Chapter 7

TARGETING LEARNING RESOURCES IN COMPETENCY BASED ORGANIZATIONS: A SEMANTIC WEB-BASED APPROACH

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1. MOTIVATION AND PROBLEM DESCRIPTION

Recent standardization and specification efforts in the area of learning technology (Friesen, 2005) have resulted in a considerable improvement in the interoperability of learning resources across different Learning Management Systems (LMS) and Learning Object Repositories (LOR). Examples are the ADL SCORM and IMS Learning Design specifications, which provide shared languages to express the packaging of learning contents and learning activity designs respectively, among other elements. The central paradigm of such reuse-oriented technology is the notion of *learning objects* (LO) as digital reusable pieces of learning activities or contents. This represents an opportunity for organizations to devise more effective mechanisms for targeting learning activities internally as a way of improving their capacity to respond to the changing business and technological environments and also to the evolving customer needs.

However, transportability of digital learning objects across platforms is only a basic step towards higher levels of automation and possibilities of delegation of tasks to software agents or modules. Such advanced technology requires richer semantics than those offered by current metadata specifications for learning resources (Sicilia and García-Barriocanal, 2005). Semantic Web technology and the use of ontologies are able to provide the required computational semantics for the automation of tasks related to learning objects as selection or composition. In general, they enable new possibilities to enhance organizational learning or even fostering systemic learning behavior inside the organization (Sicilia and Lytras, 2005). In addition, Semantic Web Services (SWS) provide the technical architecture and mediation facilities for semantic interoperability required for selection and composition of learning objects in a distributed environment in which there are potentially many heterogeneous repositories (Lama et al., 2006).

Within the context described, the dynamic search, interchange and delivery of learning objects within a service-oriented context represent a major challenge that needs to be properly addressed. In short, this entails the technical description of the solution in terms of SWS technology, and also the provision of the ontologies, facilities and components required to extend and enhance existing learning technology systems with the advanced capabilities provided by computational semantics. Semantic Web Services provide the required conceptual representations, along with the capabilities to translate and integrate diverse systems that share the common goal of reusing learning objects. A Semantic Web Service engine integrated with existing standardized LMS technology will extend the possibilities of learners, tutors and instructional designers with semantic search tools capable of asking for and retrieving learning objects from any provider that registers itself as a Semantic LOR. Semantic Web Services, as conceived in the WSMO framework[29] provide the required ontology-based representation flexible enough to specify realistic learning needs and exploit domain or specialized knowledge in the process of search for learning objects (Lama et al. 2006). A key feature of WSMO is the ontological role separation between user/customer (goal) and Web Service. This matches the concept of learning tasks being separate concept in learning literature. However, before a SWS architecture can be fully exploited, there is a need to devise the underlying framework for the expression of learning needs and their subsequent use for selecting learning resources. This chapter addresses one concrete way of expressing such learning needs in terms of competencies, which are especially adequate for organizational learning.

Competencies have been defined in terms of observable human performance, (Rothwell and Kazanas, 1992) encompassing several elements:

[29] http://www.wsmo.org/

(1) the work situation is the origin of the requirement for action that puts the competency into play, (2) the individual's required attributes (knowledge, skills, attitudes) in order to be able to act in the work situation, (3) the response which is the action itself, and (4) the consequences or outcomes, which are the results of the action, and which determine if the standard performance has been met. This kind of definitions leads to a paradigm of *competency computation* in which both organizational needs and the expected outcomes of learning resources are expressed in terms of competencies, thus enabling numerical or symbolic accounts of the *competency gap*, i.e. the (amount of) competencies that are required to fulfil some give needs or to reach a more desirable status in organizational terms. Existing work on engineering competency ontologies (Sicilia, 2005) has resulted in flexible models that can be used for the critical task of targeting learning activities inside the organization, personalized to the competency record of each employee. This chapter reports on the early implementation of such approach in a concrete organizational context.

With the aim of exploiting the advantages of a Semantic Web Service Architecture to make richer and more flexible the processes of query and specification of learning needs in the context of Learning Management Systems and Learning Object Repositories, a use case centered on competency-based selection in the Aeronautic field is depicted in the following. Based on this analysis, the viability and benefits of the approach are presented and briefly discussed at the end of the chapter.

2. COMPETENCY DRIVEN TRAINING SELECTION IN THE AERONAUTICAL FIELD

Training significantly contributes to the companies' ability to react on requirements of fast changes markets, customer needs and successful business process. Nowadays, aeronautical industries have a high demand for well-trained teams. At the same time they face continuous changes in their work processes and tools. Not only is continuous education an important process but it is managed on a contractual basis. Therefore, training management activity is a common responsibility of Human Resources (HHRR) departments. Actions and decisions about training are taken by HHRR according to the company objectives. The important requirement for training management is that it supports developing and maintaining the right range of skills and competencies needed for the employees' jobs.

The present use case aims at improving the way in which Training Management can work towards this goal. More in detail, on how to better mediate among domains by reusing or integrating knowledge that results from competency management activities for training selection. Thus, it can be stated that the ultimate mission of Training management is to support Competency management.

In the following, a brief depiction of the main aspects of the use case is presented. Such depiction helps elaborating about the benefits of a Semantic Web-based approach to e-Learning, same for the particular Aeronautical scenario presented as for learning activities in general.

2.1 Actors and roles

Several actors participate in training management processes:

1. **Training Manager** from the Human Resource Training Department. The Training Manager takes responsibility for managing training plans according to the business strategy, as well as training budgets and requests.
2. **Employees**, including Engineers and their Team Managers. They are the originators of training requests.
3. **Training organisms** provide the training offer, including training materials and courses.

