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VO CREATION ASSISTANCE SERVICES

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The concept of virtual organization (VO) appears particularly well-suited to cope with very dynamic and turbulent market conditions. The underlying rational the possibility of rapidly forming a consortium triggered by a business opportunity and specially tailored to the requirements of that opportunity. Implicit in this idea is a notion of agility, allowing rapid adaptation to a changing environment. In order to make this possible, a VO creation process is designed in the context of a virtual organization breeding environment context. A framework for VO creation is thus introduced and a set of assistance services are designed and tools developed.

1. VO CREATION IN A VBE CONTEXT

The effectiveness of the virtual organization (VO) creation process is a critical element in collaborative networks. Early works on VO creation assumed that partners could be quickly identified and selected from the *open universe* of existing enterprises / organizations, and engaged into a collaboration network. This assumption however overlooks a number of important obstacles in this process among which the following can be mentioned (Afsarmanesh & Camarinha-Matos, 2005; Camarinha-Matos & Afsarmanesh, 2003; Camarinha-Matos et al., 2005b):

- How to know about the mere existence of potential partners in the open universe and deal with incompatible and limited sources of information?
- How to acquire basic profile information about organizations, when there is no common template or standard format?
- How to quickly and reliably establish an inter-operable collaboration infrastructure, given the heterogeneity of organizations at multi-levels, and the diversity of their interaction systems?

- How to build trust among organizations, which is the base for any collaboration?
- How to quickly develop and agree on the common principles of sharing and working together?
- How to quickly define the agreements on the roles and responsibilities of each partner, to reflect sharing of tasks, the rights on the produced results, etc.?

The situation is not too critical in the case of long-term collaboration processes not limited to a single business opportunity, such as in the case of supply chains (case A in Figure 1). In this case the costs (and time) of preparation for collaboration are affordable given the long term perspectives.

On the other hand (case C in Figure 1), for some specific niche sectors in which all actors share the same or compatible tools, business culture and practices, it is possible to quickly form a consortium even for a short-term single opportunity.

For the other cases the situation is much more critical. Particularly when the window of opportunity is short, in order to support rapid formation of collaborative networks it is necessary that potential partners are ***prepared and ready to participate*** in such collaboration. Preparedness includes common interoperable infrastructure, common operating rules, and common cooperation agreement, among others. Any collaboration also requires a base level of trust among the organizations. In this case a working solution is the creation of a long-term association of entities that prepare themselves to cooperate whenever an opportunity arises. This association is a **VO Breeding Environment** (VBE) (Afsarmanesh & Camarinha-Matos, 2005; Camarinha-Matos & Afsarmanesh, 2003; Camarinha-Matos et al., 2005b) for the creation of dynamic VOs (case B in Figure 1).

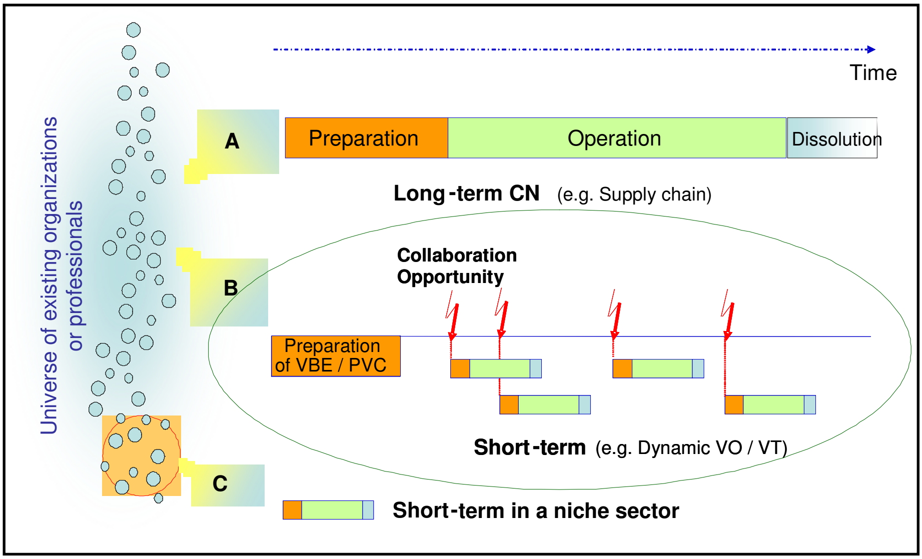

Figure 1 - VO creation in different contexts

The ECOLEAD project focus on VO creation process as that happen in the context of a VO Breeding Environment (VBE) (Camarinha-Matos & Afsarmanesh, 2003; Camarinha-Matos & Oliveira, 2005; Rabelo et al., 2000). This long term collaborative association is composed of organizations that are prepared to collaborate and thus may rapidly respond to a collaboration opportunity.

VBE makes it possible to collect and maintain data of the profile of VBE members. Furthermore, this enables the use of more sophisticated selection criteria, including aspects such as trust and historical collaboration performance. This would not be possible in an "open universe", since there is no practical means for collecting the necessary data.

As illustrated in Figure 2, it shall be noted that VBE creation and VO creation are different processes, triggered by different motivations. A VBE is created as a long term "controlled border" association and its members are recruited from the "open universe" of organizations according to the criteria defined by the VBE creators or administrators. A VO is a temporary organization triggered by a specific business / collaboration opportunity. Its partners are primarily selected from the VBE members. In case there is a lack of skills or capacity inside the VBE, organizations can be recruited from outside.

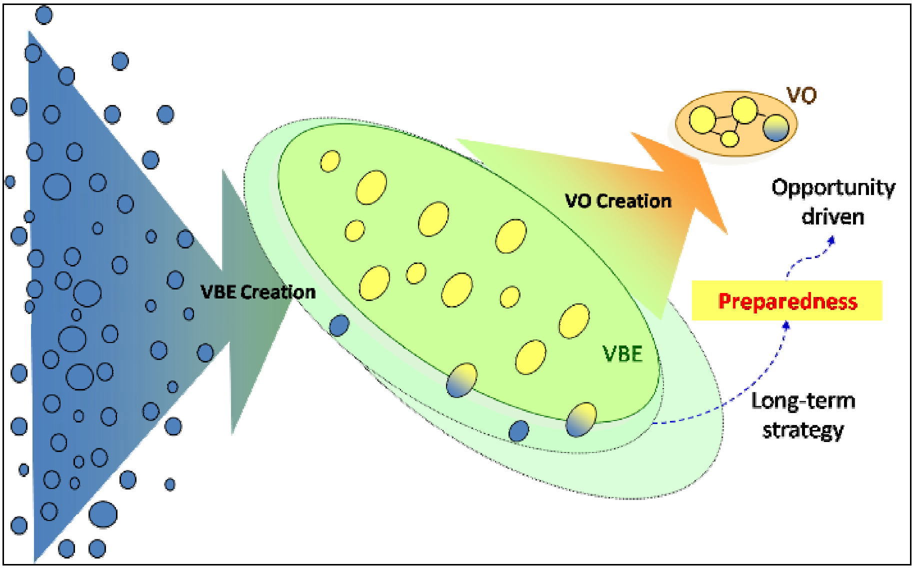

Figure 2 – VO creation in a VBE context

It is therefore necessary to develop an approach and a supporting framework to facilitate the VO creation process in order to make it effective. This chapter describes the approach developed by the ECOLEAD project for the concepts of VO creation within the context of VBE and introduces a set of developed services in the form of tools to support the various steps of the VO creation process.

2. BRIEF HISTORIC PANORAMA

A large number of R&D projects have addressed some specific aspects of the VO creation process, as found out by the VOSTER study (Luis M. Camarinha-Matos et al., 2005).

From a methodological point of view two main situations in VO creation can be considered:

- Designed VO – once a collaboration opportunity is detected by a VBE member playing the role of opportunity broker, a top-down process is launched for the VO design and creation coordinated by the VO planner (which can be the same organization that performs the role of opportunity broker).
- Emergent VO – in this case the broker would announce the collaboration opportunity to the VBE members and then would simply wait for the emergence of potential candidate consortia. In the end, the opportunity broker and/or the VO planner, or the customer, would choose the most suitable consortium.

For both cases, three approaches are so far addressed in the R&D as alternatives for VO creation:

- Manual or computer-assisted approaches
- Multi-agent based approaches
- Service-federation or service market based approaches.

2.1 Manual and computer assisted approaches

Through the years several approaches have been developed for VO planning and launching. At the beginning, when the VO paradigm was introduced, the manual approach was mainly used. Progressively, ICT tools were developed to assist the VO planner. Although the computer assisted approach predominates in today's VOs, there are still manual VO creation cases.

An earlier example of attempt to move from a manual approach to a computer assisted one can be found in the PRODNET project (Camarinha-Matos & Cardoso, 1999). This project tried to use both internal lists of suppliers and publicly available directories of enterprises. A methodology involving a preliminary filtering based on profiles and required characteristics, followed by a call for tenders, bids management, and tools-assisted human decision, was elaborated. Several other works invested on matching algorithms to find partners whose competences best fit the requirements of a business opportunity.

In the last decade a considerable effort has been put in the so-called electronic procurement. The main objectives in this area include the definition of "normalized" procedures for public announcement of business offers, reception, and management of bids.

In parallel with the progress of the technological infrastructures and standards for information exchange, more advanced assistance mechanisms have been proposed, as illustrated in Figure 3 (Camarinha-Matos et al., 2005).

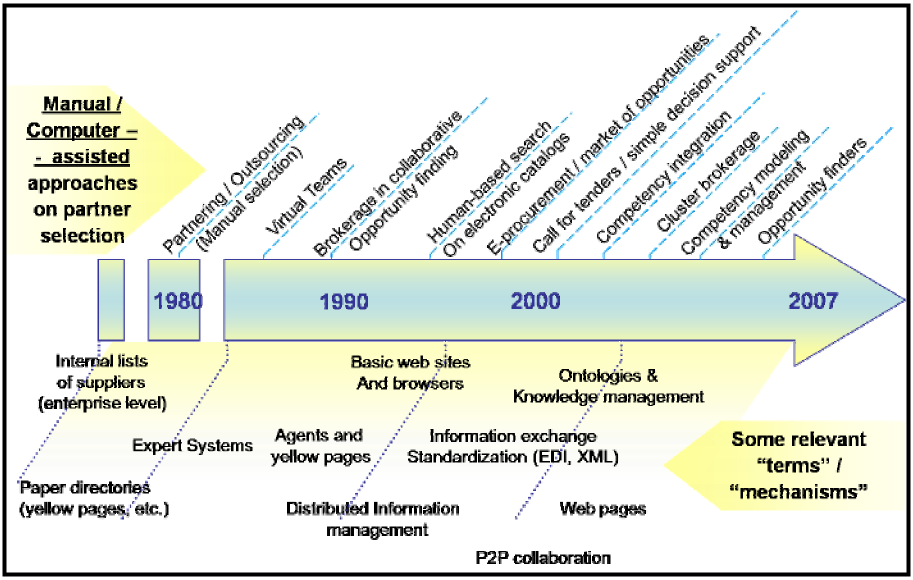

Figure 3 – Evolution of manual/computer-assisted approaches for VO creation

2.2 Multi-agent based approaches

Agents are autonomous software entities designed to operate and interact in distributed environments. They can handle sophisticated interactions due to their social abilities and also timely respond to changes in their environment (Jennings & Wooldridge, 1998). A multi-agent system (MAS) shows, at an abstract level, many similarities with a collaborative network. Therefore, a natural motivation to use MAS as a modeling and implementation support for the VO creation process has been present in many research works (e.g. Camarinha-Matos et al., 2005). Examples of such similarities are illustrated on the table below.

