of Computer Integrated Manufacturing	Accepted in 2011	Tiago Cardoso; Luis M. Camarinha-Matos	SCI WoS
P_4	Proactivity in collaborative Services Ecosystems	Conference: PRO-VE'11	Oct. 2011	(Cardoso and Camarinha-Matos, 2011a)	WoS
P_3	ProActive Service Entity Framework: Improving Service Selection Chances within large Senior Professional Virtual Community scenario	Conference: DoCEIS'11	Feb. 2011	(Cardoso and Camarinha-Matos, 2011b)	WoS
P_2	Pro-Active Service Entity Framework for a Better Mapping between Business and Software	Conference: PRO-VE'10	Oct. 2010	(Cardoso and Camarinha-Matos, 2010b)	WoS
P_1	Pro-Active Asset Entities in Collaborative Networks	Conference: DoCEIS'10	Feb. 2010	(Cardoso and Camarinha-Matos, 2010a)	WoS
P_a	Selection of partners for a virtual enterprise	Conference PRO-VE'99	Out. 99	(Camarinha-Matos and Cardoso, 1999)	WoS
P_b	Service Federation in Virtual Organizations	Conference IFIP TC5 / WG5.2 & WG5.3 Eleventh Int. PROLAMAT	Nov. 01	(Camarinha-Matos et al., 2002)	WoS

SCI – Science Citation Index; WoS – ISI Web of Science.

5.5. Contribution of the Validation Elements to the Hypotheses Validation

The final step of this validation is the assessment of the contribution that each validation element listed in Figure 5-1 gave to the hypotheses formulated in this research work. In order to make this assessment, Table 5-26 revisits each hypothesis highlighting / extracting its main composing elements.

Table 5-26 - Hypothesis decomposition

Hypothesis		Main Composing Elements	
H1	If the representation of Collaborative Network members' services is made using elements of Pro-Activeness with Social ability, these enterprises, professionals or organizations can benefit in terms of the chances they have to see their abilities selected and a better fitness between them and the clients can be achieved. This representation could be built upon Aggregation (including distinct services an entity can provide within the same construct) and behaving towards finding new Business Opportunities and promoting the represented Services, all in an auto-initiative basis.	E1	using elements of Pro-Activeness with Social ability
		E2	chances they have to see their abilities selected
		E3	a better fitness between them and the clients can be achieved
		E4	representation could be built upon Aggregation
		E5	behaving towards finding new Business Opportunities and promoting the represented Services

Hypothesis		Main Composing Elements	
H2	If a new Quality of Service Mechanism is created, based on distinct QoS characteristics, that can benefit from an active service representation, forming QoS Criteria it might be possible to feed up a collaborative Services Ecosystem with QoS data that may benefit final clients whenever a choice has to be made between two competing service provision proposals.	E1	new Quality of Service Mechanism
		E2	based on distinct QoS characteristics
		E3	forming QoS Criteria
		E4	feed up a collaborative Services Ecosystem with QoS data
H3	If a new framework is created modelling the services CN members are willing to provide through the usage of active computational elements, it might be possible to rely on such elements part of the responsibilities on service composition processes.	E1	rely on such elements part of the responsibilities on service composition processes

Table 5-27 shows a classification of the contribution that each item from the Validation Elements had to the hypothesis elements listed above.

The different patterns in this table can now be interpreted in distinct perspectives. In what concerns the above-mentioned publications, an evolution can be noticed from P-1 to P-5 progressively addressing more elements from the three hypotheses. Naturally, the two early publications only have a slight contribution.

According to the specialist's feedback, the creation of an ecosystem instead of a market of services is the perspective where PASEF has a better contribution-level. Nevertheless, it also has a motivating classification in what concerns both the contribution for shortening the distance between business and ICT worlds, as well as the application to Senior Professionals.

In what concerns the benchmarking exercises, the solution benchmark looks more populated by the "strong contribution" and "average contribution" patterns than the approach benchmark, meaning that a higher contribution came from this exercise. The reason for this result is twofold: 1) the approach followed by PASEF is innovative in the considered aspects / classification parameters, especially in what concerns the suggestion of services to include in BPMs being built; 2) the websites selected for the solution benchmarking already do provide interesting solutions that the statistics confirm. Nevertheless these solutions only consider individual work instead of collaborative work, which constitutes their main drawback and, at the same time, a base objective of PASEF.