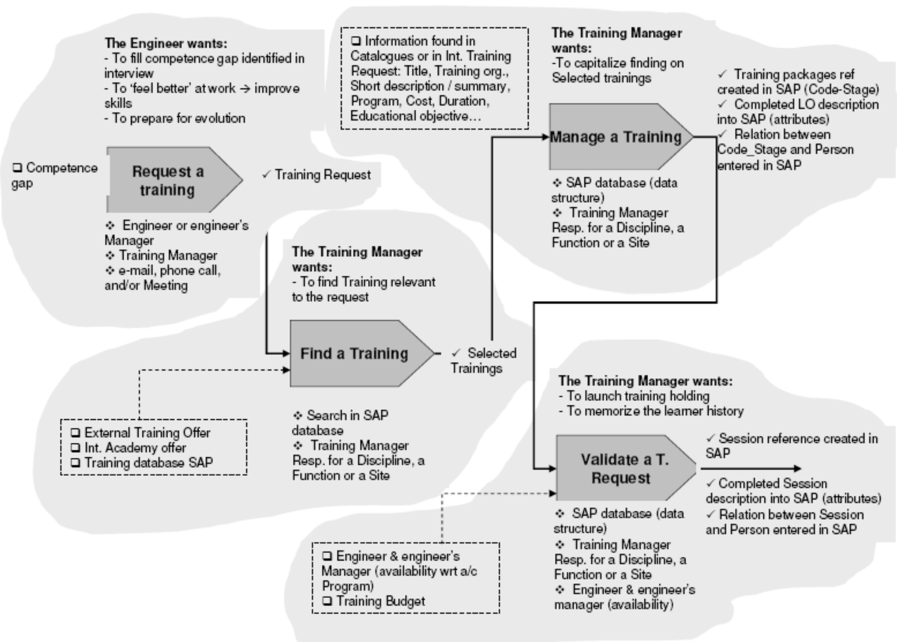

Figure 7-1. Main training processes

In the following section the particularities of the use case are briefly depicted. Figure 7-1 provides an overall view of the main elements in the training management process. The concept of competency can be used in such processes as the language for expressing needs, match learning resources, record the employee profile and measure the effectiveness of the training activities.

2.2 Training related information objects

The HR Training Department activity uses and produces various training related information. In the following, the different categories of information objects of interest for the use case are presented.

Structured Training Packages. HR manages some LO references and description in an SAP database. The granularity level under consideration is that of Structured Training Packages (Naeve et al 2005).

Core training catalogue. Metadata elements are used for publishing purposes. Web training catalogues are rendered accessible through the various subsidiary companies' intranets. These training catalogues are online abstracts of the real SAP database.

People training history. SAP database also allows the management of the people Training History. Human Resources keep track of requested, planned, rejected, accepted or completed training sessions for every Employee. Thus, it is possible to know about the training sessions followed by a given Employee or about the status of a given Training Request.

All these materials are currently stored in databases and independently maintained. A topic hierarchy (See Figure 7-2) is used to filter accesses to the SAP training database. By this means, specialized training engineers benefit for an accurate information access and are made responsible for such or such topics. It is also used to structure the display of the web training catalogue on the intranet.

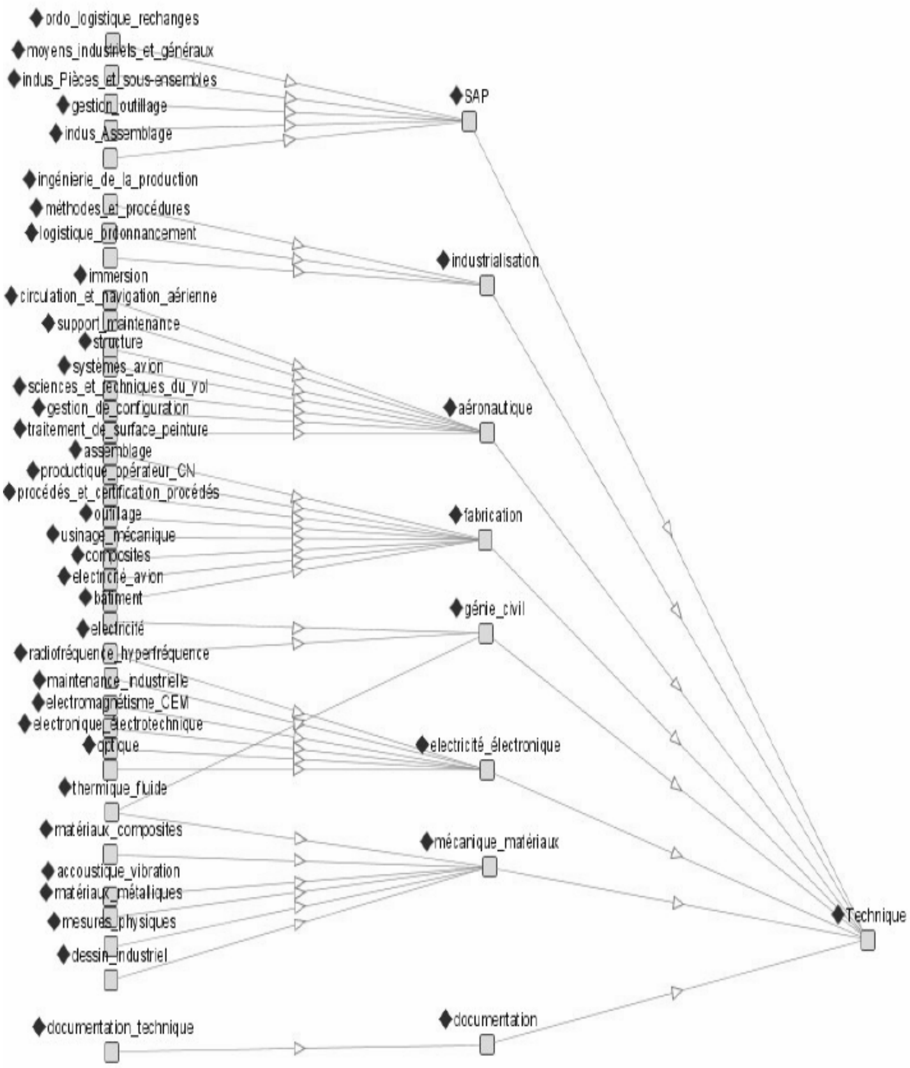

Figure 7-2. Training Topic thesaurus (excerpt)

Training packages can be assimilated to a very specific kind of learning objects, and in consequence, they can be annotated with the competencies that are the expected outcomes of the training. This is already considered in the IEEE LOM learning object metadata standard (in which classifications of learning objects may state competencies) and thus provide room for describing the resources in terms of complex models or ontologies of competencies.

2.3 Training requests

The employees' training requests are addressed to the Training Manager. Two different cases are considered when it comes to deal with training requests:

Individual training request: It involves an Engineer who wants to follow a particular training or express 'informal' need.

Competency driven training request: The request is a result of an annual interview between an Engineer and her/his Team Manager. This interview results in the Engineer competency profile update, and an agreement on associated training needs.

The training history serves as a way to encode the competency record of employees, so that competency driven requests can use that information as input. This step can be supported by the use of ontologies of competencies, which can be used to "suggest" possible paths of competency acquisition and the associated resources/activities that could be used in each of them. After the eventual completion of the activities, their effectiveness can be used as input for future learning activities, thus closing the loop.

