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Analysis & Design of a Collaboration Opportunity Characterization Tool for Virtual Organisations Creation

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Abstract: This paper presents the conceptual foundations relevant to the proper design and implementation of a software tool to support a broker or a business integrator in the context of a Virtual Organisation (VO) for partners search and selection for a specific business/collaboration opportunity. The Collaboration Opportunity Characterization tool detailed in this paper provides functionalities for decomposing a collaboration opportunity into items, which can be individually mapped to the specific competencies required for achieving the VO business/collaborative objectives, once the competencies required are specified, this competency-related information can be used for the further selection of proper VO partners to tackle a specific business/collaboration opportunity *Copyright © 2008 IFAC*

Keywords: Virtual Organisation, Collaboration Opportunity Characterization, Product Decomposition, Project Decomposition, Competency Definition, Broker, Business Integrator, Ontology Domain, Web Application Layers, Web Services.

1. INTRODUCTION

The possibility of rapidly finding a set of partners that best fit for responding a business/collaboration opportunity, and quickly configure them into a goal-oriented collaborative network such as a Virtual Organisation (VO) depends on the availability of a *broker* and/or a *business integrator* for defining and characterizing a collaboration opportunity identified. A collaboration opportunity should be defined and characterized in terms of the processes capabilities and resources capacities to be further searched using a competency-based matching approach in potential VO partners (Boucher & Lebureau, 2005; Camarinha-Matos et al, 2005; 2007).

The adoption of a competency-based approach provides a precise description of the processes, resources and standards required to characterize a given collaboration opportunity and makes easier to find the group of organisations, known as the potential VO partners, that best fit the collaboration opportunity description (Boucher & Lebureau, 2005; Camarinha-Matos et al, 2005; 2007).

In this context, a competency can be defined as: "the organisation's capability to perform (business) processes (in collaboration with partners), having the necessary resources (human, technological, physical) available, and applying certain standards (practices), with the aim to offer certain products and/or services to the customer" (Ermilova & Afsarmanesh, 2006).

The purpose of this paper is to present the analysis and design of a Collaboration Opportunity Characterization (CO-C) tool for Virtual Organisations (VOs) as temporally alliances of organisations or enterprises that come together to share their skills or core-competencies and resources in order to respond to business or collaboration opportunities, that without working together would not be possible or would have higher cost if attempted by them individually, and whose cooperation is supported by computer networks (Camarinha-Matos & Afsarmanesh, 2006).

Furthermore, the analysis & design of the CO-Characterization tool is considered in the context of VO creation process, in where VO configuration and launching is triggered by a specific business/collaboration opportunity (Camarinha-Matos et al, 2005; 2007).

2. VO CREATION PROCESS AND THE CO-CHARACTERIZATION

VO Creation Process (see Fig. 1) is integrated by three main blocks: 1) Preparatory planning in which a collaboration opportunity is identified and characterized, and a draft of the VO planning to fulfil the collaboration opportunity needs is defined; 2) Consortia Formation in which proper VO partners are searched and selected, and agreements are negotiated; and 3) VO launching in which final adjustments are made to VO plan and a contract is signed to put the VO into operation (Camarinha-Matos et al, 2005; 2007).

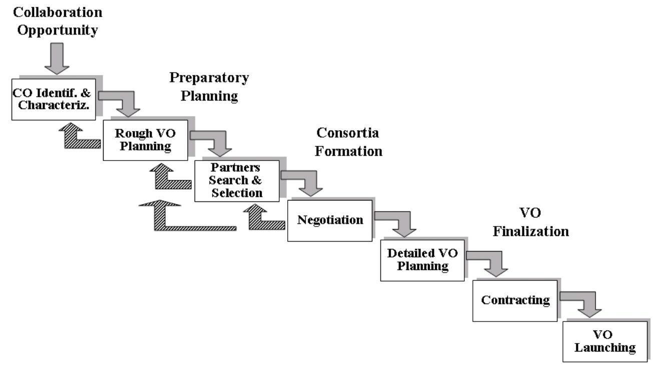

Fig. 1. VO Creation Process (Camarinha-Matos et al, 2005)

The present work focuses on the first step in VO creation process known as Collaboration Opportunity Identification and Characterization. This step involves the identification and characterization of a new business/collaboration opportunity that will trigger the formation of a new VO. Once a collaboration opportunity has been identified, it has to be characterized for obtaining the information requirements for the further VO configuration. The main issues to consider in this step are the identification and categorization of the collaboration opportunity and its representation and feasibility analysis (Camarinha-Matos et al, 2005; 2007).

