19 AN ONTOLOGY-BASED APPROACH FOR SELECTING PERFORMANCE INDICATORS FOR PARTNERS SUGGESTION

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In the current fast-paced world, organizations do not have time to postpone ideas due to the lack of suitable technical and scientific supports that can help them in a rapid connection establishment in order to develop collaborative works. This paper presents a methodology that aids the user to find the appropriated performance indicators that may be used to compare and after to suggest a suitable set of organizations to fulfill a specific Collaboration Opportunity. In this work is made an assumption that the Virtual Organization Breeding Environment has a common set of performance indicators that are known and agreed among the involved organizations.

1 INTRODUCTION

In the current fast-paced world, organizations do not have time to postpone collaboration opportunities (CO), or simply lose them, for the lack of suitable technical and scientific supports that can help them in a rapid connection establishment in order to develop collaborative works. In order to satisfy the organizations' needs of computational and methodological support to collaborate in networks, it was created the research area called "Collaborative Networks". Within the researches provided by this discipline are the studies about "Virtual Organizations". A Virtual Organization (VO) is a dynamic, temporary and logical aggregation of autonomous organizations that cooperate with each other as a strategic answer to attend a given business opportunity or to cope with a specific need, and whose operation is achieved by a coordinated sharing of skills, resources and information, totally enabled by computer networks (Rabelo *et al.*, 2004).

One of the critical aspects concerning the establishment of VOs is how to select the right partners to fulfill a specific CO. This is one of the most discussed problems addressed by VO creation process. However, it was not completely solved, requiring improvements that need to be done in order to reach a suitable level of maturity that can cope with the actual agile requirements claimed by the organizations that desire to collaborate. For example, until few years ago it was supposed that in the creation of a VO partners could be quickly and easily identified and selected from the wide-open universe of organizations. However, nowadays it is known that this is not as simple as it seems to be. Some problems are: How to acquire organizations' information; How to quickly establish a collaboration infrastructure; How to build trust among organizations (Camarinha-Matos *et al.*, 2005). The more research on VO

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creation gained maturity the more it was realized that automatic approaches for that showed unfeasibility. A result of this observation was, for example, that the term "partners selection" has been replaced by "partners suggestion", highlighting the need of more intense involvement of users along the process. Another result is that past approaches stated that costs and delivery dates would be enough to suggest partners. Today is a common sense that is necessary to utilize a well-know, agreed and meaningful set of criteria to more accurately suggest appropriated organizations for VOs. Moreover, each CO and consequently each VO tends to be so particular that suggestion criteria cannot be defined *a priori* or in a fixed way. Instead, the most suitable criteria are necessary to be elected as a way to maximize the VO effectiveness. This is what this paper is about, introducing a methodology to guide in the identification of criteria to suggest partners for the creation of VOs.

This paper is organized as follow. In chapter 2, the problem of finding the right partners for a specific VO is stated. In chapter 3, it is shown the strategy of identifying criteria to suggest partners. Chapter 4 presents in detail the methodology conceived to identify the most suitable set of criteria. Chapter 5 addresses some implementation aspects concerning the development of this methodology. At the end, it is presented the conclusion and future works.

2 CRITERIA IDENTIFICATION FOR PARTNER SUGGESTION

First works related to partners suggestion just considering as suggestion criteria information regarding costs, delivery dates and availability of resources. However, during the last years it was realized that only use these reduced set of generic information is not enough to really ensure the quality of such suggestion. Petersen (2003) emphasizes the importance to select partners using a well defined set of criteria based on a common set of attributes known by every interested organization. Following the idea introduced by Petersen, an alternative of common set of criteria to be applied in partners search and suggestion might be the utilization of the same information used to measure performance either within or among organizations, e.g., SCOR Model, Balanced Scorecard, benchmarks, etc. That is an approach that can be used by those groups of organizations (e.g., VBEs) that already have a common performance measurement model, i.e., they can use these performance indicators (PIs) as criteria for partners search and suggestion. Nevertheless, in order to use measurement models – that are very large in most of the cases – it is necessary to find a way to reduce the number of indicators that are relevant to be applied in such kind of process. Moreover, this filter of indicators should be performed taking into account the type of the CO as well as its requirements and preferences.