2.4 Competency index and profiles

Competency management, although in the sphere of Human Resources, is a parallel process generating its own information flow and data. The categories of information objects related to competency management are presented below:

Reference competency index: Lists competencies, skills and knowledge involved in professions needed by the organization;

Position profile: Resorts to the reference index to define scaled required competencies and skills at a given position. Several positions may come under the scope of a same reference profession, while requiring different proficiency levels.

Personal profile: Resorts to the reference index to define scaled actual competencies and skills of a person holding the given position.

The use case intends to make them reusable for training retrieval and selection, allowing the calculation of a competency gap between a target position profile and an employee profile. Thus, job positions serve as stereotyped models of competency aggregations.

2.5 Viability and benefits

As shown above, various data and systems are involved in answering training requests taking in account the needed and available competencies. Resorting to Semantic Web-services for the selection and combination of training courses requires that:

The training search function supports selection/combination and allows taking a competency gap description as criteria. This means:
- Handling queries with various concepts (competencies, professions, topics, etc.) from separated data sources: training database or other LCMS, (training history), profession competency index, etc.
- Handling position profiles and employee profiles to build competency gaps.
- Handling competency profiles and using them as criteria for selecting trainings.
- Handling LO target competency or pre-requisite and use them as criteria for combining trainings.

LO-based training descriptions include competencies. The key point towards context-aware learning object delivery in the aeronautical context is that both, trainings goals and pre-requisites must be described in terms of competencies. This is where a different problem occurs, related to the cost of manual annotation in time and resources, especially when the training database is continuously evolving to reflect updated offers.

A unified model applicable to the Training management and Competency management domains supports the indexing of Training Packages using Profession / competency referential; and the retrieval / selection / combination services over Training Packages.

Ontologies of competencies (Monceaux and Guss 2006) provide a rich description framework for the selection of resources, which can be extended with a organizational process view as that described in (Naeve and Sicilia 2006). The benefits in terms of increased decision support are evident from the above, and the organization could also benefit from the systematic approach to defining competencies required. However, an assessment of the viability also requires reflection on the technological challenges required. These entail the storage of competency databases and the development of query resolvers that handle the abovementioned elements. The results of the LUIS project provide the framework for these issues. In consequence, organizations that do actually have a “competency culture” can benefit from semantic technology directly, since the requirements on management and recording of competencies are currently covered by non-semantic technology, perhaps with the exception of some practices as the formal annotation of learning resources with a statement of the competencies they are intended to provide. This is thus a case of technological enhancement on existing practices.

3. THE OVERALL PROCESS VIEW: A COMPETENCY GAP APPROACH

In a service-oriented environment that aims for reusability of service components, the “process-object” – or “process-module” is of vital importance. In this section we will discuss how such process modules can be used as contextual units, e.g., connecting learning objects with learning objectives and competency gaps. Moreover, we will show how such process modules can be connected into service networks, whose overall service goals can be seen as aggregated from and composed of the sub-goals of the participating process modules.

3.1 The Astrakan™ process modelling technique

The basic ideas underlying the Astrakan™ process modelling technique[30] are depicted in Figure 7-3.

[30] www.astrakan.se

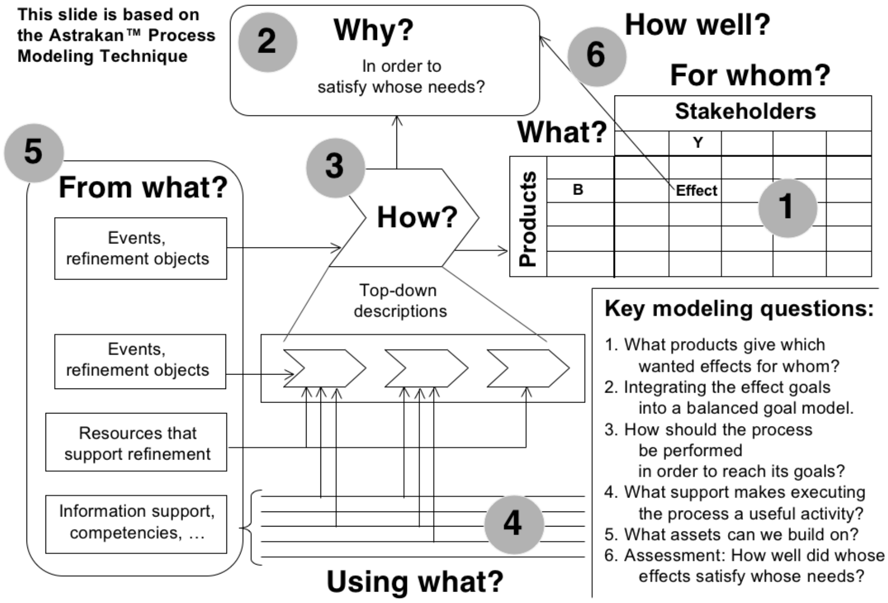

Figure 7-3. The Astrakan process modelling technique

A *Process Module* has certain *Process Goals*, produces *Output Resources* for different Stakeholders, refines *Input Resources* and makes use of Supporting Resources (Figure 7-4). The difference between an input- and a supporting resource is that the former is refined in the process, while the latter facilitates this refinement.

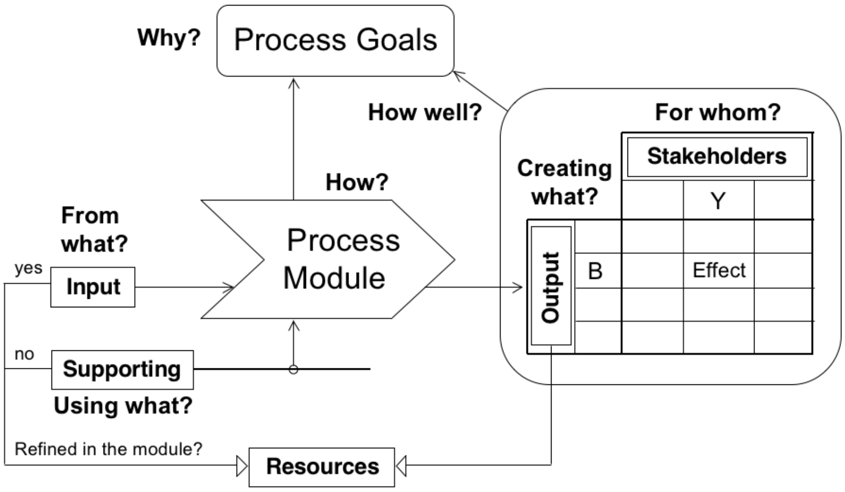

Figure 7-4. A Process Module with its Goals, and its Input-, Output-, and Supporting Resources

Figure 7-5 depicts a kind of (= subclass of) Process Module, called a *Learning Process Module (LPM)* with its corresponding *Learning (Process) Goals*, and its *Input*-, *Output*-, and *Supporting Learning Resources*.