3. CO-CHARACTERIZATION TOOL ANALYSIS

CO-Characterization refers to the process of identifying the main features of a collaboration opportunity to be developed, in terms of a product and/or a project to be manufactured or executed, from its most complex items (assemblies/activities) to the simplest ones (components/sub-activities), and to characterize the collaboration opportunity in terms of the competencies (as a set of capabilities defined by processes, resources and standards) required in VO partners to respond to a specific collaboration opportunity. Thus, the objective of CO-Characterization tool is to characterize a collaboration opportunity in terms of competencies required to further matching VO partners.

Furthermore, CO-Characterization tool scope is to characterize a collaboration opportunity already identified and to provide the competency-related information required for further VO partners search and selection in VO creation context. So considering this scope, CO-Characterization tool was designed to provide extensible interoperation capabilities in order to seamlessly integrate with other tools that support these capabilities such as automatic/semi-automatic Collaboration Opportunity Identification (e.g. CO-Finder tool) (Rabelo et al, 2000; Demšar et al; 2007) and Partners Search and Selection features (e.g. PSS tool), both considering multi-agent based approaches (Camarinha-Matos, 1999; 2001; Li et al, 2000; Crispim & de Sousa et al; 2007).

3.1 General Approach

As stated in the CO-Characterization tool objective, the main goal is to characterize a collaboration opportunity in terms of competencies by decomposing it into smaller items which could be potentially mapped into the competencies required in a VO partner for providing such item. Furthermore, to begin with the CO-Characterization process it is necessary to define the type of collaboration opportunity: a. product manufacturing b. project execution.

The product manufacturing type is related to all tangible assets that have to be provided for accomplishing the customer requirements in a collaboration opportunity. In the other hand, projects are a set of activities that a VO partner has to execute in order to accomplish in a proper manner and according the customer requirements a collaboration opportunity.

The importance of defining a collaboration opportunity type at this point is to guide the proper CO decomposition and the further steps in VO creation process. Without making any difference in the type of collaboration opportunity, both, products and projects, will contain items that at the end of the CO-Characterization process will result in the decomposition of products and/or activities considering that an activity can be needed for the manufacturing of a product, or in contrary, a tangible asset can be needed to execute an activity. Going on the CO-Characterization process, requires competencies must be defined for each item that defines the collaboration opportunity. The output of CO-Characterization tool will be the CO decomposition as well as the required competencies in VO partners for each decomposed item.

In CO-Characterization process, a collaboration opportunity (see Fig. 2) can be decomposed directly into a product and/or a project. The products and/or projects have common attributes through the item inheritance, but each one holds some attributes of their own. Additionally, an item (product or activity) can be decomposed into some other items, with no limitation imposed to the decomposition level. Saying that an item can be decomposed into other items implies the ability to decompose a product into activities and products and vice versa.

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

The result of CO decomposition is a tree with the root represented by the collaboration opportunity. In a second level, several products and activities are held by the collaboration opportunity. Below the second level, every tree node can hold its own decomposition presenting a lower level of a product or an activity.