How to identify the most important indicators considering the CO's preferences and requirements remains a question under discussion. Some of the studies carried out until now, specially those addressed by Seifert *et al.* (2005), Bittencourt *et al.* (2005) and Grudzewski *et al.* (2005), deal with PIs as criteria to suggest organizations for new VOs. However, these works did not tackle the problem of which PI to use for each particular CO.

Taking into consideration this gap of formalization concerning the identification of PIs for partners search and suggestion, this work presents a strategy to filter the whole set of PIs in order to identify those that can be used to compare and after to suggest organizations for new VOs.

In this work, it is assumed that the suggestion criteria can be represented through organizations' PIs. It means that the VO Breeding Environment has a well-defined set of PIs used to measure performance among its members. A VO Breeding Environment (VBE) represents a long-term association of organizations that are prepared to effectively cooperate, establishing a VO or another form of dynamic collaborative networked organization, in the right time that a CO is identified (Afsarmanesh *et al.*, 2005).

3 APPROACH

The strategy adopted in this work to minimize the set of PIs and thus to find the most relevant ones is described in three general steps.

1. To get as much information as possible about the description of those PIs that compose the entire set of indicators that are used to measure performance among organizations.
2. To indeed understand what they mean through the processing of the unstructured textual information and recognition of relevant words that explain what they exactly represent and measure.
3. To identify the proper PIs for a specific CO applying filters that take into consideration the CO's preferences and constraints.

The filtering of PIs can be seen as a problem of searching for information. The search for information is a field of study of the information retrieval discipline that uses search engines to perform such process. However, only applying a search engine to solve the problem of finding the most relevant PIs is a too simplistic solution that actually does not provide the expected result for this specific problem. This assertion can be supported because different PIs, described in different words, at different organizations, using different models, sometimes can represent the same thing. Yet, different PI implementations of the same model can present different scope and real meaning.

How to represent that similarity of different PIs is something that traditional information retrieval techniques do not support. Therefore, in order to cope with this it is necessary to introduce somehow an additional level of information that can understand the diversity of variation of PIs and thus retrieval the right ones even if they do not have an explicit correlation. A way to do that is using an ontology that can understand the range of variation that a PI can have as well as the similarity among them.

The problem of how to use an ontology to introduce this additional level of information within the PIs' description can be supported by the concept of semantic annotation. Semantic annotation is currently considered the state-of-the-art when retrieval of information is concerned. The term *annotation* refers to the use of auxiliary symbols that are used to modify the interpretation of other symbols (Dorado *et al.*, 2003). Semantic annotation techniques use ontologies to perform the proper annotation of the significant words included in the text. Therefore, in order to semantically annotate the PIs' description it is necessary to specify a comprehensive ontology that describes in a sensible way all the relevant concepts related to PIs' characterization. Although the semantic knowledge, introduced by semantic annotation, can add power and accuracy to information retrieval, the knowledge base needed to perform such process is difficult to obtain. In most cases, the knowledge base is created manually (Riloff *et al.*, 1997). This work fits in this problem, i.e., the

ontology as well as the knowledge base used to annotate the information had to be manually encoded using several information sources.

Regarding the input parameters used to filter the whole set of PIs it is used the CO's preferences and constraints. In fact, they are requirements provided during the CO characterization, in a textual matter, and describe the aspects that should be taking into account in order to create the envisaged VO. This requirement can be something as a recommendation, i.e., a *preference*, or something that must be followed, i.e., a *constraint*.

In order to relate COs with PIs and thus to add another level of assistance in the process of PIs retrieval, it was extended the PIs ontology to include the characterization of concepts related to COs, especially those about preferences and constraints and their relationship with PIs. These correlations are the key issues taken into account during the PIs identification.

4 PROPOSED METHODOLOGY

First of all, it is important to keep in mind that the methodology being developed and presented in this work intends to *assist* the user to identify the most appropriated PIs for a given CO instead of doing it automatically, i.e., it supports the user that is who drives the process and takes the final decision.

This methodology is composed of two parts. One that runs just once, called *preparation phase*, and another one that runs whenever a new VO needs to be created to fulfill a certain CO, called *execution phase*. The first part of the methodology comprises the setup of the environment as well as the acquisition of information in order to identify the PIs in the second phase of the methodology. It intends to be as generic as possible to be used for every VBE that has a pre-defined set of PIs applied to measure performance among its members. This methodology uses a specific ontology to perform the PIs identification. This ontology is detailed in the next section. Figure 1 shows the whole methodology that is briefly described below.