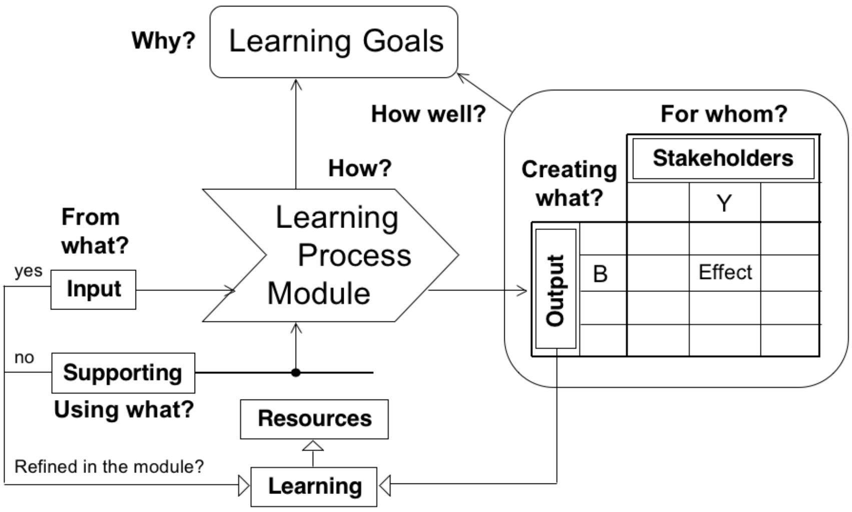

Figure 7-5. A Learning Process Module with its Learning Goals, and its Input-, Output-, and Supporting Learning Resources

Observe that, in Figure 7-5, the Learning Process Module (LPMs) provides the crucial connections between Learning Resources (LRs), which include so called Learning Objects (LOs)[31], and Learning Goals (LGs). Hence, it becomes possible to describe why we are using certain LO in a particular LPM, i.e. what pedagogical aspects that we are trying to support and what LGs that we are trying to achieve. Apart from the never-ending debate about their definition, a major criticism against LOs is that they are too often considered in isolation from the learning context within which they are supposed to be used. Hence it becomes difficult to connect LOs with the social and pedagogical dimensions of the learning process, and answer the crucial pedagogical/didactical questions of why LOs are being used and what one is trying to achieve by using them. By applying the modeling techniques introduced in (Naeve et al. 2005) and elaborated in (Naeve and Sicilia 2006), such questions can be answered in a satisfactory way.

3.2 Different types of Competency Gaps

Since individual competencies are refined and developed by learning, they can be considered as input and output data to learning processes. In fact, each Learning Process Module (LPM) can be considered as filling a Real Competency Gap (RCG), which is the difference between the *Input Competency (IC)*, i.e., what the learner knows before entering the LPM, and the *Output Competency (OC)*, i.e., what (s)he knows after having passed through it. The Formal *Competency Gap (FCG)* is the difference (as specified e.g., in a course manual) between the *Pre-Requisite Competency (PreRC)*, which is required to enter the LPM, and the Post-Requisite Competency (PostRC), which is the competency that the LPM aims to provide for learners that fulfill its corresponding PreRC.

In Figure 7-6, the ICs and OCs are modeled as a kind of Learning Resources, while PreRCs and PostRCs are modeled as a kind of *Learning Goals*. *Pre-assessment* can be used to investigate whether there is a Pre *Competency Gap (PreCG)*, i.e. whether there is a difference between what a learner knows when entering the LPM, and what (s)he should have known in order to enter it. Post-assessment can be used to investigate if the learner has actually acquired the aspired PostRC. If not, then there is a *Post Competency Gap (PostCG)*, i.e., there is a difference between the PostRC and the actual OC for this learner. If there was no PreCG, then we can conclude that something went wrong in this LPM.32

[31] As well as other types of resources, such as human resources and physical resources (materials, tools, laboratories, etc.)

[32] This is analogous to a software principle called "design-by-contract", where only data that satisfies the pre-conditions are allowed to enter a software module. If the post-conditions are not fulfilled, then we can conclude that something went wrong in this module.

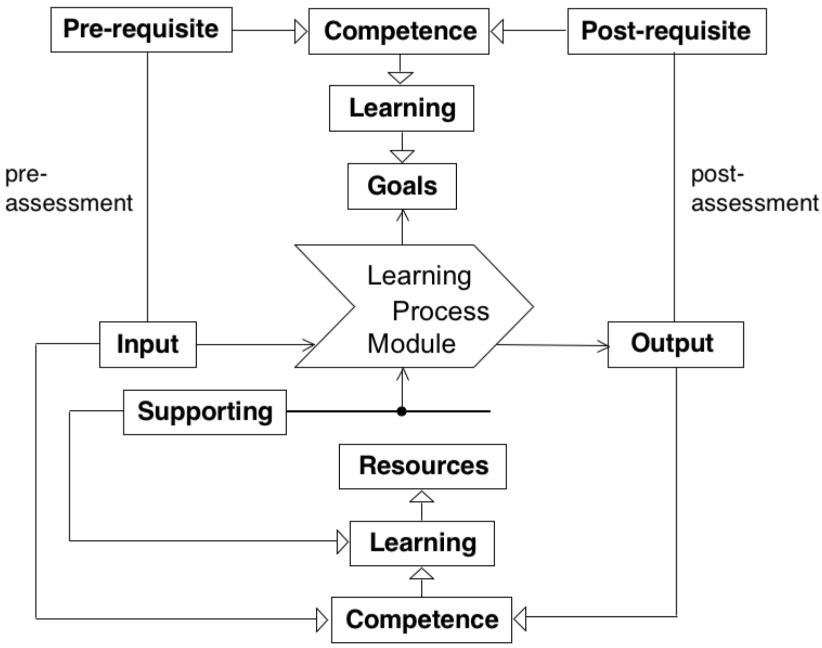

Figure 7-6. A Learning Process Module with a Formal and a Real Competency Gap

A *Forward Competency Gap (FCG)* is a difference between what the learner knows and what (s)he plans to know, while a *Backward Competency Gap (BCG)* is a difference between what the learner knows and what (s)he should have known. Hence, with respect to an LPM, a BCG is identical to a PreCG.

In the EADS use case, the difference between an employee's *Personal Profile* and her/his *Present Position Profile* is her/his BCG. The difference between the employee's *Personal Profile* and her/his *Desired Position Profile* is her/his FCG.