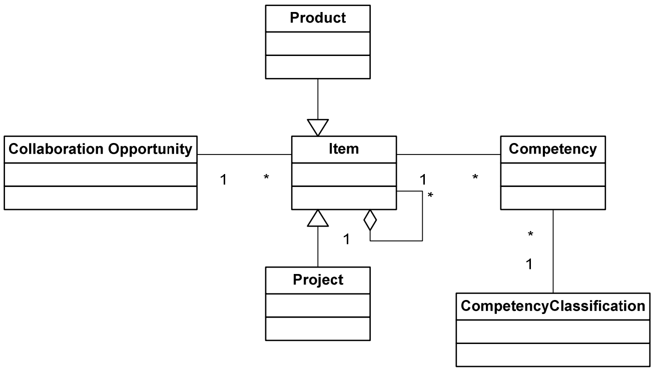

Fig. 2. CO Decomposition – UML Class Diagram

The CO decomposition model supports implicitly other concepts for product manufacturing or project execution such as: component, assembly, sup-product and activity.

- A *component* is a product that does not hold any other item (product or activity) and as such is represented in the tree hierarchy as the lowest level of nodes or leaves.
- An *assembly* is related to a set of components which could need some activities for its integration (e.g. rotor parts as products + rotor assembly as an activity).
- A *sub-product* can be a component or assembly forming part of a super-product (higher hierarchy product) that does not imply an extra activity for being into the super-product.
- An *activity* is the lowest level of project decomposition or project leaves.

3.2 *Inputs & Outputs*

The input for CO-Characterization tool will be the collaboration opportunity information to be decomposed. The output will be a graphical representation of the CO decomposition as well as its representation as a file, which will contain the general information needed by the business integrator (also known as VO planner), to model the collaboration opportunity identified. An alternative to this representation could be the exposition of its results through a web service providing more seamless integration with external tools.

The CO-Characterization tool will support VO planners or business integrators in the process of a structured characterization of a collaboration opportunity. The plain output of the CO-Characterization tool will be a list of competencies needed to respond to a specific collaboration opportunity. The expected output for the CO-Characterization tool is a list of the decomposed resulting items and a list per item of each one of the competencies required for their realisation.

3.3 *System Architecture*

The CO-Characterization system architecture contains four layers (see Fig. 3); the three upper layers are common to Web applications and the fourth or lowest layer, named data abstraction layer, is the most important layer of the system architecture by allowing different types of local or remote data sources co-exist. The data abstraction layer has been designed in such way that would be easy to implement a new data access method for an unspecified source.

Furthermore, first layer in CO-Characterization system architecture is the presentation layer implemented through JSPs (Java Server Pages) and some Struts Tag Libraries, this layer deals with the user interface allowing its easy modification without affecting the behaviour of the application. The second layer is a flow control logic layer and was implemented through Struts Framework allowing the user to navigate through the application screens as well as the error display mechanisms; if the screen flow is centralized in this layer, it would be easy to change application behaviour without affecting the compliance with the business rules applied in the business logic layer and featuring a full reuse of the existing user interface. The third layer is the business logic layer implemented with raw Java classes for supporting data management through the data abstraction layer; some hidden details in this layer are location, access method, data format, transference protocol, etc. Finally, the fourth and most important layer is the data abstraction layer implemented using the abstract factory pattern for achieving decoupling of data access methods from the upper business logic layer, hiding in this way the data source details and providing generic access methods independently of the data source.

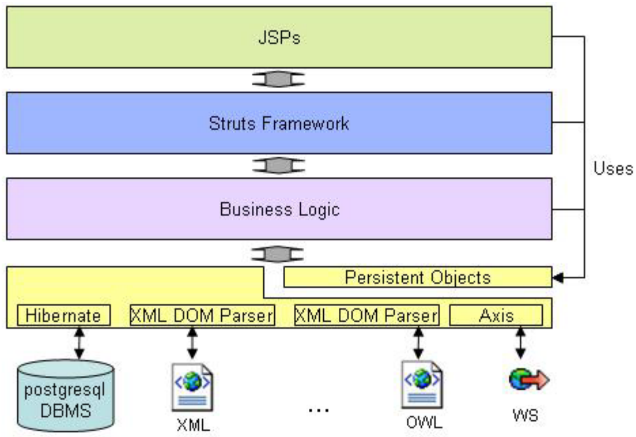

Fig. 3. CO-Characterization System Architecture

As mentioned before, the decoupling of data access methods from the business logic layer was implemented following the abstract factory pattern which is depicted for this specific case in Figure 4. As presented in the data access layer diagram, all the dependences from the business logic layer (BLogic) are directed to interfaces, and the instantiation of the implementations is assigned also to an interface, decoupling completely the business logic from the data abstraction layer. The concrete factories actually implemented are: "HibernateDAOFactory" and "DOMDAOFactory", which have the ability to create data access objects by implementing the access to data stored in a database and XML file(s) respectively.