Preparation phase:

1. Acquisition of the information related to those PIs (catalog of PIs) that are being used to measure the organizations' processes and activities in a given VBE. It means to obtain information, such as PI name, PI description and PI type.
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 given concept of an ontology to a piece of information inside a text (Kiryakov *et al.*, 2003). After that, these annotations are indexed to improve the retrieval of information.

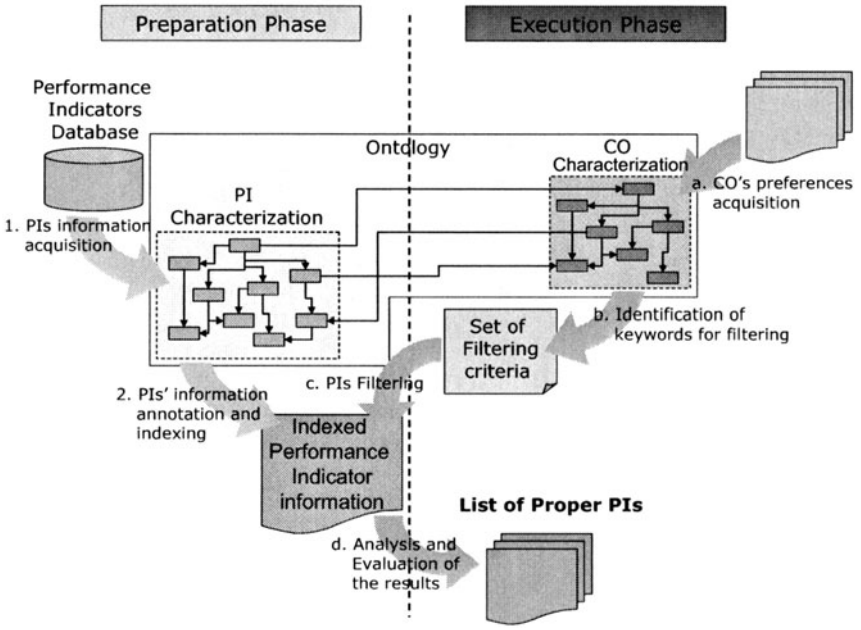

Figure 1 – Performance Indicators Identification Methodology

Execution phase:

a. Acquisition of the preferences and constraints' list that the CO needs to fulfill. This list is required to create a VO that performs the envisaged collaboration.
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.
d. Analysis and evaluation of the results in order to ensure whether the PIs are good enough to start the partners search and suggestion. This is a subjective task that should be driven by the human user, who is responsible for taking the final decision considering his expertise about the subject.

Using the methodology described above, the user can perform the partners search and suggestion process with more accurate information to firstly compare the candidates and thus to suggest those that better fit the performance expectation. Besides that, this methodology can be combined with some already developed works in order to improve their results. For instance, Bittencourt *et al.* (2005) applies Analytic Hierarchy Process in the PIs to express the importance of them for the whole CO success. Seifert *et al.* (2005) uses PIs to predict the performance of a set of potential VO partners. Jarimo *et al.* (2006) optimizes VOs' configurations using PIs as optimization parameters. Vallejos *et al.* (2006) proposes a framework to create VBEs and in this framework it is applied a benchmark that can be used as source of PIs for the methodology presented in this work.

4.1 Ontology

The objective of an ontology is to provide a representation of knowledge that can be used and re-used in order to facilitate the comprehension of concepts and the relationships among them in a given domain. By providing definitions, an ontology helps people and machines to use the same terms for expressions and thus better mutual understanding (Khan *et al.*, 2003).

It is reasonable to think that before selecting a PI it is necessary to understand it. A good way to understand PIs is representing it using an ontology. Moreover, to identify the proper PIs for a CO, it is also necessary understand COs. The ontology conceived in this work aims at describing both PIs and COs as well as the relationships between them. It intends to conceptualize every possible PI and CO and also states for each kind of CO which PIs would be better applied. However, to create an ontology manually is not an easy task that can be performed in an ad-hoc way, unlike it is necessary to follow some principles. Here, it was adopted the recommendations proposed by Missikoff *et al.* (2002):

- It was verified if there is any other ontology specified for this specific domain. In fact, it was figured out that there is no ontology specified for this domain.
- It was selected several sources of information that could help the process of understanding the concepts related to that domain. Some of these sources are: performance measurement reference models, benchmarks, PIs cases, etc.
- It was consulted some domain experts in order to realize which are the most important aspects that an ontology that describes PIs and COs should cover. These experts were, in most of the cases, business consultants and economics researchers.