Table 5-27 - Contribution from Validation Elements' Items to Hypothesis' Elements

				Hypothesis / Hyp. Elements									
Validation Element		Detail item		H1					H2				H3
				E1	E2	E3	E4	E5	E1	E2	E3	E4	E1
1	Prototype			🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩
2	Approach Benchmark	CP-1	Pro-Active Constructs	🟩	🟩	🟩	▤	🟩	▨	▨	▨	▨	🟩
		CP-2	Aggregation		▨	▨	🟩	▨					
		CP-3	QoS Certification		▨	▨	▨	▨	🟩	🟩	🟩	🟩	
		CP-4	Suggestions	🟩	▨	▨	▨	▨	▨	▨	▨	▨	
		CP-5	Self-Optimization	🟩	▤	▤	▨	▨	▤	▤	▤	▤	
3	Solution Benchmark	CP-1	Specificity		▤	▤	▤	▤	▤	▤	▤		
		CP-2	Effectiveness		▤	▤	▤	▤	▤	▤	▤	▤	
		CP-3	QoS Reward		▤	▤	▤	▤	🟩	🟩	🟩	🟩	
		CP-4	Collaboration	▨	▨	▨	▨	▨	🟩	🟩	🟩	🟩	🟩
4	Refereed Publications	P-1	DoCEIS'10 Conference	🟩	▤	▤	▨	▨	▨	▨	▨	▨	
		P-2	PRO-VE'10 Conference	🟩	🟩	🟩	▤	▤	▤	▤	▤	▤	
		P-3	DoCEIS'11 Conference	🟩	▨	▨	▤	▤	▤	▤	▤	▤	▤
		P-4	PRO-VE'11 Conference	🟩	▨	▨	🟩	🟩	🟩	🟩	🟩	🟩	🟩
		P-5	IJCIM Journal	🟩	▤	▤	▤	🟩	🟩	🟩	🟩	🟩	🟩
		P-a	PRO-VE'99 Conference	▨	▤	▤			▨	▨	▨	▨	
		P-b	PROLAMAT'01 Conference	▨	▤	▤			▤	▤	▤	▤	
5	Specialists Feedback	Introduction of Pro-Activeness in Service Constructs.		🟩	▤	▤	▤	▤	▨	▨	▨	▨	▤
		Aggregation of Distinct services provided by the same provider weithin a single construct.		▤	▤	▤	🟩	▤	▨	▨	▨	▨	▤
		Creation of an Ecosystem instead of an open market over the Internet.		▨	🟩	🟩	▨	▤	🟩	🟩	🟩	🟩	🟩
		Shorten the distance between Business and Software worlds.		▨	🟩	🟩	🟩	▤	▤	▤	▤	▤	▨
		PASEF Applied to Senior Professionals		🟩	🟩	🟩	▤	▤	▤	▤	▤	▤	🟩

🟩 Strong Contribution
▤ Average Contribution
▨ Detail Contribution
☐ no contribution

> Men will die upon
> dogma but will
> not fall victim to
> a conclusion.
>
> (John Henry
> Cardeal Newman)

6. Conclusions and Future Work

This chapter summarizes the main findings and results obtained with this research work. It begins with a summary of the work undertaken, followed by corresponding findings and contributions. The identification and discussion of a set of open issues for future work end this chapter and the dissertation.

6.1. Research Work Synthesis

The main challenge addressed in this research work is a way to overcome the static mechanisms that current information and communication technology approaches use for modelling the services that CN members provide. In fact, the passiveness of these elements is seen as their main drawback, especially considering small and medium sized organizations or free-lancers. In these cases, the inexistence of a “marketing machinery” devoted to promote the services, so that new clients may get to know them and make subsequent calls, results on a frustration of the potential usage of such resources. In fact, only big companies, such as for instance Amazon, Google or booking.com, benefit from the vision of a worldwide potential set of new clients for their Web-Services. In the case of a free-lancer that decides to provide some consultancy services, e.g. in the marketing area, and that creates some web-services towards achieving such world-wide potential set of new clients, the results stay far from such wide expectations. To some extent, this frustration results from the passiveness characteristic of these ICT constructs, as they do not perform any action towards attracting more clients.