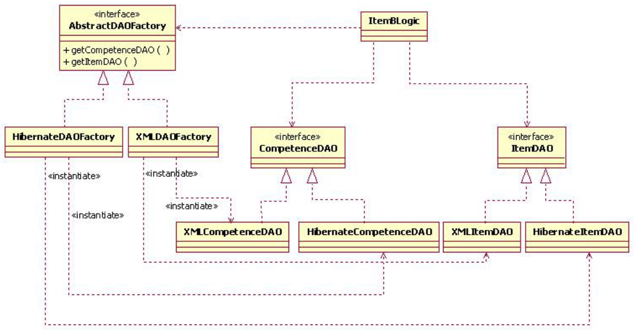

Fig. 4. Abstract Factory Pattern Implementation for Data Access Layer

3.4 *Integration Requirements*

Envision of the CO-Characterization environment in an ICT-infrastructure is depicted in Figure 5, where it is presented at least two tools interacting with the CO-Characterization tool. First and providing an input for the CO-Characterization tool is a Collaboration Opportunity tool (e.g. CO-Finder tool) for automatic/semi-automatic identification of business/collaborative opportunities (Rabelo et al, 2000; Demšar et al; 2007) and lastly a VO Partners Search and Selection tool (e.g. PSS tool) whose competencies aggregation fulfil the whole collaboration opportunity requirements (Camarinha-Matos, 1999; 2001; Li et al, 2000; Crispim and de Sousa et al; 2007).

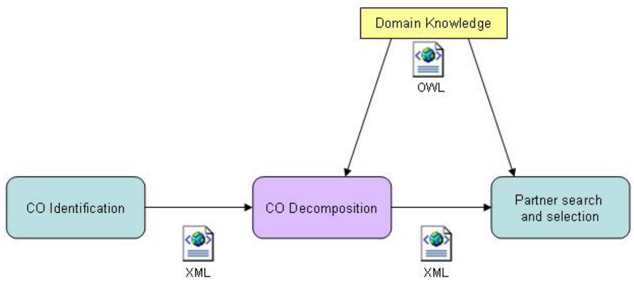

Fig. 5. XML Information Exchange

Web services provide integration in data integration level by common information formats and transference protocols. Also in data integration level, XML files can be used by applications like the CO-Characterization tool, independently of the internal data source or internal data structures representation. The XML standard can be used and it's used in CO-Characterization tool for the interoperating applications for agreeing the data structures and terms for use in the interoperation. The XML standard can be used as well for exchanging data in conformance to the agreement. The semantic mediation between applications is supported by the use of an ontology that reinforces the meaning of the required terms.

Again, in Fig. 5, CO decomposition tool (also known as CO-Characterization tool), and partners search and selection tool make use of a domain ontology expressed in OWL (Ontology Web Language). This ontology serves as a semantic mediator assisting the *VO Planners* with a common vocabulary through the whole business domain. For this specific case, the ontology presents the meaning of terms related to the classification of competencies (e.g. NACE Classification - Nomenclature of Economic Activities) (NACE_URL). The exposure of the terms as well as their meaning in different applications can help *VO planners* for a uniform use of term avoiding wrong interpretation of a term once the data has leaved the original application.