A way to start to evaluate what an ontology will describe is preparing some questions that this ontology should provide answer for. A list of the most important questions is:

- 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?

A manner to shortly describe which conceptualization an ontology supports is trying to write statements that represent what this ontology characterizes. For that, both PI and CO definitions must be robust enough to represent them generically and hence to allow the conception of an ontology (figure 2, in a top level) for them. In this work they are defined as:

– A PI, in a general way, 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* require performance of *something*, delimited into a *perspective*, having as target an *objective*, comprising a *specific domain*

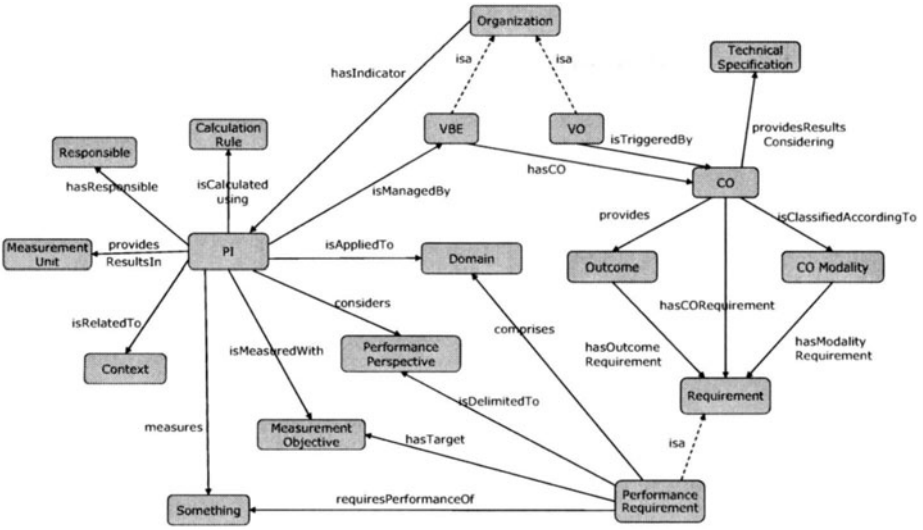

Figure 2 – PI and CO Ontology Top Level

5 IMPLEMENTATION

In order to implement the methodology presented in chapter 4 a prototype is being developed. A list of tools and technologies that provide the necessary features required for the envisaged system have been selected as part of the strategy of taking advantage of using already existing software. The whole environment, presented in figure 3, is composed of:

- The KIM Platform used to semantically annotate, indexing and retrieval information (Kiryakov *et al.*, 2003).
- A web service API that encapsulates the PIs identification programming logic.
- A GUI, developed using the web technology called portlet, where the user can directly access and use the PIs identification system.

The KIM platform was selected mainly because it offers a powerful, well-documented and easy-to-use API for remote access that facilitates the connectivity with other applications. In this particular case, these features are sufficient to implement the PIs identification system.

The tool used to specify the PI & CO ontology was Protégé. This ontology was included as an extension of the ontology provide by KIM. This extension in the KIM's ontology enables KIM to perform the proper semantic annotation of the PIs' description.

The PIs annotation and identification programming logic was coded as a web service API to facilitate other applications to have access to it, for instance Partners Search and Suggestion

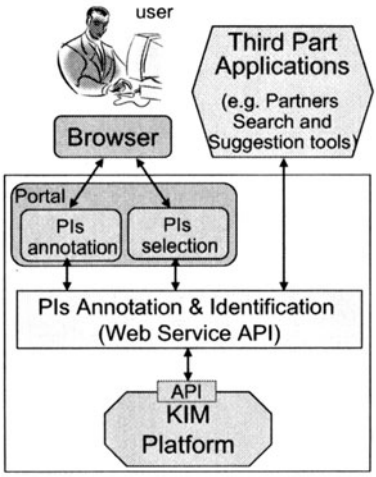

Figure 3 - System Environment

tools, rather then just to provide a predefined GUI as most of the tools used to do. It was decided to follow this approach in order to promote its dissemination as well as because using web service it can be accessed more easily through the utilization of standard web protocols. These API provides services both to annotate and to search for PIs, the former is used during the preparation phase of the methodology, the latter is used in the execution phase of this methology (see Figure 1). The web portal also reflects the approach presented in the methodology. It has two portlets, one devoted to annotate PIs (comprising the preparation phase) and the other one dedicated to select PIs (comprising the execution phase).