In general, FCGs are more associated with strategic learning needs (what a company needs to learn in order to stay in business), while BCGs are more associated with operational learning needs (what a company needs to know in order to deliver in its present undertakings). BCGs often appear because employees leave the company and have to be replaced by others who do not quite know what they (ideally) should have known in order to serve as good replacements.

3.3 Competencies as Connectors of Learning Process Modules

A Learning Process (LP) can be modelled as a chain of successive LPMs, where the PostRC of the LPM_k is identified with the PreRC of the LPM_{k+1}. In this way, the large learning goal of the entire LP can be broken down into a sequence of smaller learning (sub)goals for each LPM. This map well to the concepts of goals and sub-goals in WSMO, where there are gg-mediators, use to meditate mediate between goals.

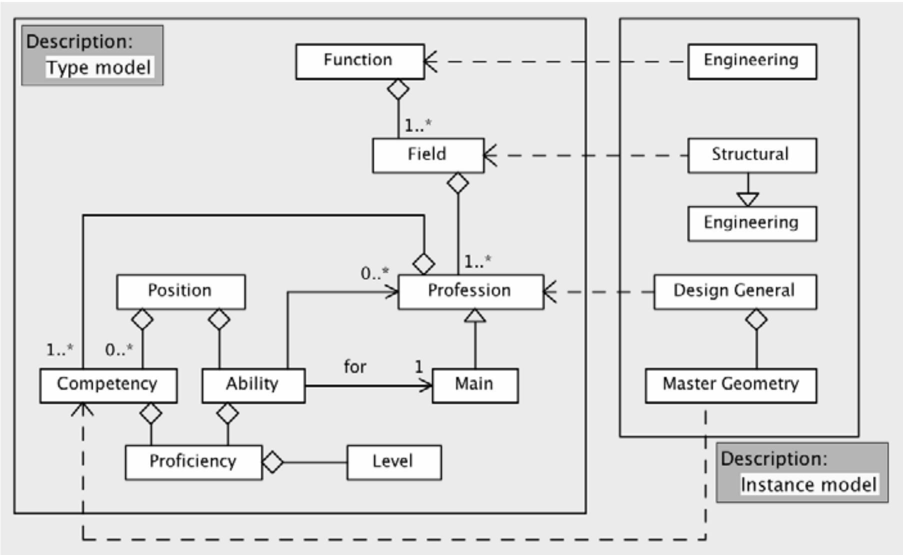

Figure 7-7. The EADS employee competency model

3.4 Modeling with a general competency ontology

Reuse-oriented learning technology emphasizes the role of metadata that describes the properties of learning resources as a mean to provide advanced support for the location and selection of learning resources. These properties are of a various kind, but one of its principal categories is that of describing the *learning needs* the resource facilitates in some way. In semantic approaches to learning technology, ontologies that enable the description of learning needs are thus a critical piece. Learning needs can be stated in many different ways and can be considered to be dependant on theories of learning to some extent. Among them, the concept of *competency* emphasizes the specification of external, observable behavior oriented to performance in activities. In organizational contexts, this entails that competencies are oriented to describe performance in concrete work situations.

The literature on formalizing competencies to date is scarce and fragmentary, and specifications dealing with competencies as *HrXML-Competencies*[33] or *RCDEO*[34], while useful for data interchange, do not provide the required computational semantics. A general purpose schema for competencies (call GCO –General Competency Ontology –) based on the schema describe in (Sicilia, 2005) has been approached in an attempt to increase the re-usability and flexibility of the resulting technologies.

3.5 Addressing flexibility in the definition of the competency concept

Flexibility in competency specification is currently approached in the ontology in two ways. On the one hand, a competency definition is made up of competency elements, and competency elements are specialized in several components (skills, attitudes and knowledge elements in actual version), allowing for the inclusion of other elements in the future. On the other hand, current schema allow for incomplete definitions of competencies. A competency is completely defined if it is explicitly indicated as such, and this entails that the presence for an individual of all the elements that compose the competency is a necessary and sufficient condition to describe the competency. A competency can be partially defined if it is defined as a primitive competency (i.e. its elements are not defined) or if the described components do not define the competency completely.

See the following example (Figure 7-9): The competency "Programming Java with Eclipse" is composed by two knowledge elements "To know Eclipse environment" and "Programming Java". The competency has been explicitly defined as a *completely defined competency*. If a person P1 has acquired both knowledge elements, a reasoner can deduce that this person has the competency "Programming Java with Eclipse", although it is not expressly stated.

The general competency model described in this section is used in the architecture of the LUISA project[35]. Figure 7-8 depicts an scenario inside LUISA, in which a search component talks to the Negotiation Layer (a part of the SWS infrastructure) to get matches for some given competency gap. The resources are stored in (one or several) LOMR (learning object metadata

[33] http://www.hr-xml.org
[34] http://www.imsproject.org/competencies/
[35] http://www.luisa-project.eu

repositories), and the metadata in such repositories can be edited through SHAME tools[36].

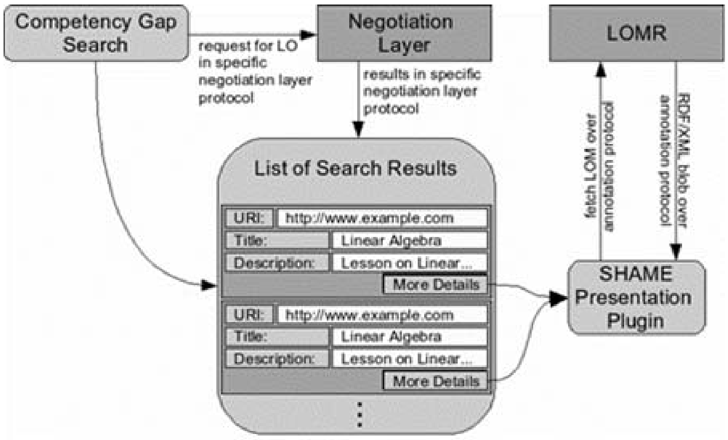

Figure 7-8. Scenario from the LUISA architecture

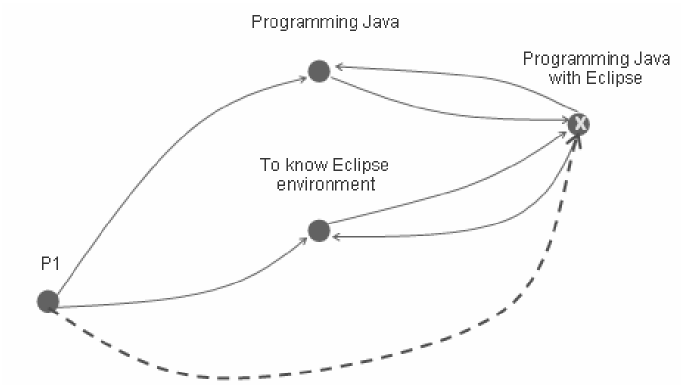

Figure 7-9. Example of completely defined competency

3.6 Competency Components

One important issue to deal with in the ontology refers to the need of separate actual competencies, associated to particular individuals, and the definition of competencies as stereotypes. Given that the *Competency* concept represents a discrete competency of an individual generally

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[36] http://kmr.nada.kth.se/shame/

portrayed as processors. Such processor provides room for software systems that are able to exhibit some competencies.