The vision behind this research work is that if Web-Services, or some other ICT constructs, could have some auto-initiative and become active constructs, several benefits could be attained from that. In other words, if they had the ability to behave towards pursuing business interests, several activities or behaviours could be defined or configured towards addressing the limitations of current approaches.

On the other hand, the distance between the business world and ICT world in what concerns the service concept has also constituted a driving force for this initiative. In fact, the business perspective and interests are not adequately modelled in current approaches. One example of this distance is the fact that current ICT constructs model services in an independent form, even though they might be provided by the same CN member. If an extension of the ICT elements that model services could become business-oriented, a clear benefit could be attained from that. This extension could aggregate the services provided by each CN member and, as a result, create integrated bids, for example, or include some promotional elements.

Finally, this work is based on the assumption that the globalization has introduced a reality where the collaboration between distinct and geographically disperse actors became mandatory. This is due to the need of maintaining a competitive role in the economic landscape, which leads to the context of Collaborative Networks as the main pillar of this research work. In fact, current global economy reduces several geographical barriers, leading to the possibility of creating new modelling mechanisms for the creation of consortia composed of partners that might even be unknown, *a priori*. The benefits of this collaborative environment, in terms of competitiveness or simply a better positioning in the market have already been extensively addressed in the literature.

Therefore, for this potential to become possible new mechanisms and tools have to be developed and the Pro-Active Service Ecosystem Framework (PASEF) intends to move a step forward in this direction: **Collaborative Networks** where CN members' services are **actively represented** by ICT constructs towards **pursuing business interests**.

This "vision" is addressed through the creation of a collaborative Services Ecosystem, where CN members can benefit from an active representation of the services they are willing / able to provide. This environment is a cyberspace composed of ICT elements that represent the services CN members provide – the Pro-Active Service Entities. As an ecosystem, it also provides a set of functionalities that foster the collaboration among the composing elements, namely: 1) tracking and supporting the collaboration opportunities, 2) providing a QoS assessment mechanism that benefits from the active ICT constructs representing CN members' services and from a client perspective towards rewarding the best CN members in terms of QoS, and 3) introducing a broker role that helps clients detailing their needs and posting calls for proposals in a supporting blackboard-like infrastructure – the CO_Board.

The active representation of services is inspired in an ambassador role, meaning that it fosters the success of the represented elements – the CN members' services. In order to perform such representation, the pro-activeness element is introduced in the PSEs, through the definition of behaviours. Some example behaviours are implemented as *proof of concept*: 1) finding new collaboration opportunities, and 2) improving the chances that the represented services have to be selected among competitors. It is also worth to mention that these PSE elements are the ones responsible to create proposals whenever a collaboration opportunity is found. Although this might not appear innovative, as it constitutes a simple bidding process, the possibility of an autonomous behaviour configured by the corresponding CN member constitutes the innovation factor. Furthermore, as the service connection concept is also introduced, these PSE elements not only have the ability to create bids, but also suggest the inclusion of additional services they represent in BPMs that are being built, which constitutes one innovation factor.

The service composition process itself has also benefited from an improvement change because of this active service representation. In spite of having to contact a limited set of potential providers, known *a priori*, the clients of a CN implementing PASEF have the possibility of posting similar calls in the CO_Board and wait for the PSEs to become aware of such opportunities and make their bids / suggestions. This mechanism constitutes an improvement as it extends the set of potential providers and the ecosystem itself helps filtering the bids, namely excluding the ones that are out of scope or do not meet some pre-defined QoS Criteria threshold.

This bidding mechanism also overcomes one of the identified problems concerning the possibility of current service catalogues becoming outdated. In other words, as service providers might become unavailable, even for a limited timeframe, the existing catalogues do not have the mechanisms to reflect such unavailability. With PASEF, as the PSEs are the ones posting the bids and suggestions, the problem of service catalogues becoming outdated is automatically solved.

Table 6-1 summarizes the main aspects of the progress beyond the state of the art contributed by this research work.