4. CO-CHARACTERIZATION TOOL DESIGN

As mentioned earlier the general functions to be covered by the CO-Characterization tool are: a. Collaboration opportunity decomposition, b. Item competency assignment, and c. Reporting or data exporting. The actor making use of the COC tool functionalities is the broker or the business integrator (VO planner) as shown in Figure 6:

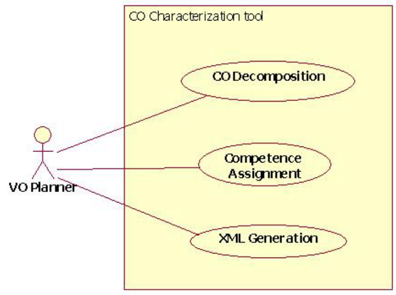

Fig. 6. COC Tool – UML Use Case Diagram

4.1 *Collaboration Opportunity Decomposition – Use Case*

The functional requirement implemented by this use case is the decomposition of a selected collaboration opportunity for the further required competencies identification. This functionality is intended to be provided to the VO planner. The trigger of this use case is the identification and the explicit selection of a collaboration opportunity to be decomposed.

The expected action flow will be as follows: a) A previously collaboration opportunity is selected. Once the collaboration opportunity has been selected, a screen will be shown with the collaboration opportunity definition (see Fig. 7) providing access to the next step in CO-Characterization process through the <decomposition> button. b) Once the user presses the <CO characterization> button, the CO-Characterization tool will present a tree structure (see Fig. 8) with the selected collaboration opportunity as root. At the second level of the tree there will be two ramifications, once for products and a second one for projects c) If a product node is selected, the option for <adding a product> must be presented; if selected, the new product screen (see Fig. 9) will be presented. After correctly supplying the new product data and pressing <save> button, the data will be committed to the database and the CO decomposition tree will be refreshed. d) If the project node is selected, the option for <adding a new activity> will be offered, after selecting this option the new activity screen (see Fig. 10) has to be presented. After supplying the activity data correctly and pressing the <save> button, the activity data will be committed to the database and the CO decomposition tree will be redrawn. f) If a product node is selected, the data of the product will be presented aside from the option for <editing> it, <adding an activity> or <a product> and also an option for specify some <view constraints> for that product (see Fig. 11). If the add constraints button is pressed, the constraints screen will be presented asking for the necessary information (see Fig 12).

In the other hand, if an activity node is selected, the data of the activity will be presented aside from the option for <editing> it, <adding an activity> or <a product> and also an option for specify some <special requirements> for that activity (see Fig. 13). If the <add constraints> button is pressed, the constraints screen will be presented asking for the necessary information (see Fig 14). This means that a product can be decomposed into other products or activities, in the same way activities can be decomposed into products or sub-activities without limitation in the CO decomposition level.