On top of that, the elements influencing competencies are of a various kinds, including *knowledge*, *skills*, *abilities*, and also *attitudes*. By using these concepts a clear separation about three types of traits that represent different aspects of competency is clearly achieved.

For example, an employee may have the knowledge about the different phases of a given internal process, since he or she has attended trainings about it. This is different than having the skill of implementing the process correctly. In fact, the knowledge about the internals of the process may not be necessary for its proper usage, and on the contrary, knowing the internals does not guarantee that the employee is able to use the process efficiently. In addition to that, attitudes represent elements that are not necessarily connected to specific knowledge or skills. For example, having good influencing skills does not always entail that an employee would have the attitude to make his/her opinion prevail. Figure 7-7 provides a screenshot of the modeling of EADS competency ontology. In that case, the terminology was slightly different, but after a mapping phase, they were assimilated to similar concepts in the GCO.

It should be noted that from an ontological perspective, attitudes are mostly domain independent, while knowledge items and skills are not. Examples are “service orientation” or “attentive to details” attitudes that are equally applicable to employees, irrespective of the industry. Some skills are also of a generic nature, like “social aptitude” or “leadership,” but many others refer to concrete elements or artifacts that are specific of the industry. Typical examples are “PHP programming skill,” “Unix administration,” “repairing Aston Martin engines,” and the like.

The part of the current version of the ontology that models competencies and competencies definitions is depicted in Figure 7-10. For the sake of clarity, not all the ontology properties are shown.

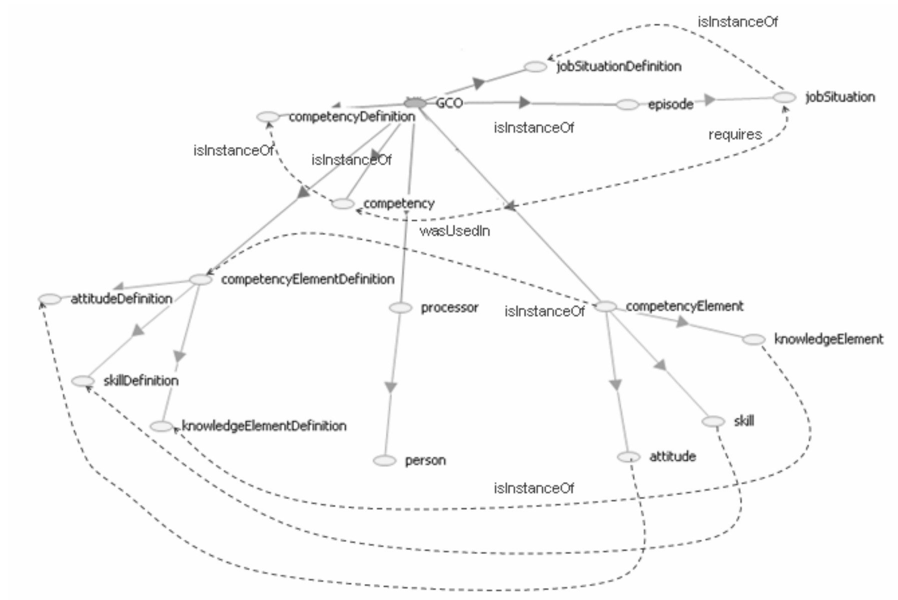

Figure 7-10. Partial graphical view of the ontology: Competencies and Competencies definition.

3.7 Work situations

Competencies are put into play in concrete job situations, which can be considered as a kind of *Episode* in the life of the organization that occurs at a concrete moment in time. The *consequence* attribute in the concept *JobSituation* simply represents the outcome of the episode, which can be used as a source of assessment for various purposes, including the revision of the beliefs the system has about the competencies of the participants.

Competencies and job situations are connected to their respective "definition" elements. These definitions are used to represent stereotypical competencies and job contexts, so that they can be used to describe, for example, job position characterizations in human resource selection processes, or as a way to state the needs of a project.

Each job situation definition requires a number of competencies as defined in *CompetencyDefinitions*. This is a way to describe work situations in terms of required competencies.

Figure 7-11 briefly depicts work situations in the current version of the ontology.

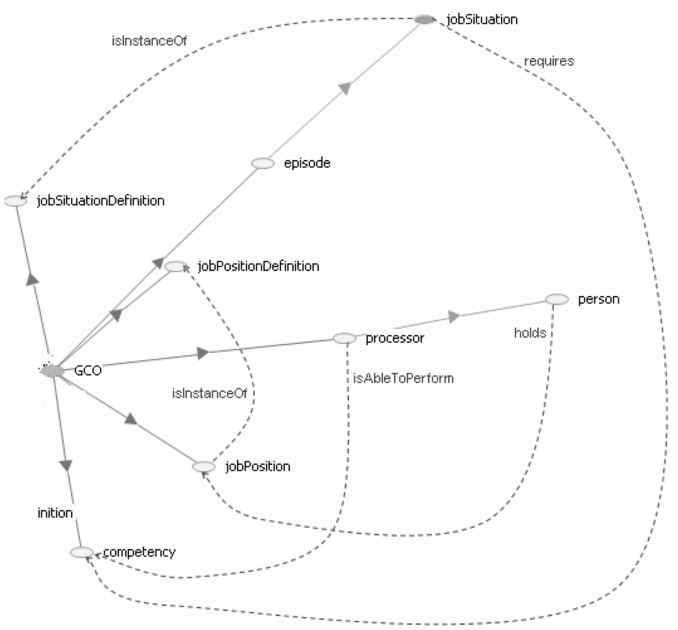

Figure 7-11. Partial graphical view of the ontology: Work situations

3.8 Relationships between Competency Specifications

Competency specifications are implicitly related by the relationships among competency components. For example, if a competency c1 is considered to require some knowledge k1 then, the competency implicitly requires the knowledge of any k1 pre-requisite knowledge. This is represented through the *prerequisite* relationship (knowledge trees can be modeled this way). Skills can also have knowledge elements as prerequisites, and they could be considered to be composite (not in that version of the ontology).