Table 1 – VO creation requirements vs. multi-agent based mechanisms

VO creation requirements	MAS mechanisms
Members are autonomous entities	Autonomous operation of agents
Different levels of cooperation	Scalability and multiple configuration options
Composed of distributed, heterogeneous and autonomous components	Easily mapped into a MAS
Flexible management and decision making	Coordination and distributed problem solving
Need for rapid reactions in execution and supervision of distributed business processes	Having agents representing each organization, it is possible to distribute tasks and use agent's communication to facilitate supervision
Market characteristics and negotiation needs	Ability to interact with other agents and several negotiation and auction protocols

	available
Structure of VO might need some reconfiguration during its life-cycle	Allows a flexible modeling as MAS can quickly adapt to new circumstances
Dynamic change of roles of its members	Easily mapped into MAS, namely as behaviors
Need to handle the requirements of autonomy vs. cooperative behavior	Federated MAS approaches may provide a balanced solution
Need for an unambiguous and precise terminology that can be jointly understood	Can be fulfilled through means of the use of a common communication language and ontology

The first efforts related to conceptualization of computational agents were carried out in the earlier 80's. Since then, the multi-agent paradigm has been applied to a large variety of research domains. Some milestones of MAS application to VO creation are summarized in Figure 4.

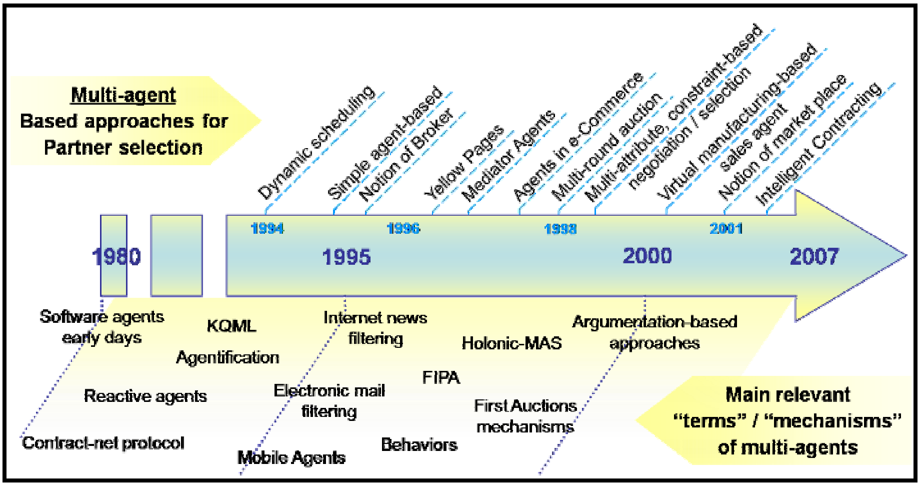

Figure 4 – Multi-agent based approaches for partner selection

A growing number of research prototypes applying multi-agent systems and market-oriented negotiation mechanisms for the VO formation are being developed. An early example is the work of (Rocha & Oliveira, 1999) that introduced a virtual market place where geographically distributed and autonomous enterprises are represented by agents. The work described in (Li et al., 2000) follows a similar approach. (Rabelo et al., 2000) developed a multi-agent-based architecture to support partners' selection in the context of a cluster of twelve enterprises in the moulds and die sector.

Various negotiation protocols have been elaborated for partners selection and coalition formation. Auction mechanisms became popular in agent-based consortia formation due to its simplicity and well predefined rules, as can be found in (Norman et al., 2004). There are several action mechanisms (Wurman, 2001), and the most used one is perhaps the combinatorial auction approach. This is a sophisticated type of auction where multiple units of multiple (potentially inter-related) items are traded simultaneously.

Given so, a multi-agent based approach can be very suitable in this domain since there are a number of characteristics that can fulfill the VO requests.

2.3 Service market based approaches

According to the service federation approach, companies (potential members of the virtual organization) are considered as "service providers", i.e. the potential collaborative behavior of each company is "materialized" by a set of services (Camarinha-Matos et al., 2005). The approach assumes the existence of one entity that keeps a catalog of services where service provider companies publish their service offers. This entity is sometimes called a "service market", a "service promoter node", or even "service portal". Regardless the different implementation approaches the general three major functions of service oriented architectures – publish / advertise, discover, invoke – are usually considered.

In this case, standard technologies should be used for service description, communication and data formats. In the case of web services such standards include, for instance, WSDL (for service description), UDDI (for repository organization), SOAP (for service invocation), etc.

This approach reflects an indirect partners' selection – what is selected is the service (not the provider), i.e. the immediate task is the composition (or orchestration) of complex services based on simpler ones, not the consortia. Partners are implicitly selected via the specific services that are chosen. It is nevertheless possible to include partners' characteristics in the service search query. The processes of service publishing, discovering, selecting, invoking and binding provide an alternative to the provision and management of organization competencies, selection of partners and negotiation to configure the VOs in a VBE.

Figure 5 shows a brief historic overview of the development of the service technologies and their adoption in VO creation. One early example of the service-based approach applied to the tourism sector can be found in (Afsarmanesh & Camarinha-Matos, 2000), which has introduced service-oriented approaches to VOs for the tourism sector called federated Web-based Tourism Information System (WTIS). Another example is given by the OSMOS project (Rezgui 2005), which was focused on the construction industry and followed a service-based approach for the design and development of its ICT infrastructure. OSMOS platform federates services inside a common framework, and allows their use and collaboration.

Besides the "popularity" of the web services paradigm which gives this approach considerable relevance, there are still a number of limitations in the current service model when we envisage applications that go beyond simple transactions, including: Are services always available? What is the level of commitment of the provider? Which underlying business model and how is the workload balanced? What is the level of awareness of the service provider? What are the levels of visibility and access to services? Are there dependencies between services? Can all skills be represented as services? Does it make sense to consider specific services for the partner search / negotiation phase?

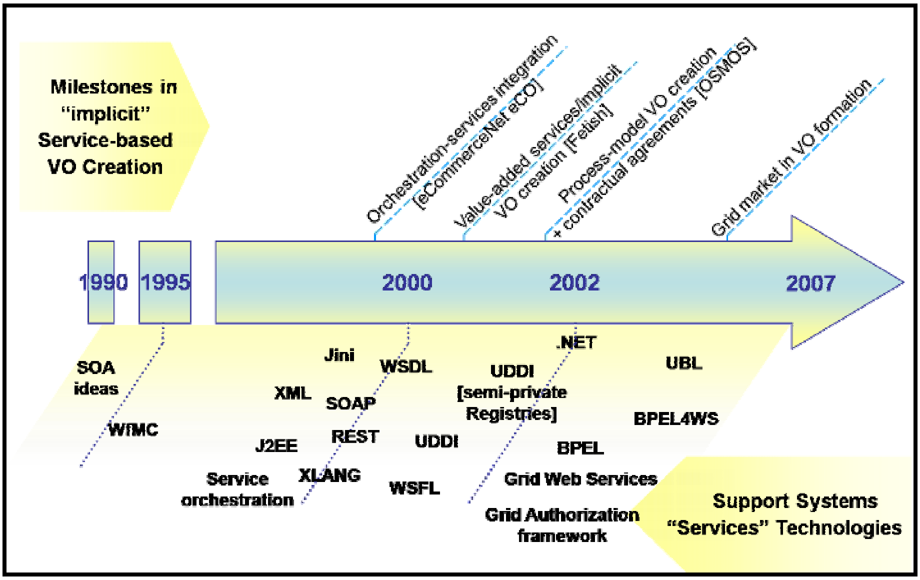

Figure 5 - Service federation based approaches in VO creation

3. VO CREATION PROCESS

According to the approach adopted by ECOLEAD, when creating a new VO, partners are primarily selected from the VBE members, nevertheless, in case there is lack of skills or capacity inside the VBE, other organizations can be recruited from outside the VBE boundaries.

However, partners' selection is not a single step operation. Furthermore, choosing the adequate partners for the VO (consortia formation) is not the only task that needs to be performed. There are other topics that need to be taken care of such as preparation and finalization phase. Figure 6 illustrates the main phases of the VO creation process for a given collaboration opportunity.

The **preparatory planning** phase includes:

- Collaboration Opportunity Identification and Characterization: a step that involves the identification and characterization of a new Collaboration Opportunity (CO) that will trigger the formation of a new VO. A collaboration opportunity might be external, originated by a customer and detected by a VBE member acting as a broker. Some opportunities might also be generated internally, as part of the development strategy of the VBE.
- Rough VO planning: determination of a rough structure of the potential VO, identifying the required competencies and capacities, structure of the task to be performed as well as the organizational form of the VO and corresponding roles. At this stage it is important to define the partnership form which is typically regulated by contracts and cooperation agreements.

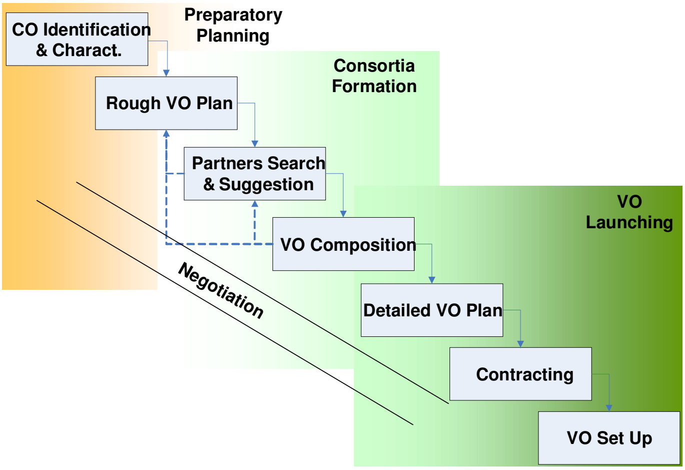

Figure 6 – VO creation process for a given collaboration opportunity

The **consortia formation** phase departs from the previous characterization and rough planning and mainly includes:

- Partners' search and suggestion: perhaps one of the most addressed topics in past research, this step is devoted to the identification of potential partners, and their assessment and selection.
- VO composition: in which the detailed organizational structure is defined and the assignment of roles to VO members is made.
- Negotiation: is an iterative process to reach agreements and align needs with offers. It can be seen as complementary to the other steps in the process and runs in parallel with them as illustrated in Figure 6.

The **VO launching** phase includes:

- 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.
- Contracting: involves the final formulation and modeling of contracts and agreements as well as the contract signing process itself, before the VO can effectively be launched. In other words, this step is the conclusion of the negotiation process.
- VO set up: 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 and orchestration of the collaboration spaces, selection of relevant performance indicators to be used, setting up of the VO governance principles, assignment and set up of resources / activation of services, notification of the involved members, and manifestation of the new VO in the VBE.

Basically with the consortia formation phase but also spreading to the other phases there is a very important step: Negotiation. The negotiation steps might also include the "contracting" activity.

The previous sequence is applied in cases where the process is well defined and phases can be performed in an almost sequential mode (exception made for the negotiation with the suggested partners).

On the other hand, there are often some business domains where it is necessary to consider two major phases as illustrated in Figure 7.