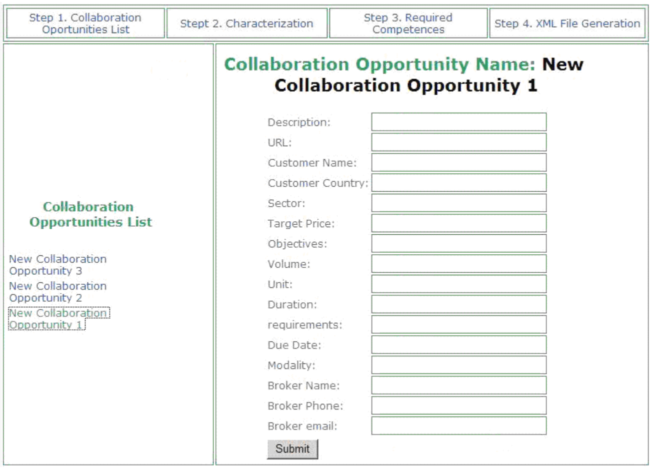

Fig. 7. Collaboration Opportunity Data Template

Fig. 8. Initial Decomposition Tree

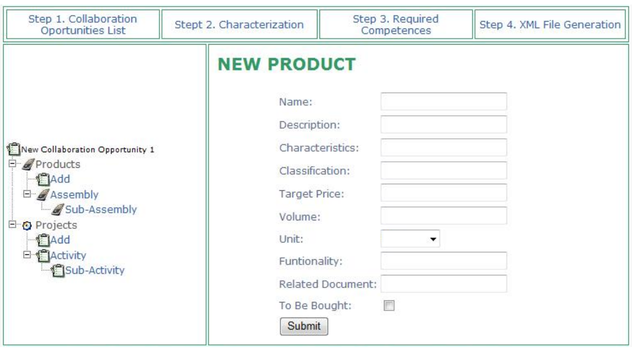

Fig. 9. Add Product Data Template

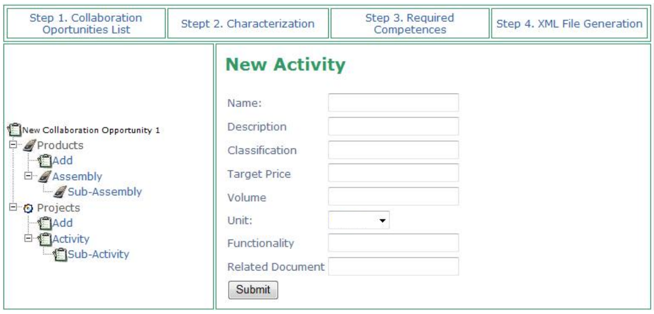

Fig. 10. Add Activity Data Template

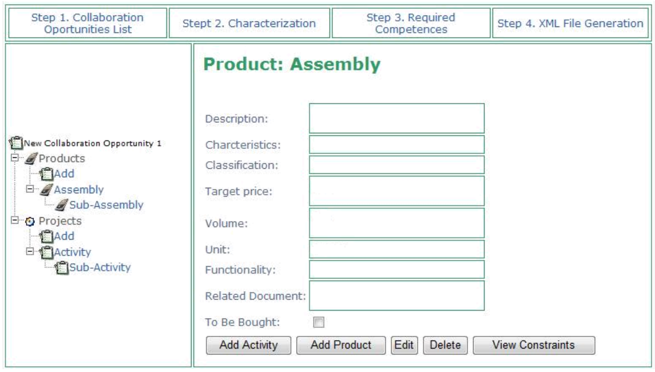

Fig. 11. Product Data Template – Adding a Product, an Activity or constraints

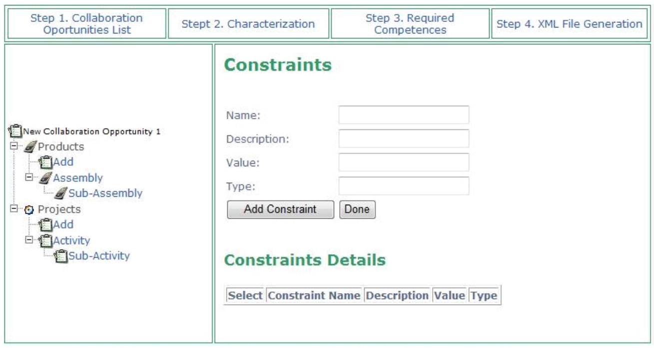

Fig 12. Add Constraints

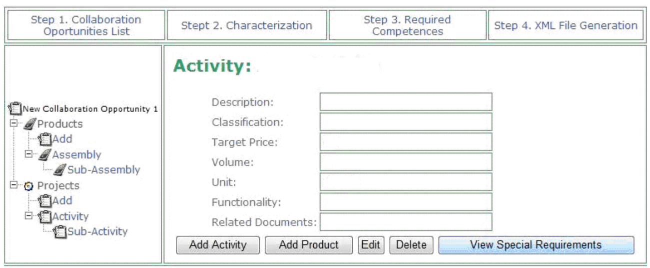

Fig. 13 Activity Data Template – Adding a Product, an Activity or Special Requirements