Relationships between competencies can be of a diverse kind. Initially, we only deal with *prerequisite* and *details* relationships here. The latter is conceived as a form of "specialization" in the sense that a competency provides a more detailed description to an existing one. For example, "Administering Oracle databases in large installations" stays at a higher degree of abstraction than "Administering Oracle 9.0 databases in large installations." The specialized competency usually requires more specific knowledge elements. Both the "prerequisite" and "details" relationships entail some form of prerequisition, but the semantics are not exactly the same. For example, the *C1 ≡ "relational database design"* competency is a prerequisite for *C2 ≡ "Administering distributed Oracle databases in large installations"*, but it is not a detail, since it reflects only a previous component of knowledge. In other words, the competency C2 cannot be considered as a specific kind of competency C1.

Some other simple competency relationships are *equalTo* and *similarTo*. The former is a simple way to state that two competencies are the same, while the latter is a way to express different strengths of correlation or resemblance between competencies.

Figure 7-12 depicts relationships between competencies in the current version of the ontology.

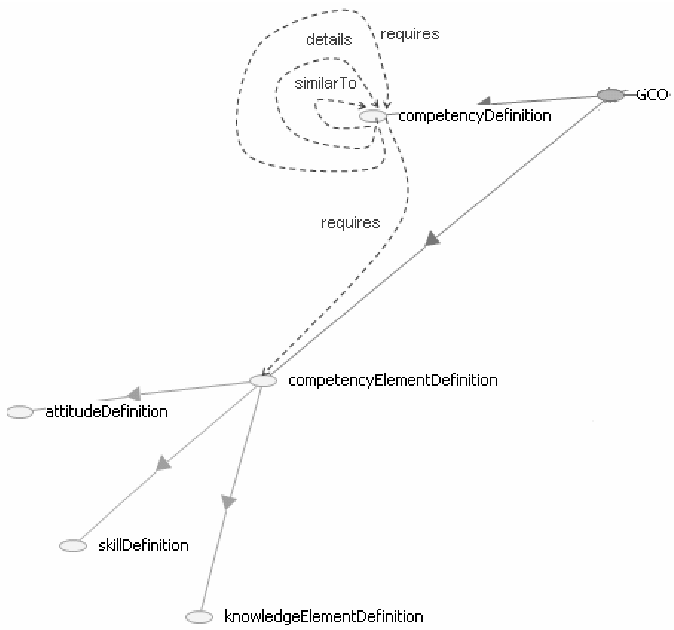

Figure 7-12. Partial graphical view of the ontology: Relationships between competencies

3.9 Defining Competency measurement scales

Measurement scales for competencies can also be of a diverse nature. Although the development of simple integer scales is common, other kind of scales could also be allowed. In the ontology, a Measurement is connected to competencies as an elaboration of the simple Level attribute of the *Competency* concept in Figure 7-12. Measurements are always related to a given *MeasurementScale*, and usually some *MeasurementInstruments* associated to such scales are available (e.g., questionnaires or interviews). From this basic level, several types of scales and their associated measurements can be defined. Specific scales can be defined as an instance of *IntegerMeasurementScale*. Each scale must provide some definitions that act as constraints on the description of the measurements.

In the ontology, a *JobPosition* is described in terms of competency definitions by specifying a given *MeasurementLevel*, connected to the scale in which the level is expressed. This is an example of how other elements different from processors can be described using the ontology. The elements in current version of the ontology could be complemented with other ontology terms that better describe each measurement instrument, and also with "conversions" from one scale to another, when available.

Figure 7-13 depicts the part of the current ontology that represents measures. For the sake of clarity, properties have not been labeled.

4. ARCHITECTURAL SOLUTION

In the following the architectural solution provided is putting in the context of the use of competencies. Firstly, the LUISA architecture is presented. Secondly, how it is applied to computing competency gaps is sketched. Finally, the particularities on how it tackles the use of training resources by means of a specialized *QueryResolver* are carefully depicted.

4.1 The LUISA Architecture

Currently, the LUISA includes the following core building blocks that are directly related to the competency approach:

Competency Gap Search: It provides the means for finding competencies and filling the competency gap. In short, given a target position and the employee profile, the competency gap search takes care of calculating the competency gap, requesting LO using a specific negotiation layer protocol and finding an appropriate set of learning objects that can in principle fill the competency gap.

Negotiation Layer: The negotiation layer fulfils a two-fold purpose. It receives requests for LO expressed using the specific negotiation protocol. It also takes care of providing the results of a particular competency gap search. This layer is an interface for the WSMO-based SWS layer that integrates heterogeneous sources of LO by means of semantic description of conventional Web Services.

SHAME: Taking as input the results of a competency gap search the SHAME plug-in takes care of presenting them as appropriate. In order to obtain all the necessary metadata it closely communicates with the LOMR module.

LOMR: The LOMR receives LOM metadata from the SHAME plug-in. Additionally, it provides SHAME with RDF/XML blobs, also using the same annotation protocol for its presentation.

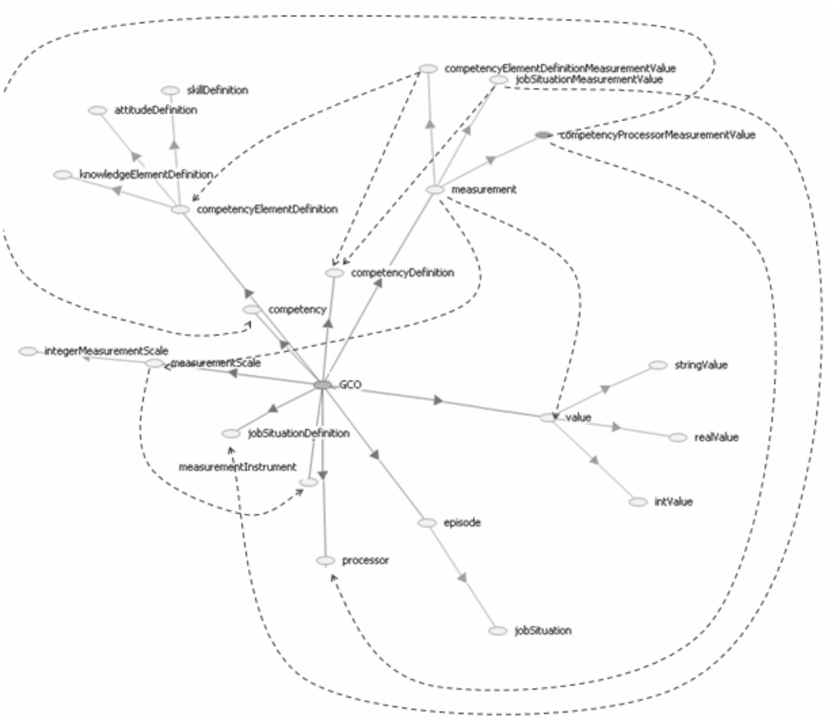

Figure 7-13. Partial graphical view of the ontology: Measurements in ontologies

4.1.1 Computing competency gaps

Competency gaps are calculated by subtracting the training requirements from a particular target position from trainings already attended by a given employee as detailed on his profile. As a result a collection of metadata that needs to be mapped to learning objects descriptions is produced. Once such process has been achieved, it is the task of the negotiation layer to locate the most appropriate set of learning objects for filling the competency gap. Should that matching set of LOs be available, the competency gap, is indeed filled. Of course this is only one of the many possible competency gap analyzers that could be devised, but it serves as the ground for the future integration of other, perhaps more complex, analysis schemes.