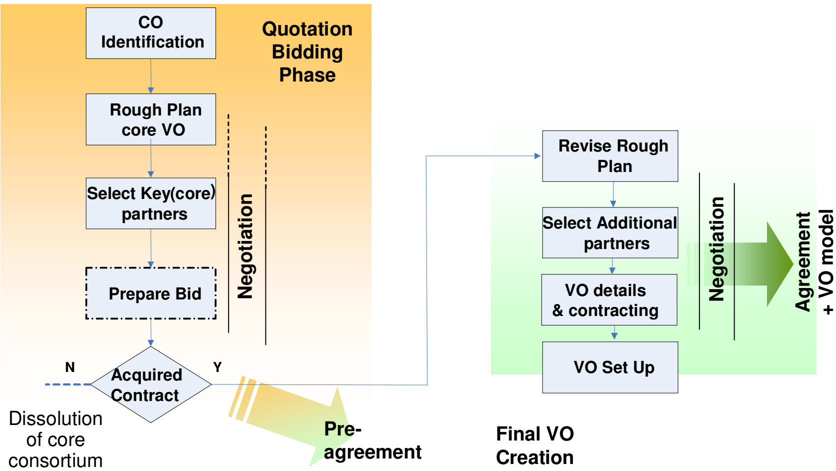

Figure 7 – VO creation process for quotation/bidding

These two phases are:

Quotation / bidding – when a collaboration opportunity is found it is necessary to prepare a bid / quotation in order to try to get a contract with the customer. For the preparation of this bid, it is necessary to make a rough plan of the foreseen VO and to also select the core partners. The bid is often prepared by this initial consortium. In case the bid is unsuccessful, the core consortium dissolves; otherwise we move to the next phase.

Final VO creation – In case the bid is successful, the VO's rough plan needs to be revised, based on the specific conditions of the contract with the customer, new additional partners might be necessary, and the VO will be finally detailed and launched.

As a result of the interactions with industry end-user networks and in order to correspond to the two processes illustrated above, four tools were designed and developed in ECOLEAD for the VO creation framework: collaboration opportunity finder (coFinder); CO characterization and rough planning (COC-Plan); partners search and suggestion (PSS); and agreement negotiation wizard (WizAN).

Although these tools attempt to assist and facilitate the entire process of the VO creation, the assumption when designing these tools was that the decisions are always responsibility of human actors. Figure 8 illustrates the main interactions among the four tools of the VO creation framework as well as the actors involved in the process. As VOs are created in a VBE context, it is also necessary to interact with the VBE management system that will provide critical information such as members' profiles and competencies, previous performance record, trustworthiness levels, etc.

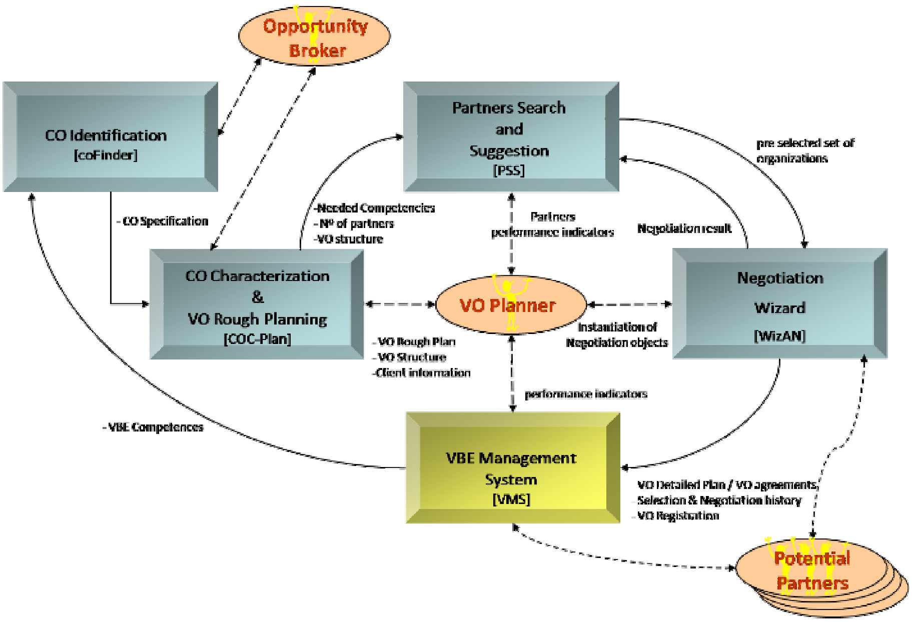

Figure 8 – Main interactions among the VO creation framework tools

3.1 Interoperability among VO creation tools

A global VO Model data structure provides the "vehicle" for data flow among the various tools. This solution enables to simplify and solve all the issues related to integration: any tool can work with its own architecture, database tables, servers, etc. The only interface is at the data model which means that any tool will save and add part of the VO creation model during the execution of its activities. This solution is justified by the huge number of dependencies that may arise for performing the integration at the application level: all modules will have its own database structure, with different tables, different user GUI, and different programming languages. Creating a unique integrated environment may require a great effort. For this reason the solution to leave its own architecture to the modules and performing integration only at VO model level can simplify and solve the above problems.

The VO Model was designed as an XML file aimed to allow data sharing among all VO creation tools (see Figure 9). According to the COC-Plan tool design specifications, the tool is required to interoperate with the Collaboration Opportunity Identification (CO-Finder) tool and the Partners' Search and Suggestion (PSS) tool:

COC-Plan tool and CO-Finder tool: The information of a collaboration opportunity identified and described in the CO-Finder tool is saved in a XML file and sent as an input to the COC-Plan tool. The XML file is included into the VO

Model file and the manipulation of data is done through the VO Model Web-services.

PSS and COC-Plan tool: Once the COC-Plan tool information is processed, all its data is stored in an XML file made available to the PSS tool and added to the VO Model. The PSS tool also includes its information in the VO Model file using a XML file.

WizAN and PSS: After the PSS tool update the XML with the relevant information, the WizAN tool can use it in order to collect the significant data on the potential parters to negotiate the consortium creation.

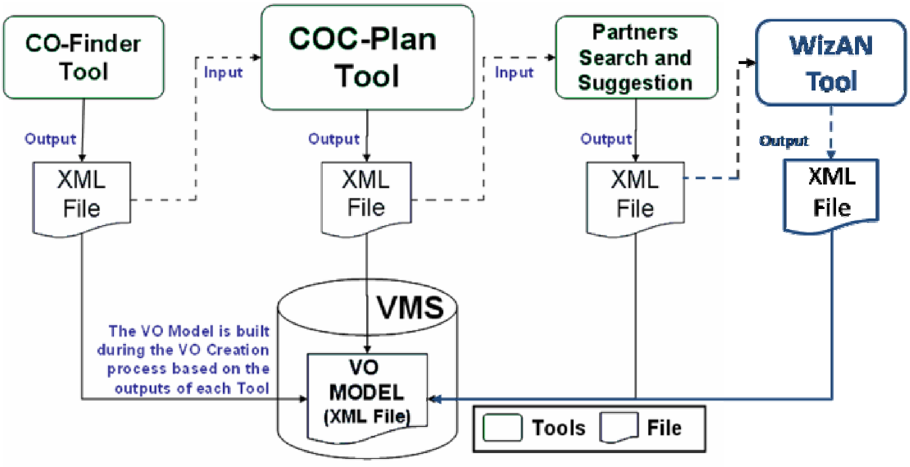

Figure 9 – VO Creation Tools Interoperability

In the following sections the first three tools (coFinder, COC-Plan and PSS) are described whereas, WizAN is described in chapter 2.6 of this book (*Agreement Negotiation Wizard*).

4. CoFinder TOOL

The coFinder tool is aimed at facilitating the work of a VO broker. It uses the same approach that is usually carried out manually by the broker: comparing potential collaboration opportunities (CO), identified from Calls for Tenders (CfTs), with the actual competencies of the VBE, stored in the Profiling and Competency Management System (PCMS, which is part of the VBE Management System VMS) (Ermilova & Afsarmanesh, 2007). In order to automate this process, the coFinder tool needs comparable structure of information contained at both sides. These structures can then be aligned and matched with each other in order to detect similarities and consequently detect possible collaboration opportunities. The matching in the coFinder tool is based on the comparison of textual descriptions of CfTs and VBE competencies. Like the broker, the tool is able to browse public CfTs available on the web and extract CfTs' descriptions from the relevant web pages. Similarly, competencies are also described in web pages or can be manually entered in text format within the coFinder tool, and collected from PCMS. Once the CfTs' descriptions and competencies have been provided, coFinder is able to compute their similarity in order to estimate the interestingness of CfTs and identify the most promising ones, and finally to propose them to the broker as potential collaboration opportunities.

4.1 coFinder System Overview

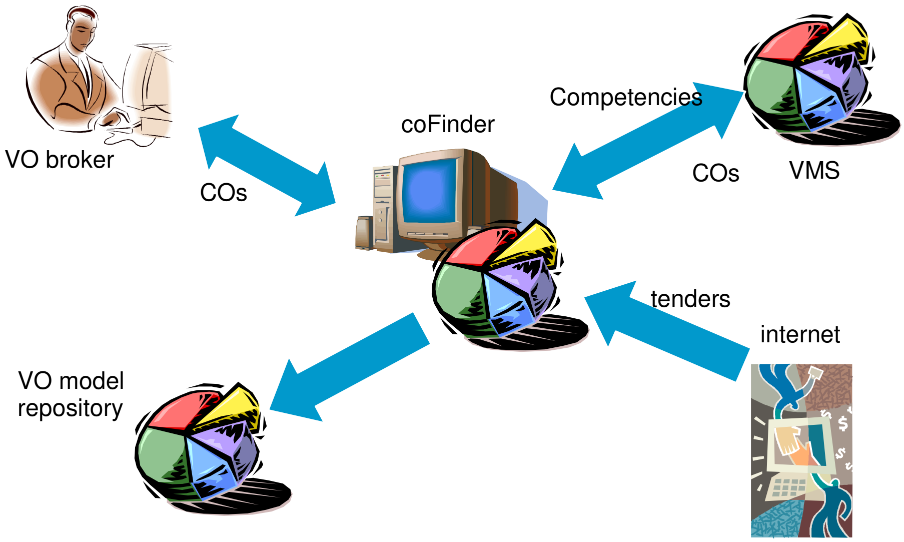

Figure 10 – Overview of coFinder (CO denotes a collaboration opportunity)

The overview of coFinder and its interactions are shown in Figure 10. The tool is accessed through a web interface by the VO broker. The coFinder tool accesses internet to collect the data from specified CfT servers. It also accesses the VMS (PCMS) to gather the competencies data, it stores the selected COs in the VO model repository and makes the COs in its internal database available to the VMS tools for further analysis (e.g. analysis of needed competencies).

Implementation-wise, coFinder is a set of PhP tools around a local MySQL database. The most important tools are crawler, parser, browser, and the CfT server template set up tool. The CfT server template set up tool is used to help the user to set up a template, which is used to separate CfTs from other web pages and collect the information from CfT web pages. Additional simple tools are used to collect other information needed to run coFinder.

Some of the tools like CfT server template set up tool are used only during the set up, other tools run on a regular schedule (like crawler and parser), and the rest are used as an interface between the user and the database (for browsing and searching the data) while web service clients and server access and provide data from and to other tools.