Table 6-1 - PASEF innovation factors / progress beyond the SotA

Short Name	Short Description
Pro-Active Service Representation	CN members have the possibility to configure and launch a computational system that represents their services under a business perspective.
	Distinct Services provided by the same CN member are represented in an aggregated manner.
	PSEs take the initiative and avoid outdated repository data to be propagated.
Pro-Activeness Configuration	Specialists may create commonly used behaviours, defined through workflows of actions.
	CN members select and configure the behaviours that best fit their needs.
	Pre-defined behaviours act as guides in the PSE configuration.
Service Selection Chances Improvement	The creation and configuration of the behaviours of the PSEs opens the possibility to create behaviours that may be considered aggressive in terms of their positioning in the market, actively behaving towards making the represented services selected among competitors.
	The introduction of the service connections that supports the service suggestions increases the selection chances of services for which the clients might not have identified a need, *a priori*.
QoS Assessment Mechanism	Feed up a Services Ecosystem pool of QoS data that supports the selections that clients have to make.
	Client's opinion concerning QoS also feeds up the QoS assessment mechanism.

The area of Active Ageing has been selected as one of the areas where the limitations identified in current scenarios have particularly relevant consequences. In fact, Senior Professionals (SP) that have the will to remain active to perform some marketing consultancy services, for example, do not have the proper environment created to address their specificities. The usage of PASEF for an SP to benefit from an active service representation that might represent his or her services has been considered as a major improvement from these persons' perspective. As a result, the prototype implementing PASEF concepts has tackled a Professional Virtual Community of Senior Professionals devoted to help entrepreneurs.

This application scenario has been validated in a first place by the Associations that have been contacted. Nevertheless it did not become possible to use the developed prototype working in these associations in real life projects afterwards due to lack of time. As a result, the validation of this research work was divided in five validation elements, as explained in Chapter 5, towards gathering distinct perspectives for that process.