The PIs annotation and identification tool is being developed in the scope of the ECOLEAD project (www.ecolead.org). More specifically, it is part of the partners search and suggestion functionality and both belonging to the VO creation system suite.

5.1 Use Case

It can be taken as an example a new CO that arrives in the VBE's domain. This CO has as part of its information some preferences and constraints concerning quality, price and performance. The performance information, stated in a textual manner, serves as input to perform the PIs identification. The process of identification is driven by a human user who is in charge of translating the textual preferences and constraints present in the document that describes the CO in a high-level semantic query. This translation and semantic query construction is supported by the tool. Actually, the tool provides some templates of possible queries where the user just needs to fill in with the keywords took from the textual requirement description. There is a list of templates comprising queries that are more generic, i.e. statements with less parameters, as well as more specific queries, i.e. statements with more parameters. However, if the user prefers to create a semantic query from scratch there is a wizard that guides this process.

For instance, a performance requirement got from the CO description to create a semantic query would be something as: "For a specific CO in the manufacturing industry sector, it is mandatory that the suggested organizations follow the planned schedule of activities, because the deadlines between tasks as well as the time to delivery the final product are short". Instantiating this against the PI definition, the query template generated for that would be: "look for PIs that measure *tasks*, with the objective of *scheduling*, considering the perspective of *responsiveness*, in the domain of *manufacturing industry*". After the user fills this semantic query, it is submitted to the system where the execution phase of the methodology (presented in figure 1) is performed. The resulting PIs will be able to measure things like: the average of delay to fulfill tasks, the percentage of tasks completed on time, etc. At last, with the retrieved PIs, the user can refine this set and thus just to select the most relevant ones. Figure 4 presents a GUI that shows the example explained above.

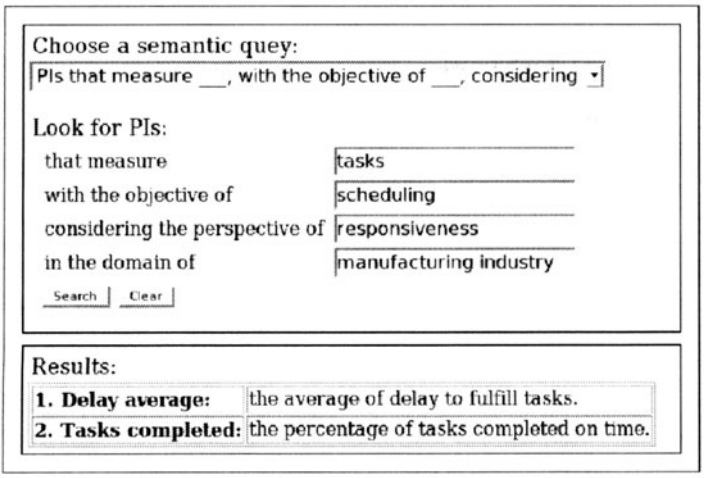

Figure 4 – Screenshot of the tool to identify PIs

6 CONCLUSION

This work has as main contribution the definition of a methodology for PIs identification for VO partners search and suggestion. Actually, it improves the user's decision concerning the selection of organizations giving addition information about what can be used to compare the possible candidates in a more effective way. The user can have different criteria to compare candidates for different types of COs. Hence, he can find better partners comparing them via PIs that better can represent the performance expected in this VO.

Some preliminary tests have pointed out that the methodology works appropriately for, at least, one instance of the manufacturing industry sector. This assertion is based on the fact that part of the information used to test it came from the partners of ECOLEAD project that belong to this sector.

Next short-term goals of this work involves two main actions. The first one refers to the improvement of the wizard semantic query construction with some additional assistance in order to analyze the CO's requirements (in what performance is concerned) and to further generate a list of suggested relevant PIs to select partners for the given CO. The second action consists in the deployment of the system at some project's pilots and hence the application of the methodology in a real case scenario.

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