The initial set up data (along with the addresses of the CfT servers and templates for each of the servers) is stored in the database. Additional to the initial set up data the information about VBE competencies is regularly collected from PCMS. The data about servers is then collected by the crawler and used to gather all new information (web pages) from each of the CfT servers. Web pages are again stored in the database, from where they are collected by the parser. Parser uses the templates to sift out the CfT web pages from the rest and to extract the information about the CfT. This information (in an XML form), along with the calculated similarity to the VBE's competencies, is stored in the database. The users are notified of the best collaboration opportunities (or CfTs) via e-mail. All collected data is available for browsing by users.

4.2 The collaboration opportunity identification process

The collaboration opportunity process comprises several steps:

1. Input of necessary data, such as list of tender servers' URLs, templates, XML schemas, etc,
2. Collecting additional data from PCMS,
3. Crawling CfT servers,
4. Parsing the crawled web pages,
5. Matching the CfT descriptions with the VBE competencies,
6. Browsing, editing, adding new CfT data and selecting the CfTs suitable for VO creation, and
7. Uploading the data about selected CfTs to other tools (using the VO model repository).

Steps 1 and 6 require user interaction, while steps 2-5 and 7 are automated. Step one must be taken only once, but can be accessed at any time in order to change or add additional information (for example new servers).

In step 1, the user has to provide some information such as a list of CfT servers that he intends to use for finding potential collaboration opportunities. In addition, for each server, the user must create a template that is used to help the system identifying CfTs' descriptions inside the HTML pages. Indeed, the HTML format itself does not provide any semantics to access this information directly; therefore a template is needed to detect the CfT structure and its contents within the HTML page. Usually, the CfT pages on the same server are generated automatically from data stored in a database and thus share the same structure to represent CfTs. And a template makes it possible to match different parts of CfT HTML pages to their corresponding fields in the CO description part of the VO model.

The template is usually created by comparing different CfT web pages on the same server. Since they are generated automatically, they have the same structure but different contents. Only the contents, not the form, should change from one CfT to another. This makes it possible to figure out where are the variable parts of the page. The meaning of the variable parts is defined by the user by matching the parts of the web pages to fields in the XML schema for the output of collaboration opportunities (the CO schema). The template is stored along with the server data in a local database.

Another input needed is the competencies of the VBE. Competencies are entered manually by the broker in a textual format as well as collected automatically and periodically from PCMS (in step 2). Textual competencies are organized in two categories: general competencies and specific competencies. While data collected from PCMS is also in two categories: available competencies and processes.

In step 3, the coFinder tool crawls all the servers specified by the user and gathers CfT pages. This step usually runs regularly on a schedule.

The next, step 4, is to parse CfT pages. The template built previously is used here to extract CfTs' descriptions from their web page. The information is then stored in the database using the CO XML schema.

Step 5: Once the CfTs' description have been extracted and structured, it is possible to identify potential collaboration opportunities by matching CfTs' description with the competencies available. The interestingness factor is computed for each CfT. This measure is a weighted sum of the similarity between textual fields describing the CfT and fields describing the VBE competencies.

Step 6: To limit the number of potential collaboration opportunities, a threshold is used for the interestingness measure. This threshold is set by the user at the beginning of the process. The VO broker will be notified by an e-mail only about the potential collaboration opportunities that are above this threshold.

It is also possible to browse and search through all the collected CfT data, select the CfTs suitable for VO creation, or just select the data to be send by an e-mail to the VO broker. Since all needed data is not always available in the CfT data supplied by the server, the system offers the possibility to include some data that the VO broker may collect using other methods (phone calls, email correspondence, etc.). Such data can be useful in further steps of VO creation. In this step broker can also select CfTs that are suitable for VO creation

In strep 7, coFinder sends the data about the selected CfTs to the VO model repository and thereby makes data available to other VO creation tools.

The coFinder structure and data flow is shown in Figure 11. CoFinder first crawls each website from the list of servers and stores the web pages in the local database. Then it parses the collected web pages using CfT templates. For the resulting CfT data the interestingness measure is calculated, and finally the VO broker is notified. The VO broker then checks and possibly edits the data and selects the CfTs which are suitable as a basis for potential VO creation. The selected CfTs (which can now be called collaboration opportunities) are then delivered as the output of coFinder.

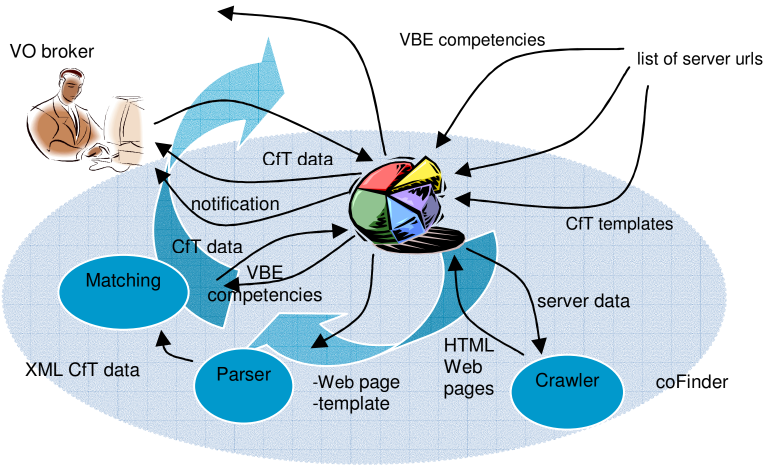

Figure 11 – coFinder working procedure

The whole process is meant to automatically find the structured web pages (from specified servers) that best match the data we have (VBE competencies) and thereby reduce the need to manually search and extract the data available on the web.

4.3 An example of use

In this section we show an example of the use of coFinder. When the tool is used for the first time, initial data has to be set up. Most of that data is a simple text like VBE competencies, the e-mail addresses for notification, and the URL addresses of CfTs servers. The most important part of the setup is the definition of CfT server templates. The template is usually generated from two or more CfTs on the server, using a tool in coFinder. This tool compares the web pages of CfTs and asks the user to define the meaning of the differences. The tool in use can be seen in Figure 12, a CfT provided as an input to the tool in Figure 13, and the final template in Figure 14.

After the initial data has been set up, coFinder crawls the specified servers, parses the collected web pages and puts the information about the collected CfTs into the internal database. All CfTs are compared to the VBE competencies as they were set up at the beginning as well as additionally collected from the PCMS and interestingness factor is calculated. A notification by e-mail is then sent to the specified address, giving information about the best CfTs found on the servers (those that are above the pre-specified interestingness threshold).

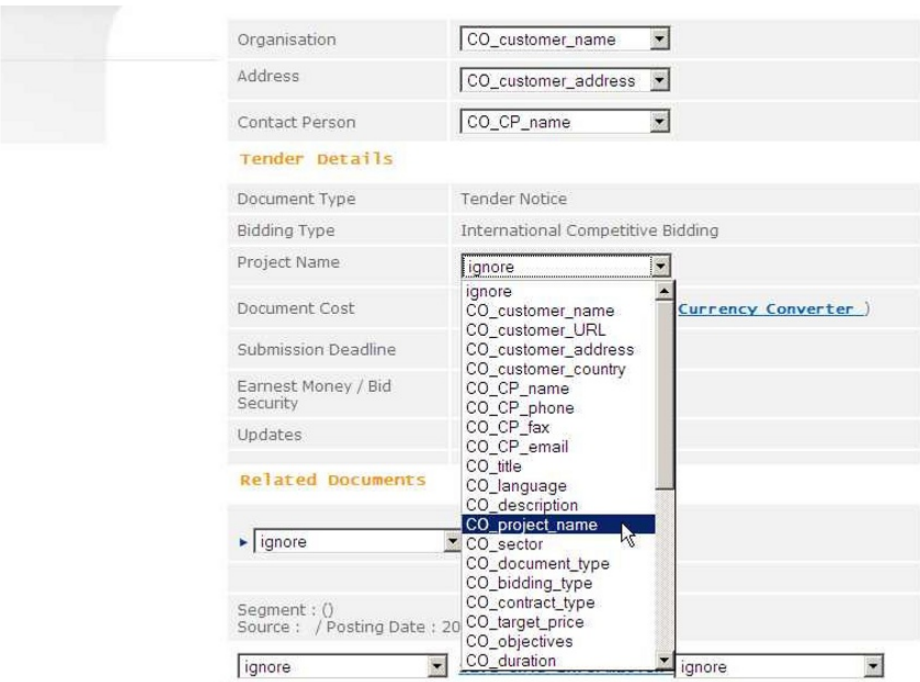

Figure 12 – An example of template generation tool in coFinder

The user/broker can use coFinder to browse and search through the collected CfTs (

Figure 15). Both, the complete data of the selected call for tender (
Figure 16), as well as the original web page can be inspected. The data can also be edited in order to add additional information collected by the broker (e.g., through e-mail, phone calls or other methods) and thereby enrich the data needed during further steps of the VO creation process. To start the process, the broker selects the appropriate CfTs, and selects them as appropriate for VO creation. coFinder then uploads the data about the CfTs to the VO model repository, making it available to subsequent tools that plan the process needed in VO, suggest the partners, help with negotiation…

The selected CFTs and all other CfT data is also available to VMS tools using web services in order to analyze the competencies gaps and other possibilities of VBE improvement.

Bidding Type	International Competitive Bidding
Project Name	CAIRO NORTH COMBINED-CYCLE POWER PLANT PROJECT (THE EGYPTIAN ELECTRICITY HOLDING COMPANY (EEHC), A JOINT STOCK COMPANY ESTABLISHED BY LAW NO. 164 YEAR 2000 (FORMERLY EGYPTIAN ELECTRICITY AUTHORITY), HAS SECURED A LOAN FROM THE ARAB FUND FOR ECONOMIC AND SOCIAL DEVELOPMENT AND HAS REQUESTED THE PARTICIPATION OF THE EUROPEAN INVESTMENT BANK (EIB) TO FINANCE THE PROCUREMENT OF MATERIALS AND ASSOCIATED SERVICES FOR SEVERAL PACKAGES OF THE CAIRO NORTH COMBINED-CYCLE POWER PLANT PROJECT)(
Financier	
Tender Notice No.	Not Provided
Description	DESIGN, FABRICATION, FURNISHING, DELIVERY, INSTALLATION, TRAINING, TESTING, START-UP AND COMMISSIONING FOR 2 X 250 MW (ISO) GAS TURBINE GENERATORS AND AUXILIARIES (TWO 250 MW (ISO) COMBUSTION TURBINE GENERATORS, AND ONE 250 MW (NOMINAL) STEAM TURBINE GENERATOR), INCLUDING ALL MECHANICAL AND ELECTRICAL WORK REQUIRED FOR A COMPLETE OPERATIONAL SYSTEM.
Estimated Project Cost	Not Provided (Currency Converter)
Document Cost	Not Provided (Currency Converter)
Submission Deadline	Not Provided
Earnest Money / Bid Security	Not Provided
Updates	