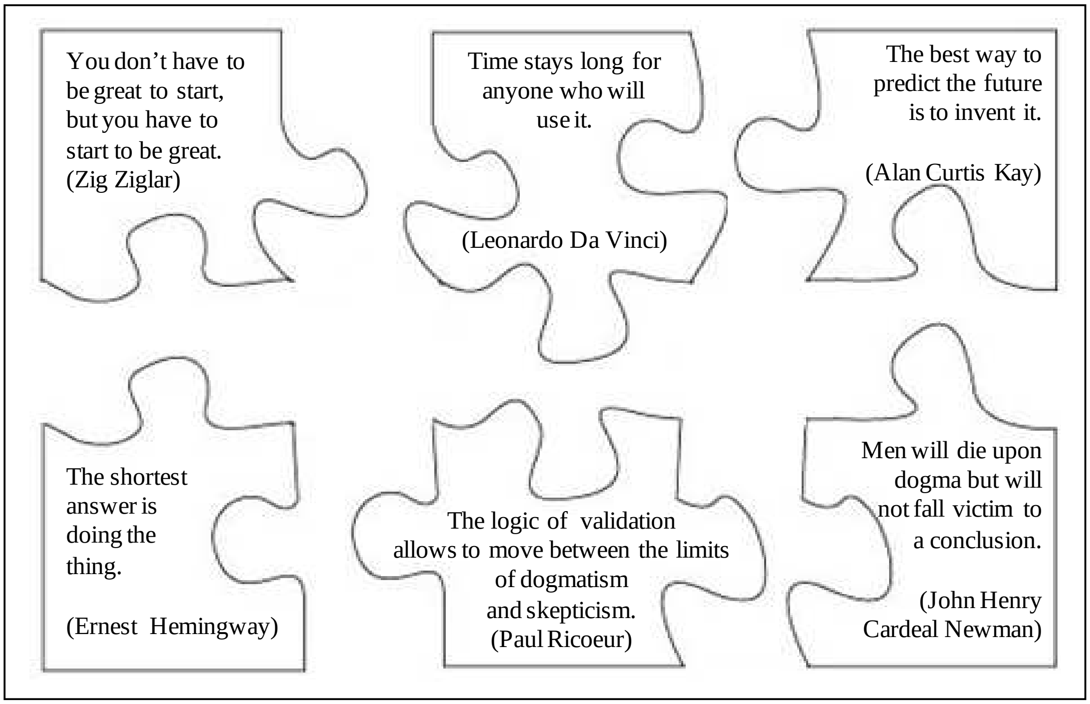
6.2. Future Work

PASEF opens a wide range of potential improvements, extensions and future work directions. In fact some issues related to PASEF have not been addressed in this research work mainly because of one of two reasons: 1 – they are not central to the intended active representation of CN member's services; 2 – they represent aspects that were already extensively addressed in the literature but have not been integrated to PASEF, yet. The following list highlights some of these future work elements, including a brief description.

- Negotiation – The process of bidding may go through several negotiation iterations where the brokers or clients decrease their demands and CN members improve their proposals in order to reach an agreement. This negotiation process was not included in PASEF. Nevertheless, there is already a considerable effort in the Multi-Agents Systems research area tackling this issue. Thus, integrating a negotiation module within PASEF, gathering insights from the MAS world is a near future work.
- Semantic Aggregation – Other forms of aggregating services may be considered, other than aggregating services based on their provider. The inclusion of rich semantic descriptions to the services CN members can provide would support other aggregation means. As a result, complementarities may be found and longer-term agreements could be established. This additional characteristic would also support some form of gap analysis to identify missing services in the ecosystem.

- Non-Functional Services – The services that a business entity may provide do not always cope with the proposals that the information and communication technology counterpart provides. In the case of Web-Services, for example, a function call wraps the services of CN members. Nevertheless, there may be cases where a service cannot be restricted to a function call. This may be the case of some Business Process Specification that evolves through time and may be provided by some consultant. In this case some stateless constructs, like web-services, do not cope with the needs from the business side. A near future extension of PASEF is to consider services that CN members provide as assets that are not restricted to the functional form, but may include, for instance, intelligent content.
- QoS Assessment – although the QoS assessment mechanism was introduced, two factors may improve it: 1 – the automation of the client satisfaction manifestation process to feed up the QoS data in a more accurate manner (a mandatory satisfaction manifestation could be considered in some scenarios); 2 – the creation of standards in terms of QoS Characteristics and Criterion that can improve a wide usage of the QoS mechanism.
- PSE Self-Optimization – Another near-future work direction is the study of the usage of techniques like machine learning in order to provide the PSE the ability to evolve in time. In fact, the active representation of services could benefit from experience in order to improve the success rate. A simple example may be a Senior Professional that provides some consultancy service on innovative marketing initiatives. In this case, after several cases of provision proposals for this service, the corresponding PSE might conclude that the ones that succeeded where the ones where the delivery time was faster or some innovative classification factor was higher. This knowledge attained based on experience might help the process of creating the provision proposals.
- Cloud based on PASEF – based on the notion that the Pro-Active Service Entities are inspired in Web-Services and that Web-Services have been the base for the so called cloud-era, it is reasonable to consider a cloud-era based on active service representatives – similar to the PSEs. In such environment, all the large-scale computational power and storage services could also be represented by pro-active constructs that behave towards attracting the clients.
- Taxonomy / Interoperability – the Service Stereotype related concepts, presented in section 3.2.1 were introduced as a crucial element on top of which PASEF was built. Nevertheless, because this was not the central research point, an extra effort is still needed towards improving these elements for a higher level of interoperability support.
- Behavioural aspects – Finally, the last and most important element for the near future work is the systematization of the definitions of the behavioural aspects of the PSEs. The usage of formal languages is a possibility that could avoid the restriction to specific

“hand-made” tasks towards a more generic mechanism for the definition of the PSE’s behaviours. As a result, a behaviour template library could be created.



You don't have to be great to start, but you have to start to be great.
(Zig Ziglar)

Time stays long for anyone who will use it.

(Leonardo Da Vinci)

The best way to predict the future is to invent it.

(Alan Curtis Kay)

The shortest answer is doing the thing.

(Ernest Hemingway)

The logic of validation allows to move between the limits of dogmatism and skepticism.
(Paul Ricoeur)

Men will die upon dogma but will not fall victim to a conclusion.

(John Henry Cardeal Newman)

THE END

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