4.1.2 Targeting training resources through an specialized QueryResolver

One of the main tasks of the specialized *QueryResolver* is to manage queries that affect multiple data sources. In short, it takes care of consolidating the results obtained from training repositories, training histories, LCMS or any other that needs to be checked in order to bridge a competency gap. Additionally, it provides indexing capabilities for easing and speeding the combination and location of materials. The idea of having a *QueryResolver* for gap analysis enables the design of several of these components that could be “pluggable” inside the LUISA architecture.

5. CONCLUSIONS

Competencies represent a paradigm of observable workplace behaviour that can be represented in terms of ontologies. These ontologies can be used for the expression of learning needs, and also for the expression of the expected outcomes of these activities. This creates a link between needs and resources that can be exploited for advanced targeting capabilities. A concrete case of organizational learning has been described, followed by a general conceptual model that details how competencies and learning resources can be mapped in a process-oriented framework. Competencies provide the organizational meaning to learning resources, and they can be used as input and outputs in learning process models. Finally, the results of project LUISA have been described as a technical solution using Semantic Web Service technology that uses a given, flexible and generic competency schema. The LUISA solution provides the required semantic technology to fulfil the needs of competency-centric approaches to organizational learning of any arbitrary complexity.

6. QUESTIONS FOR DISCUSSION

Beginner:

1. Competencies are a model of observable human behavior that is widely used in the literature about organizational learning. However, the term “competency” (plural *competencies*) is used in the literature with different meanings. The GCO model presented in this paper provides a flexible definition of competencies but other ways of referring to the same things can be found. The following questions are oriented to:

It is common in the literature on theories of learning to refer to concepts as declarative knowledge, procedural knowledge and values as related to learning. How these three terms relate to the competency elements skills, knowledge items and attitudes?

The O*Net database[37], containing information on hundreds of standardized and occupation-specific descriptors. They include the concept of "skill". How does the O*Net concept of skill related to the GCO described in the chapter? And how the rest of the concepts in O*Net map to the GCO?

2. The key ingredient of competency-based approaches is a correct understanding of what competencies, their components and their relationships are. This is an understanding and analysis phase that requires reflection on how competencies are defined and measured inside the organization.

Intermediate:

1. Expressing organizational needs in terms of competencies requires some kind of forecasting or at least a consideration of the requirements for the short terms regarding the capacity of the employees. The competency gap then expresses the competencies (or competency components) currently not available among the employees, and then the process of matching and targeting learning resources (learning objects) takes the gap and attempts to select the best learning activities/contents that can be used to facilitate the learning process that eventually might result in the required increased human capacity. However, this process is not as simple at seems at first glance, and many issues that require the use of complex models – as those that can be expressed in terms of ontologies – demand attention. The following questions are oriented to reflect on some of these issues:

   How can learning resources be described to facilitate search in terms of competencies?

   Once learning activities have been programmed and carried out by the target employees, there is a need to evaluate the acquisition of the required knowledge. How does this impact the assessment of the learning resources for future learning programs?

   How can the agenda and constraints of the employees be taken into account in the delivery of the learning activities resulting from a competency gap analysis process?

2. Learning object metadata in semantic form is an alternative for resolving question (1) – some answers can be found in (Sicilia, 2006). Question (2) points out to the possibility of using the evaluation of the activities to rate

[37] http://www.onetcenter.org/

in some way the learning resources used, so that those that have effectively facilitated the required learning are considered best, and those that have not can be considered to be discarded or improved. Question (3) introduces the complex issues of time planning. Gap analysis can be combined with temporal (or spatial) constraints for a more informed way of targeting learning activities inside an organization.

Advanced:

1. There is not a single, universal approach for computing competency gaps from a given record of competencies. This is among other factors because the relationships between competencies can be of very different natures; there is not a universal method to assess competencies and competencies can be described at different levels of granularity. In consequence, competency ontologies as the GCO described in the chapter are "upper models" or general schemas that can be used and extended in several directions. The following questions pose some of the issues that could be considered for concrete applications.
   How can competencies be measured for particular employees? Since competencies are related to workplace performance, which type of methods are more reliable? Peer assessment might be one of them?
   How can competency components be aggregated into composite competencies? What is the difference between dependencies between competencies and competency components? What are the implications of these kind of issues for computing competency gaps?
   When considering a concrete organizational need expressed in terms of competencies, the matching process should require an exact mix of competencies? In other words, if some employee possess competency level 3 for competency X and the requirement is a level of four, could this be compensated, for example, by an "excess" in other of the required competencies?

All these questions are actually research questions and they do not have a unique answer. Many different approaches can be devised considering variants of the algorithms of gap analysis and/or tailored models of competencies. This is essentially the approach of the LUISA project, different *QueryResolvers* can be used to implement different (perhaps competing) approaches, creating opportunities for contrast and customization.

7. SUGGESTED READINGS

The recent book on competencies in organizational e-learning edited by Sicilia (2006) provides a selection of chapters about the competency approach for organizational learning. It includes chapters on the key organizational dimension, but also several chapters that describe concrete applications of Semantic Web technologies to managing competencies. As such, it is an excellent complement to the approach described in this chapter.

The description of learning resources can be accomplished through metadata. Standards and specifications regarding different aspects of learning-oriented metadata are introduced in Friesen (2005). After a basic understanding of the specifications mentioned by Friesen is achieves, it is worthwhile to go through some papers that deal with the extension of such standards with Semantic Web technology. Many examples can be found in the "Applications of Semantic Web technologies for e-Learning" (SW-EL) workshop series[38], and Sicilia and García-Barriocanal (2005) can be used for a general understanding of the issues behind those approaches.

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