Figure 13 – An example of Call for Tender from the TerndersInfo.com server

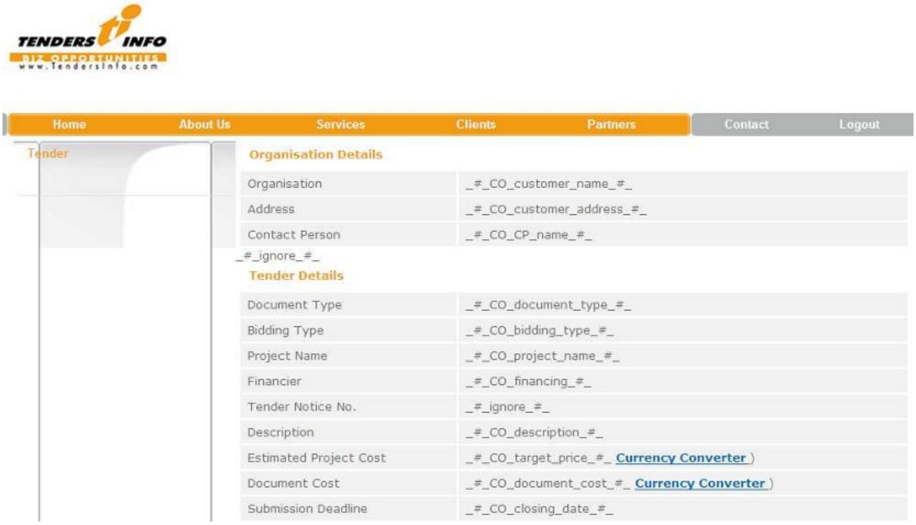

Figure 14 – The generated template for the TendersInfo.com server

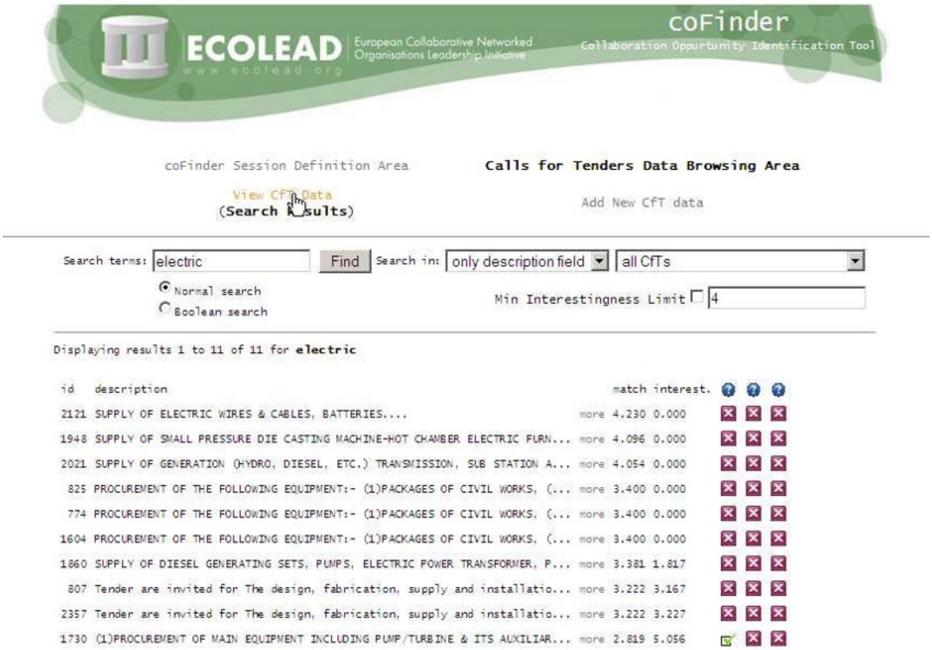

Figure 15 – Searching through collected CfTs

CO_customer_country	egypt
CO_CP_name	
CO_CP_phone	
CO_CP_fax	
CO_CP_email	mktg@tendersinfo.com
CO_title	DESIGN, FABRICATION, FURNISHING, DELIVERY, INSTALLATION, TRAINING, TESTING, START-UP AND COMMISSIONING of gas turbines
CO_language	english
CO_description	DESIGN, FABRICATION, FURNISHING, DELIVERY, INSTALLATION, TRAINING, TESTING, START-UP AND COMMISSIONING FOR 2 X 250 MW (ISO) GAS TURBINE GENERATORS AND AUXILIARIES (TWO 250 MW (ISO) COMBUSTION TURBINE GENERATORS, AND ONE 250 MW (NOMINAL) STEAM TURBINE GENERATOR), INCLUDING ALL MECHANICAL AND ELECTRICAL WORK REQUIRED FOR A COMPLETE OPERATIONAL SYSTEM.
CO_project_name	CAIRO NORTH COMBINED-CYCLE POWER PLANT PROJECT (THE EGYPTIAN ELECTRICITY HOLDING COMPANY (EEHC), A JOINT STOCK COMPANY ESTABLISHED BY LAW NO. 164 YEAR 2000 (FORMERLY EGYPTIAN ELECTRICITY AUTHORITY), HAS SECURED A LOAN FROM THE ARAB FUND FOR ECONOMIC AND SOCIAL DEVELOPMENT AND HAS REQUESTED THE PARTICIPATION OF THE EUROPEAN INVESTMENT BANK (EIB) TO FINANCE THE PROCUREMENT OF MATERIALS AND ASSOCIATED SERVICES FOR SEVERAL PACKAGES OF THE CAIRO NORTH COMBINED-CYCLE POWER PLANT PROJECT)(
CO_sector	energy
CO_document_type	="68%" class="rowbg"> Events
CO_bidding_type	International Competitive Bidding
CO_contract_type	
CO_target_price	Not Provided (
CO_objectives	DESIGN, FABRICATION, FURNISHING, DELIVERY, INSTALLATION, TRAINING, TESTING, START-UP AND COMMISSIONING of 2 gas turbines
CO_duration	one time
CO_issuing_date	
CO_opening_date	
CO_due_date	1.1.2008
CO_closing_date	Not Provided
CO_closing_time	
CO_product_description	

Figure 16: coFinder parsed data from the call for tender shown in Figure 13

5. COC-PLAN TOOL

The Collaboration Opportunity Characterization &VO Rough Planning (COC-Plan) tool consists of two modules: a) One component, described in Section 5.1, supporting the COC process with the aim of assisting the *opportunity broker* – in designing the VO and deciding which roles and partners best fit with the VO structure; and b) a second component, described in Section 5.2, supporting the VO-RP process with the aim of assisting the *VO planner* and/or *VO coordinator* with the mapping of the tasks to be carried out during the VO operation phase (Camarinha-Matos et al, 2005).

5.1 Collaboration Opportunity Characterization

The CO-Characterization process refers to the identification of the main features of a collaboration opportunity to be developed, in terms of a product and/or project to be manufactured or executed from its most complex items (assemblies/activities) to the simplest ones (component/sub-activities), plus the specification of collaboration opportunity competency-related information (per item) required to carry out partners' search and selection (Concha et al, 2008).

Once the collaboration opportunity has been identified (e.g. using coFinder), the *opportunity broker* or the *VO planner* should describe the business opportunity as a product and/or a project as part of the CO-Characterization process. **Figure 17** presents product and project definitions under a decomposition context of their items:

- Products can be defined by components, sub-assemblies and assemblies. A *component* is the smallest part of a product. In some cases, many components are integrated in a special order forming a *sub-assembly* or an *assembly* (depending on the complexity of the product) to fulfil a specific requirement.

- Projects are defined as temporary endeavours undertaken to create a unique service. As in the product decomposition, projects decomposition has lower levels: activities and sub-activities. An *activity* is a component of work performed as a *task* that has an estimated duration, cost and resources requirements to turn inputs into products and/or services. Depending on the complexity of a project, an activity can be divided into as many sub-activities / tasks as it is needed to execute the project.

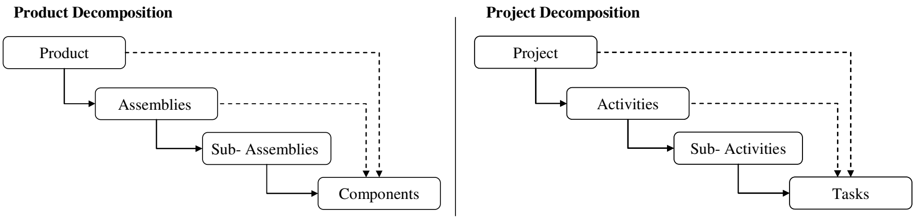

Figure 17 – Product and Project Decomposition

Products and projects have their own attributes which are inherited by their lower items in the decomposition process; there are no limitations to the number of levels that can be defined (see **Figure 18**).

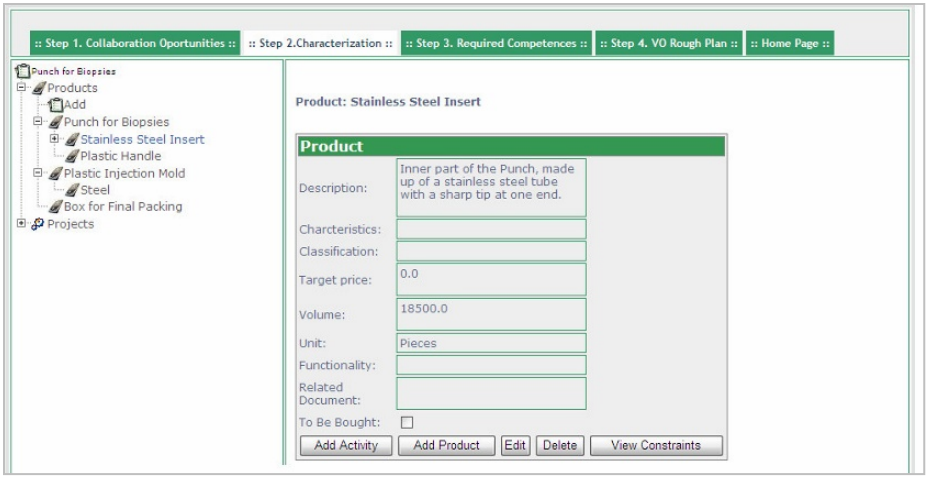

Figure 18 – CO Characterization in the COC-Plan

After a collaboration opportunity has been described as a product and/or a project and its items decomposed, the next step in the CO-Characterization process is the competency requirements definition in terms of the necessary processes, resources and standards for future matching the potential VO partners that posses them. Each item of a product and/or a project decomposed in the first step has to include the specification of the necessary competency to accomplish their production or execution. A *competency* as defined by Ermilova & Afsarmanesh (2005) is understood as the organisation's capability to perform (business) processes (in collaboration with partners such as suppliers), having the necessary resources (human, technological, physical) available, and applying certain standards, with the final aim to offer certain products and/or services to the customer (see Figure 19); furthermore a *capability* is the potential ability to perform a process; a *process* is a structured, measurable, manageable and controllable set of interrelated and interacting activities that use resources to transform inputs into specified outputs; *resources* are classified into: human resources (e.g. engineers, technicians), technological resources (e.g. software) or physical resources (e.g. machines). For the development of some products or services it is necessary to have formalized techniques, methodologies and/or procedures that are frequently used in organisations to perform specific processes known as *standards*.

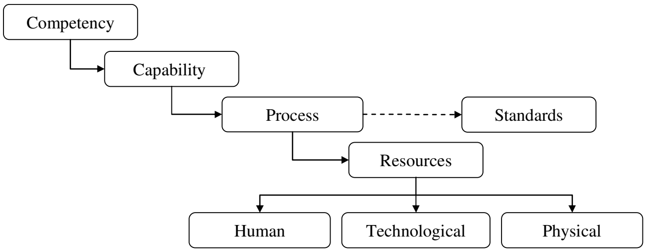

Figure 19 – Competency Definition
(Adapted from Ermilova & Afsarmanesh, 2005).

The COC module will simplify the collaboration opportunity decomposition by presenting the decomposition as a tree, making easier the navigation through the resulting items (the leaves), and allowing to find and access the information related to a specific item (a leaf) in a faster way thanks to the tree hierarchical view. The CO decomposition hierarchical structure represents a similar schema to the Bill of Materials (BOM), term used in manufacturing processes to describe the components needed to complete in a product. As in the CO decomposition, the BOM decomposition presents different levels of a product (assemblies, sub-assemblies and raw materials) necessary to manufacture a product.