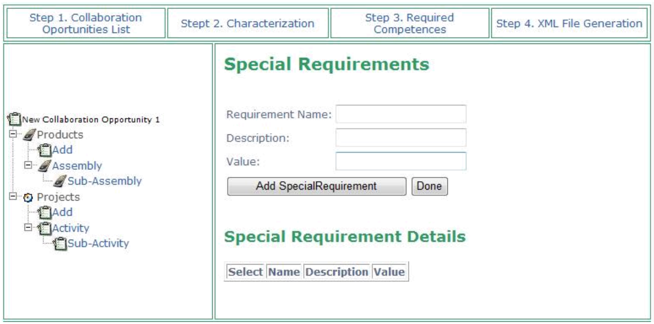

Fig 14. Add Special Requirements

4.2 Competency Assignment – Use Case

The requirement covered by this use case is the per item competency assignment. For achieving this requirement, the following sequence is expected:

a) A previously identified collaboration opportunity is selected for decomposition.

b) The CO-Characterization tool presents a tree structure with the selected collaboration opportunity as the root. At the second level of the three there will be two ramifications, one for products and the other for projects, these two branches holding all the CO decomposition that were previously defined (see Fig. 15).

c) Every time a tree node is selected, a form containing the necessary fields for attaching a competency to the item has to be shown, as well as the competencies previously added to the item.

The competencies are defined in terms of capabilities, and capabilities are defined by processes conformed by resources and standards. In the screen (see Fig. 15) there are two buttons that allowing these options. A second tree representing the part of the domain ontology referent to the competency classes has to be shown also to allow the user to select the correct classification of the competency in compliance with the domain ontology (see Fig. 16).

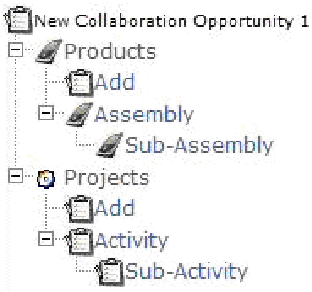

Fig. 15. Decomposition Tree for Competency Assignment

Fig. 16. Competency Identification with Partial Example Ontology

4.3 XML Generation – Use Case

The goal of this use case is to create an XML file containing the result of the CO-Characterization. The XML generation only requires a single user action; this action consist on clicking in the XML File Generation link located in the upper-right corner of the COC tool screen (see Fig. 13).

5. CO-CHARACTERIZATION TOOL PROTOTYPE IMPLEMENTATION

A functional prototype of the CO-Characterization tool was implemented following the conceptual analysis and design described in sections 3 and 4.

The CO-Characterization tool was developed as a J2EE Web application based on Struts Framework and Hibernate. DOM java XML parser was implemented for retrieving XML contents as objects elements.

CO-Characterization tool was tested over Tomcat Application Server 5.0.27. The Integrated Development Environment used was Eclipse 3.1 with MyEclipse 4.0 plug-ins.

Section 3.3 presents a short description of the implementation of each conceptual architecture component.

6. SUDY CASE

IECOS (Integration Engineering and Construction Systems), is a Brokerage company, created at CIDYT (Center of Innovation in Design and Technology) of the Tecnologico de Monterrey, Mexico, with the primary aim to demonstrate how a Broker company could be designed, developed and operated.

In 2000, IECOS initiated operations, searching for business opportunities and selecting several Mexican SMEs as its main manufacturing partners (IECOS_URL).

IECOS is an engineering company which is focused on innovation technology projects through the capabilities and competencies integration of its allies and partners, guarantying customer satisfaction and cost reduction through an efficient supply chain management and an effective integration of core competencies SMEs (small and medium enterprises).

For the scope of this study case, this paper will focus on IECOS supply services , as the business unit that offers the integration of associated enterprises capable to deliver manufactured products (metal-mechanic and plastic parts mainly) in terms of quality, cost and delivery time expected by the customer.

6.1 IECOS Supply Services

IECOS supply services usually receives product drawings and customer specifications at the start of a supply project. Next, product information is identified and the supply project starts.