Figure 20 shows the COC-Plan tool competency definition template, where a product is described by its minimal components and decomposed in terms of competencies (as a set of capabilities defined by processes, resources and standards).

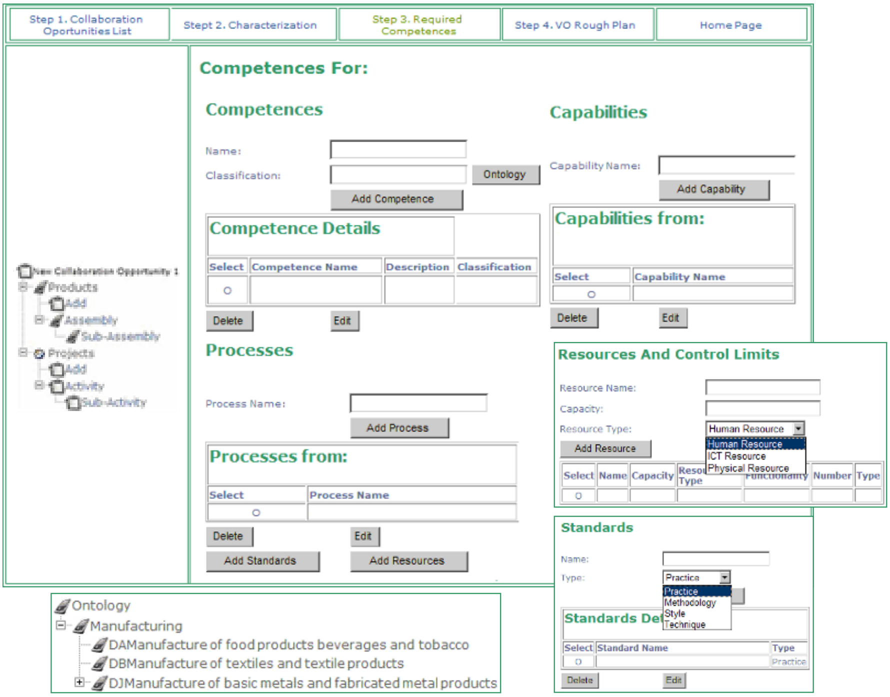

Figure 20 – COC-Plan Tool Competency Definition Template

5.2 VO Rough Planning

VO Rough Planning (VO-RP) represents the second module of the COC-Plan tool. The tasks supported in this module and carried out by the *VO planner* and/or *VO coordinator* are: *collaboration opportunity modality* identification and VO *rough plan* design. The following sections describe these tasks in detail.

5.2.1 Collaboration Opportunity Modalities

When the CO-Characterization process is finished, it is necessary to classify the collaboration opportunity under a *collaboration modality* in order to facilitate the creation of a VO rough plan. Four modalities have been defined (Camarinha-Matos et al 2005) for this purpose:

1) *Collaborative Business Process modality*, representing a set of heterogeneous activities normally distributed in cross-organisational sub-processes;
2) *Collaborative Project modality* aimed to support the performance of multi-projects through the definition of a work breakdown (WBD) structure. This structure is composed by projects, activities, tasks and resources that belong to multi-organisations;
3) *Collaborative Problem-Solving modality,* describing a specific situation or problem (AS-IS situation) that wants to be improved or modified. The desired scenario (TO-BE scenario) should be defined and modelled and working groups should also be identified; and

4) *Ad-hoc Collaboration modality,* designed for organisations that are not used to work under collaboration schemas and join their efforts to quickly respond to a specific external request.

5.2.2 VO Rough Planning Process Definition

The VO-RP module supports the process of determining a rough structure for the potential VO in accordance to each *collaboration modality*, and by considering the competencies and capacities required from VO partners to respond to a specific collaboration opportunity. Thus, VO-RP objective is to determine possible VO configurations as WBDs, and associate competencies and capacities required from each VO partner to execute the tasks corresponding to its roles and competency domain during VO operation phase.

In the COC-Plan tool, the VO-RP module is accessed through an editor, with enhanced and innovative features for importing/exporting files from both proprietary and open-source project planning tools. Figure 21 shows the VO-RP module template, which allows creating and removing tasks to/from the BOM and its further presentation in a project Gantt diagram.

Figure 21 – VO-Rough Planning: Tasks Creation and Gantt diagram.

5.3 COC-Plan tool technical characteristics

5.3.1 System Architecture

Figure 22 presents the COC-Plan tool architecture. Users access the VO framework Web-server through a client machine (a PC or a laptop). COC-Plan tool modules can be accessed through the CO-Characterization module that will invoke the related server, and also the VO-RP module (CO-Plan editor) that resides on top of the COC-Plan tool and can be used by a Java Web start. Both modules store their information at the VO model repository.

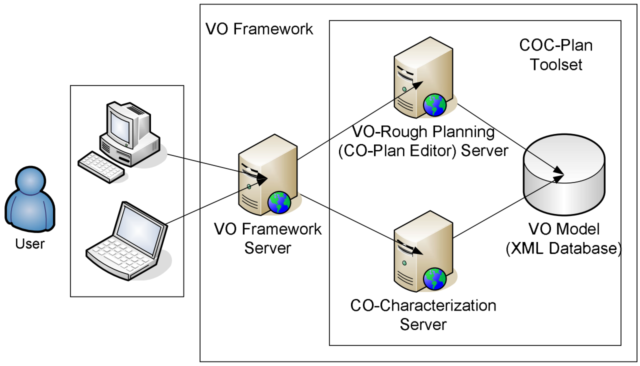

Figure 22 – COC-Plan System Architecture

5.3.2 Database Schema

The database model describes the interactions between the objects (classes) that take part in the CO-Characterization process. Figure 23 presents the relations among the most important elements in the COC module database.

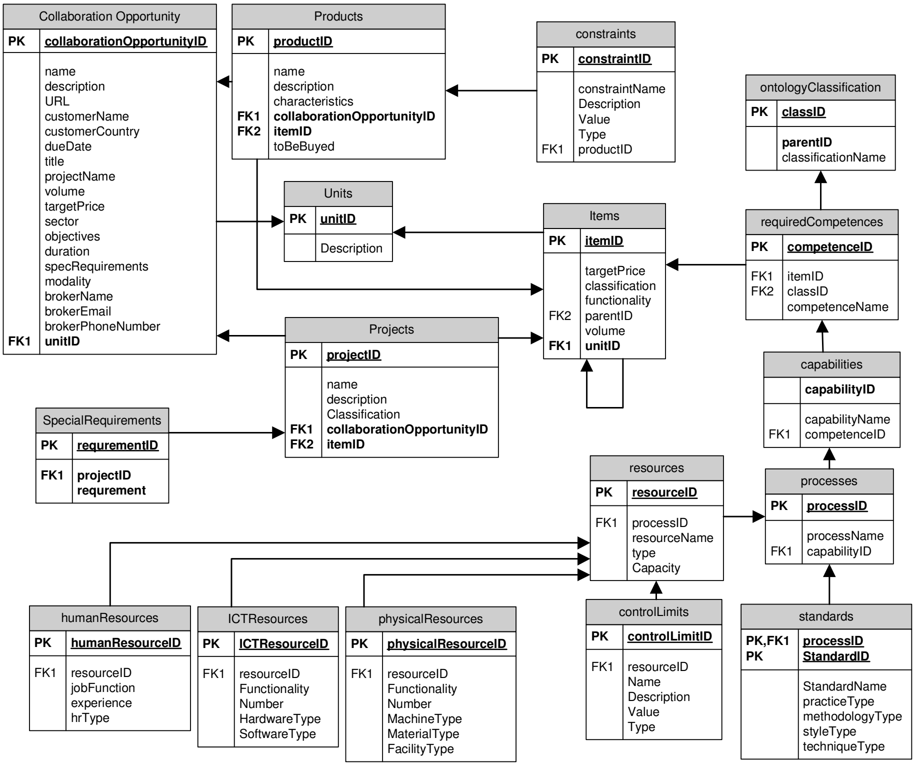

Figure 23 – COC module Database Schema

5.3.3 Development Platform

To guarantee the integration and optimal data transfer (interoperability) among the

VO creation tools, the following development platform was built-up using the following technologies and software tools.

Table 2 - Development Platform.

Design	UML Tool	Microsoft Office Visio 2003
		Enterprise Architecture
Development	Language	J2EE (Java 2 Enterprise Edition)
	IDE	Eclipse + plug-in (MyEclipse)
	Libraries	Apache - Axis
	Serviettes Container	Tomcat v5.5.15
	Portal	Liferay 3
	Objects Persistency	Hibernate 3.1
	Application Framework	Struts
	Code Documentation	Javadoc (installed with J2SE)
	Code Building	Ant (installed with MyEclipse)
Data Storage	Database	PostgreSQL 8.1
	Mapping Tool (object - Relational DB)	Hibernate Framework

6. PSS TOOL

6.1 Purpose

The purpose of the partners' search and suggestion (PSS) tool is to assist the VO Planner in the selection of the most suitable members for a VO regarding the requirements of a given collaboration opportunity (CO). These requirements are received from the previous VO creation phase "CO characterization and rough planning" (COC-Plan), which provides a VO macro structure, concerning the CO work breakdown structure, the tasks assigned to each CO part as well as the competences and resources necessaries to fulfill each task.

The output of the PSS tool is a list of potential VO configurations, including the configurations' expected performance with respect to the specified criteria. These possible VO configurations are presented to the VO Planner for a further decision making and final VO composition.

Partners are suggested based on a set of criteria that, besides traditional elements like price, delivery date and quality level, includes also performance indicators. These criteria are applied both in the searching (filtering inadequate organizations) and in the suggestion (electing the ones that better fit the desired indicators) steps in order to achieve faster and potentially better results.

6.2 Functionalities

The PSS tool is composed of three functionalities responsible to perform the partners' search and suggestion process. These three functionalities are described as follows and Figure 24 depicts the interrelationship among them, highlighting the control and information flows:

- **Suggestion Criteria Identification**: As the main purpose of the PSS tool is to suggest partners, first it is necessary to identify the criteria that will be taken into account to compare the potential candidates. This comparison is important to ensure that the suggested organizations are the best ones among the potential candidates.

- **Partners' Search**: The partners' search looks for potential partners that have the required competences / processes as well as resource availability to be part of the new VO.
- **Generation and Analysis of Suggested VOs**: With the potential partners already identified, this functionality generates optimized arrangements of organizations. Using a suitable GUI, the user can see additional information regarding each arrangement and thus select the most appropriate one.

Besides the three PSS functionalities, Figure 24 also presents two entities that play an important role during the partners' search and suggestion process: the VO Creation (Supporting) Services and the VBE supporting services (VMS). The former represents the services used to integrate all the tools that are part of the VO Creation framework and its main purpose is to intermediate the VO Model exchange among the VO Creation tools. The latter represents the services provided by VBE and used to integrate the VBE tools with the other ECOLEAD tools (e.g. VO Creation framework, VO management tools). Especially concerning PSS tool, these services are used to have access to the competences information and trustworthiness information.

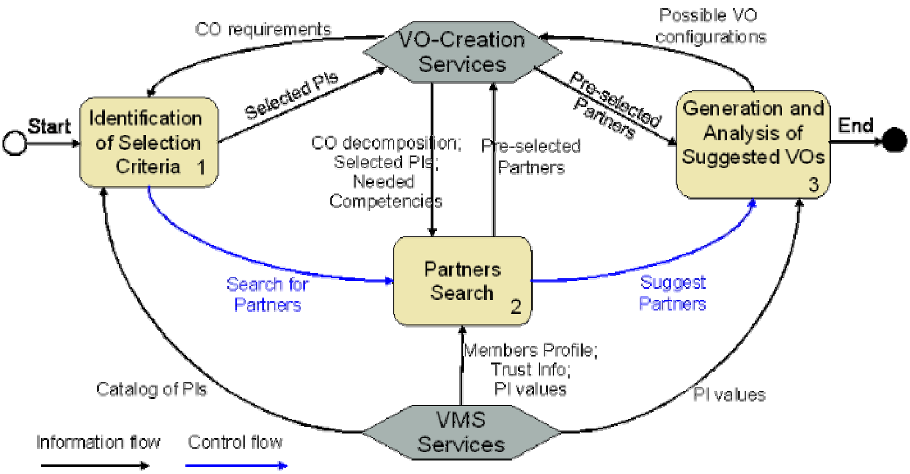

Figure 24 – PSS tool functionalities

6.2.1 Suggestion Criteria Identification

To identify the most suitable Performance Indicators (PIs) to be used to compare and afterwards suggest the proper potential partners for a new VO, a methodology that aids the human user to easily identify these PIs was developed. This methodology is composed of two parts. One that runs just once, called *configuration phase*, and another one that runs whenever a new VO needs to be created to fulfill a certain CO, called *operation phase*. Figure 25 shows the whole methodology which is briefly described below.

Configuration phase*:*

1. Acquisition of the information related to the PIs (from a catalog of PIs) that will be used to measure the organizations' processes and activities. It means, collect information, such as PI name, PI description, PI type, etc.
2. Application of a semantic annotation technique, combined with an ontology that describes PIs, to create annotations in the PIs' information gathered in the previous step. A semantic annotation links a concept stated in an ontology to a piece of information inside a text (Kiryakov *et al.*, 2003).

Operation phase*:*

a. Acquisition of the preferences and constraints' list that the VO needs to fulfill. This list is required to create a VO that performs the envisaged CO.

b. Identification of the CO performance requirements based on the match between the preferences and constraints list and the CO ontology. These performance requirements comprise a list of keywords that will be taken into account for filtering the set of PIs.

c. Search for the proper PIs based on the keywords selected previously. In this step, information retrieval techniques are used to search for PIs indexed in the preparatory phase.

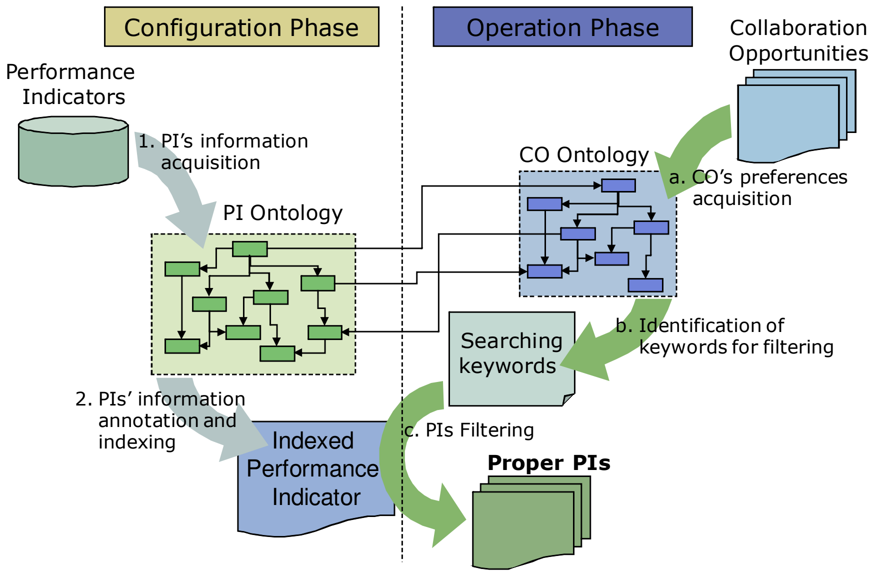

Figure 25 – Performance Indicators Identification Methodology

Ontology**:**

The ontology conceived here aims at describing every concept related to PIs and COs as well as the relationships between them. Nevertheless, it is important to mention that this ontology was developed following such recommendations (Missikoff *et al.*, 2002):

- It has been verified that there is no other ontology specified for this domain.

- Several sources of information to understand this domain have been used. Some of these are: performance measurement systems, benchmarks, etc.
- Some domain experts have been consulted to realize which concepts should be cover. These experts were either business consultants or economic researchers.

The most important questions that this ontology can provide answers include:

- What is a PI?
- What is a CO?
- Which aspects are relevant to classify a PI?
- Which are the correlations between a CO and a PI?

Two statements that express what this ontology stands for are:

– A PI, in general terms, has the purpose to measure *something*, with an *objective*, considering a specific *perspective*, applied to a *domain*, using a *calculation rule* and providing results in a certain *measurement unit*.
– A CO is an entity that provides an *outcome*, considering some *technical specifications*, classified according to a *modality* and that has some *requirements*. More specifically, the *performance requirements* imply performance of *something*, delimited into a *perspective*, having as target an *objective*, comprising a *specific domain*.

Figure 26 shows the top level of the PI and CO ontology. The ontology is basically used to organize the knowledge about the PIs and COs. Besides that, it is also used to refine the search of proper PIs through the contextualization of what is being searched. For example, instead of searching for PIs that are related to "flexibility", it can be searched PIs that are related to the perspective of "flexibility" with the objective of "order fulfillment". It means that this ontology characterizes both "flexibility" and "order fulfillment" as instances of different concepts as well as many other instances of other concepts.

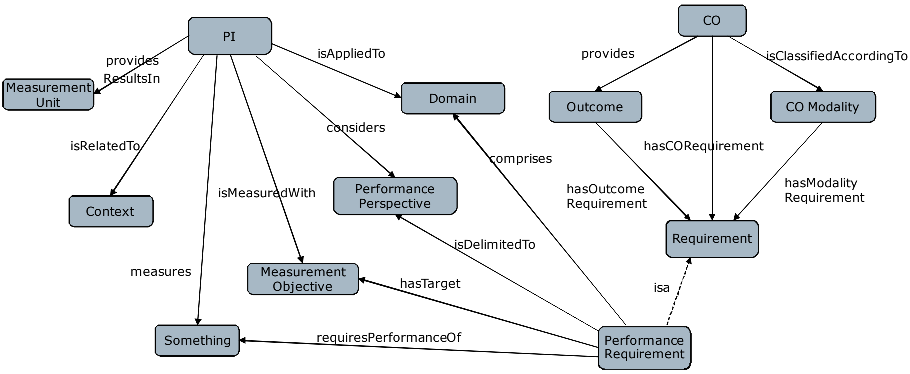

Figure 26 – PI and CO Ontology Top Level

6.2.2 Partners' Search

The partners search is divided into two steps. First, the search for the potential partners is performed. It means, all the VBE members that have some competences required for the new VO that is being created will be selected as potential partners. The second step is to classify the potential partners in groups of similar competencies. In fact, it is expected that more than one VBE member has the same competences and thus will dispute for the same position in the VO. In order to identify which members are the proper ones to be invited to participate in the VO, it is necessary to compare them using a common set of criteria. For this purpose the PIs identified in the previous functionality are used. Using such PIs, the VO planner can make a more precise decision about which are the more suitable VBE member to be part of the new VO. As PIs are measured periodically, it is possible to always compare the potential partners with up to date information.

The partner search process can be roughly understood as the matching of required competencies from the CO decomposition with the competencies provided by the VBE members. An organization's competency constitutes the triple of organization's "capability-capacity-conspicuity" (Ermilova et al., 2007). An organization's *capability* represents the set of *processes* and *activities* that an organization is able to perform and can potentially contribute to the development of the VO (Ermilova et al., 2007). An organization's *capacity* represents the availability of resources that can be applied within the new VO. An organization's *conspicuity* can be given by a number of different documents that can add different levels of validity to the organizations' claims.

Based on these concepts, in order to figure out if an organization can be a potential partner it is necessary to verify if it fulfills the following constraints:

1. It has the capability to perform a certain process required by the CO;
2. It has the capacity to satisfy the demand of the CO. To declare that an organization has capacity regarding a process, the process execution rate (number of times that the process runs within a specific period) must be greater than or equal to the CO process demand (number of outputs required within the same period). This aspect ensures that the VO execution flow can be fulfilled;
3. It has availability of resources (human and physical) that can be allocated to attend the CO. To declare that an organization is available to perform such process, the amount of resources available in a period of time must be greater than or equal to the total of outputs required by the CO for this period.

Bellow, the process of identifying the potential partners is presented in more details.

Let $M = \{1,...,m\}$ denote the set of organizations belonging to a given VBE and $N = \{1,...n\}$ the tasks that should be performed by organizations in order to fulfill one specific CO. Let us also consider other important information elements used in the partners' search process:

C_i – the set of competences that an organization $i \in M$ has.
Cr_j – the set of competences that a task j requires to be performed.
X_{mxn} – the matrix where each element $x_{i,j}$ represents whether or not the organization i has the whole set of competences to perform the task j. So that,

$$xi,j \begin{cases} 0, & if \;\; Crj \not\subset Ci \quad \forall i \in M \wedge \forall j \in N \\ 1, & if \;\; Crj \subset Ci \quad \forall i \in M \wedge \forall j \in N \end{cases}$$

and
R_i – the set of resources that an organization i has.
Rr_j – the set of resources that a task j requires to be performed.
So, an organization i has the required resources to fulfill a specific task j whether

fi,j is not a empty set, as follow:

$$f_{i,j}\begin{cases}\phi, & \text{if } Rr_j \not\subset R_i \quad \forall\, i \in M \wedge \forall\, j \in N \\ Rr_j, & \text{if } Rr_j \subset R_i \quad \forall\, i \in M \wedge \forall\, j \in N\end{cases}$$

Therefore, an organization $i \in M$ can be considered a candidate partner for a task $j \in N$, if it satisfies the following restriction:

$$x_{i,j}\,g(f_{i,j,k}) \geq g(Rr_{j,k}) \quad \forall\, k \in Rr_j$$

where,
g(w) – amount of resources assigned to w.

6.2.3 Generation and analysis of suggested VOs

This functionality finds and evaluates feasible VO configurations with respect to user-defined criteria. The feasibility of a configuration is defined through its ability to perform the requirements of the CO. These requirements are described by tasks, each of which requires a specific competence. In addition, work-loads (e.g. person month) can be attached to the tasks.

The functionality formulates the VO partner selection as a work-allocation problem, which is approached by multi-objective mixed integer linear programming (MILP, Jarimo and Pulkkinen, 2005). This approach has been chosen for two reasons. First, a reasonable size MILP model is computationally solvable using well known algorithms. Computational experiments suggest that the MILP models are tractable for problems of reasonable size and consequently potentially useful for VO decision making. Second, MILP models are flexible to modifications. The multi-objectivity is captured by goal-programming techniques (e.g. Taha, 1997) or additive value functions (MAVT, Keeney and Raiffa, 1993). Heuristic algorithms are used to find Pareto-efficient solutions.