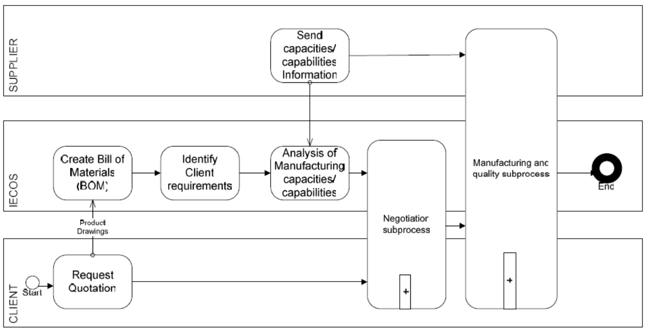

Fig. 16. IECOS Supply Business Process

As Figure 16 shows, the first phase of the supply project aims to clearly define the product requirements. In this step, Bill of Materials (BoM) definition is used to identify materials, standard components, quality standards and delivery times according to customer requirements.

At the second phase of the supply project, after the definition of product requirements has been carried out, the assessment of manufacturing capabilities and capacities from different associated enterprises starts with the purpose of verifying who are the best enterprises, according to their competencies, for being integrated as temporary business partners for successfully comply with the customer requirements.

In the third phase of the supply project, the product components are manufactured by their respective supplier, according to their competencies, and control metrics are established and monitored all along through the manufacturing process.

Through the use of the CO-Characterization tool prototype it was possible to confirm the possibility of capturing all the required data for making proper product decomposition. Once the product decomposition was carried out, it was also possible to capture all the competencies required for each resulting item of the product decomposition. In the case of IECOS supply services, the information related to the business partner's competencies is stored in a MS-Excel file. For making all the captured information available for the partner search and selection process, a XML file was created with the option to be exported into MS-Excel file were the competency-based approach for further business partners matching was carried out.

6.2 Key Findings in IECOS Supply Services

The key findings after CO-Characterization tool take-up in IECOS supply services real-life environment were:

- The use the CO-Characterization tool changed the way IECOS was executing product decomposition process for the BoM definition, customer requirements identification and manufacturing competency analysis.
- Without the CO-Characterization tool, the BoM definition consists in the listing of product components in a MS-Excel spreadsheet, with this technique some items were missing from the initial BoM; this was reflected later into the BoM when the missing components became evident.
- With the tree representation of the product decomposition, it became clearer the whole product composition and some ambiguity was removed from repeating items components. The final count for each required item was faster because of the explicit identification of the number of item components that compose other items.
- Without the use of the CO-Characterization tool in the customer requirements identification, some requirements were not taken into account because of the omission of components in the BoM definition. This didn't happen with the use of the CO-Characterization tool because of the full identification of components during the product decomposition. The same case of this process was applied for the manufacturing competency analysis, and some competencies that weren't considered in the initial listing, where consider when using the CO-Characterization tool.

7. CONCLUSIONS

Key remarks are based on the fact that CO-Characterization tool was able to facilitate the identification of required competencies for accomplishing new business/collaborative opportunities in real-life environment.

The results of the IECOS supply services study case shown how easy and more accurate competency requirement identification can be done with the support of the CO-Characterization tool, in contrast with the results obtained without the support of CO-Characterization tool.

Some observations related to the CO-Characterization tool achievements in real-life environment are:

- The design of the CO decomposition model resulted in an accurate representation of the reality as shown by the IECOS supply services study case, past attempts with different models resulted in an inconsistent or an incomplete CO decompositions (e.g. product/project decomposition).

- The database design for storing the CO decomposition proved its ability to store the CO decomposition model without visible constraints.

- The attempts of implementing objects for accessing new data sources showed that the effort for extending the interoperation capacity to the new data source was minor. This was tested by changing the original implemented data source (local database) of collaboration opportunities to a newer one as a XML file located at any URL.

Furthermore, IECOS supply services study case also pointed out some missing features in the CO-Characterization tool that are part of the further research and tool development:

- CO-Characterization tool does not consider the possibility for contemplating different CO decompositions for the same collaboration opportunity; this could help to identify different scenarios and to free the broker or the business integrator from a single CO decomposition structure.

- Implementing the functionality required to import existing CO decomposition branches into a different CO decomposition tree for avoiding rework on similar cases.

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