The approach accounts for a large variety of selection criteria. First, total costs include fixed and variable work costs and transportation costs. Second, stochastic risk measures are applied to model risks of failure, delays, or capacity shortfall. Third, network interdependencies, such as collaboration history or total number of partners can be taken into account.

Using this functionality, a decision-maker (DM, e.g. VO planner) can identify a set of Pareto-optimal configurations, of which the DM can manually select the preferred one. In other words, it suggests several alternatives that are "good" in respect of different preferences over the selection criteria. Hence, the DM does not need to explicitly weight the criteria, but instead can identify configurations that reflect different preferences.

The inputs for this module are as follows. There are n tasks with a work-load (e.g. person month) attached to each of them. The tasks also have a relational work sequence, and information on possible transportation needs between tasks. For each task j, there are m_j candidate partners, the total number of candidates being $m = \Sigma_j m_j$. Each candidate has a capacity, and fixed and variable costs for working on the tasks to which it is a candidate. The data is easily represented by matrices, where the rows and columns represent the candidates and the tasks. A candidate can have a probability distribution over its capacities, reflecting the uncertainty on the true capacity. Moreover, each candidate can have a fixed cost for working on the project, a geographical location, a collaboration history with other candidates, etc. Also the selection criteria that will be used in partner selection are to be defined for each case.

Its output is a set of Pareto-efficient work allocations, i.e. VO configurations. The constituents of this set depends on how the DM has expressed his/her preferences over the selection criteria. The DM can then manually select the most preferred configuration.

The scores of the identified configurations on the selection criteria are also given. Hence, in addition to the partners in Pareto-efficient configurations, the DM can compare the expected performance of the configurations.

Bellow, the computational model behind the generation and analysis of suggested VOs is described in more detail.

Computational multi-criteria model:

Let M = {1,…,m} denote the set of partners candidate. The project is divided into tasks, denoted by N = {1,…, n}. Each task $j \in N$ has a work load w_j, which describes the amount of work required (e.g. person months) in order to perform that task. The information gathered from candidates includes the following parameters:

- $c_{i,j}^k$ - capacity, or amount of work that member $i \in M$ can perform on task j (e.g. person months), with probability pi,j(k)
- $p_{i,j}$ - probability measure on set $C_{i,j}$, which includes $c_{i,j}^k$'s for given i and j
- $v_{i,j}$ - variable costs of member $i \in M$ working on task j (e.g. €/person month)
- f_i - fixed cost of member i becoming part of the VO, i.e. working on at least one task of the project
- $f_{i,j,k}$ - performance of member i starting to work on task j, according to performance indicator k.
- λ_k - weight of the relative importance of performance indicator k.

The actual decision variable is the work-allocation matrix $X_{m\times n}$, whose element $x_{i,j}$ denotes the amount of work that VBE member i performs on task j. In addition, we define the following dummy variables, whose values depend completely on x's.

First, let

$$y_i = \begin{cases} 0, & \text{if } x_{i,j} = 0 \forall j \in N \\ 1, & \text{if } x_{i,j} > 0 \text{ for at least one } j \in N. \end{cases}$$

That is, y_i is binary, denoting whether any work in the project is allocated to VBE member i. Furthermore, let

$$y_{i,j} = \begin{cases} 0, & \text{if } x_{i,j} = 0 \\ 1, & \text{if } x_{i,j} > 0. \end{cases}$$

In words, binary $y_{i,j}$ denotes whether any work on task j is allocated to i.

The objective function sums fixed and variable costs and other performance indicators:

$$\min_{X,Y} \lambda_{\cos t} \underbrace{\sum_{i=1}^{m} f_i y_i}_{(I)} + \lambda_{\cos t} \underbrace{\sum_{j=1}^{n} \sum_{i=1}^{m} v_{i,j} x_{i,j}}_{(II)} + \sum_{k=1}^{l} \lambda_k \underbrace{\sum_{j=1}^{n} \sum_{i=1}^{m} f_{i,j,k} y_{i,j}}_{(III)},$$

where X is m×n matrix consisting of x's and Y is m×(n+1) matrix of y's. Interpretation of the sum terms is the following:

(I) Sum of fixed costs for adding a new member to VO

(II) Sum of variable costs of each member's work on tasks

(III) Weighted sum of performance indicator data.

It should be noted, however, that the model is flexible in the sense that some costs can be ignored if considered irrelevant. On the other hand, the model allows accounting for completely new criteria.

The constraints of the optimization problem assure the requirements of the CO are met. First the work load of each task has to be covered:

$$\sum_{i=1}^{m} x_{i,j} \geq w_j \quad \forall j \in N.$$

Second, the work allocation may not exceed expected capacities:

$$x_{i,j} \leq \sum_{k=1}^{|C_{i,j}|} p_{i,j}(k) c_{i,j}^{k} \quad \forall i \in M, j \in N.$$

Third, work loads are non-negative:

$$x_{i,j} \geq 0 \quad \forall i \in M, j \in N.$$

Optimization Results:

The above multi-criteria optimization model is linear, thus it can be solved with normal binary programming algorithms, such as simplex and branch-and-cut. Since it is unreasonable to expect that the decision-maker would give point estimates for the relative importance of the selection criteria, we solve the problem with a set of weights. Hence, the solution is a set of Pareto-efficient VO configurations, in which the performance of the configuration with respect to any criterion can not be increased without compromising another criterion.

The generation of the Pareto-efficient VO configurations enables the use of different sensitivity analyses and finally the manual selection of the most preferred VO configuration. Comparing the expected performance of whole VO configurations instead of sole individual partner candidates gives the decision maker a better view on the overall performance of the VO. Moreover, the comparison of whole VO configurations enables the incorporation of inter-organizational dependencies, such as collaboration history or geographical distance, in partner selection.

6.3 PSS tool technical characteristics

6.3.1 System architecture

The PSS system architecture, presented in
Figure **27**, is composed of the following elements:

- Three portlets that are the GUIs where users can interact with the PSS tool.
- KIM Platform (www.ontotext.com/kim/) used to semantically annotate, index and retrieves the PIs' information.
- One database management system that stores and manages the information.
- One portal that contains the three portlets aforementioned.
- One web server that contains the web portal.

- One client web service used to exchange the VO Model file and thus realize the integration.

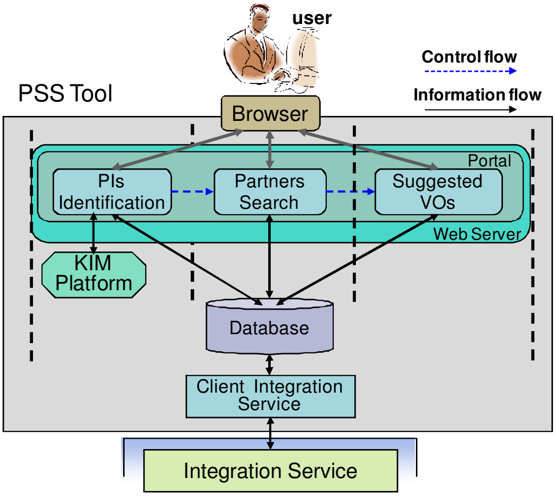

Figure 27 – PSS System architecture

6.3.2 Database Schema

The information used by PSS tool needs to be stored in order to be used and reused whenever necessary. To store all the information required by PSS a database schema was designed. Figure 28 presents the most important information that is stored.

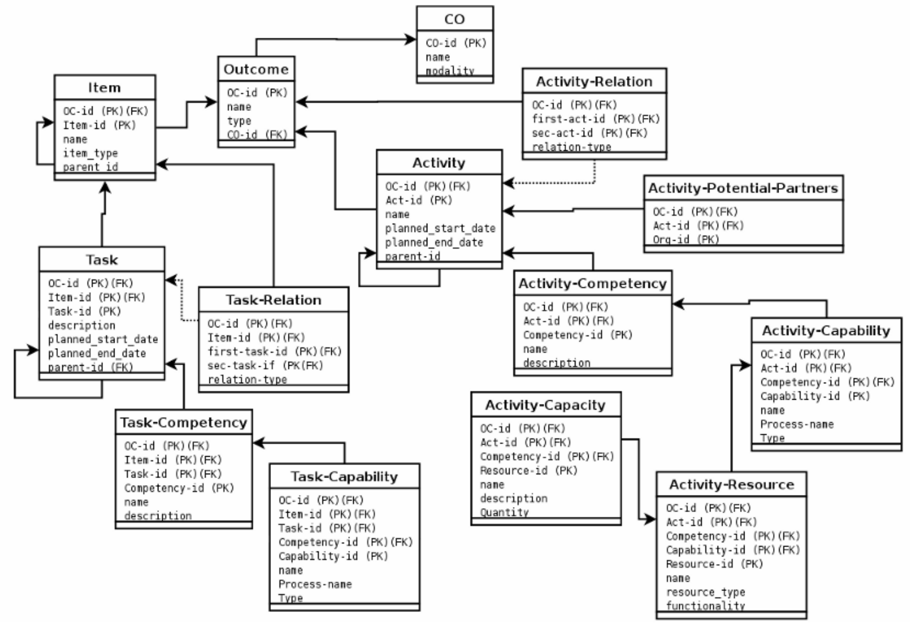

Figure 28 – PSS tool database schema

6.3.3 Development Platform

Table 3 presents the tools and technologies used to implement the PSS tool.

Table 3 – PSS development platform

Design	UML tool	Enterprise Architecture
Development	Programming language	J2EE (Java 2 Enterprise Edition)
	IDE	Eclipse + Lomboz plug-in
	Script language	JSTL and JSP
	Web service libraries	Apache – Axis
	Web application container	Tomcat v5.5.15
	Portal	Liferay 3
	Objects persistency	Hibernate 3.1
	MCV framework	Struts
	Code documentation	Javadoc (installed with J2SE)
	Mixed Integer Linear Programming Solver	Ip_solve (http://groups.yahoo.com/group/lp_solve/)
Data Storage	Database	PostgreSQL 8.1
	Reverse engineering	JBoss Tools: Eclipse Plugins
	Mapping tool (object - Relational DB)	Hibernate Framework

7. FURTHER STEPS

The process described in previous sections is simplified and incomplete. In fact, the results of the PSS tool are based on the available information about potential candidates. But in reality, the actual engagement of an organization in the VO will depend on a successful negotiation between the VO planner and this organization or among all members of the potential consortium. The negotiation process might imply several iterations, changing conditions and trying alternative configurations.

In order to facilitate the negotiation process, another tool – WizAN (Camarinha-Matos & Oliveira, 2006; Camarinha-Matos et al., 2007) – was developed and is described in another chapter.

When finally a VO consortium is established and an agreement is reached among all participants, the outcome represented in the VO model data structure is passed to the VO management system (also introduced in other chapters) to actually launch the VO.

8. CONCLUSIONS

Computer assistance in the process of creation of virtual organizations is an important element for the possibility of having truly dynamic VOs, in response to collaboration opportunities in fast changing market contexts. A realistic approach to materialize agility in VO creation is defined with the assumption of a VO Breeding Environment (VBE) that guarantees the preparedness of its members to quickly get engaged in collaboration processes. The ECOLEAD approach to VO creation is developed under such assumption, and proposes a detailed process covering all required steps from the identification of the collaboration opportunity till the actual launching of the VO that will exploit that opportunity. A set of tools are proposed to support an iterative decision-making process in which the final decisions are made by the broker / VO planner. These tools were specified in interaction with end user networks.

Acknowledgements. This work was funded in part by the European Commission through the ECOLEAD project.

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