USING SEMANTIC TECHNOLOGIES AND CASE BASED REASONING TO SUPPORT COURSE CURRICULUM DESIGN TASKS

Javier Vaquero, Carlos Toro
VICOMTech Research Centre, Mikeletegi Pasalekua 57, 20009 San Sebastian, Spain
jvaquero@vicomtech.org, ctoro@vicomtech.org

Ricardo Ferrería, Josune Prieto
MIK, Mondragon Unibertsitatea, Onati, Spain
ferreria @mik.es, prieto@mik.es

Nieves Alcain, Jesús Rosel
Alecop, Arrasate, Spain
nalcain@alecop.es, jrosel@alecop.es

Mar Segura
Department of Computer Science, University of the Basque Country, San Sebastian, Spain
mar.segura @ehu.es

Keywords: CBR, Ontologies, Course Design, Knowledge Based Systems.

Abstract: This paper presents a novel approach to Course Curriculum Design (CCD) where Semantic Technologies and Case Based Reasoning (CBR) techniques are used to assure *(i)* a better understanding of the course being designed and *(ii)* an efficient use of the available resources. Our work focuses on re-utilization of previously modelled information (courses, tasks, evaluations, etc.) in order to maximize the efficiency of the Course Design process while at the same time embedding implicit and experential knowledge of the course designers. Our approach is presented through an easy to follow architecture that can be adapted to course curriculum regulations of most European and American models. As a test case, we present an implementation for a Spanish technician-level telecommunications course, to demonstrate the benefits of our proposal.

1 INTRODUCTION

A good teaching process should provide the student with the highest possible quality. It can be argued that such quality, is strongly related to the best use of the available resources, the proper design of the subjects and evaluations, and generally, in the design of the courses and course components which are part of the education process (Högskoleverket, 2008).

For the aforementioned reason, the importance of course/curriculum design is gaining interest for teachers, education centres and researchers.

It has been reported, that in the present situation (Rubio Oca, 2006) many curriculum designs do not met requeriments, due to different factors, e.g. the evolution of technical tools used when the original design took place. This fact can lead to problems in technical adaptation. In many cases the lack of effective adaptation to the actual situation in curriculum plans generates a situation where students are not sufficiently qualified for industry, implying longer adaptation times when they become workers.

Typically, a course design starts with the definition of competences. In other words, the objectives that must be met at the end of the course cycle. Diamond (Diamond, 1998) points that educators need to clearly identify goals prior to any kind of course assessment. In our case, those goals are indistinguishable to what we understand as a competence evaluation. Based on the competences the course designer builds the content, and later, the evaluations, producing an output for the students to follow (a process known as CCD).

Whitin our scope, we have found that CCD presents several challenges, the following being the most interesting from a computational perspective:

- Course Curriculum Designers have differing points of view, which lead to a non-homogenized, case curriculum.
- The re-use of knowledge and prior user experiences is not included in the approach.
- Every country has its own course design legislation. Successful experiences in one country cannot be easily applied to another.

For these reasons, a computerized system that aids the competences based CCD is required. We address this need by presenting a novel approach in where Semantic techniques are combined with a Case Based Reasoning (CBR) schema in order to enhance the precision of the system.

This paper is structured as follows: In chapter 2, we present an overview of related concepts. In chapter 3, we introduce our proposed schema using Semantic technologies and CBR. In chapter 4, we describe a case study, briefly explaining key points. Finally in chapter 5, we draw conclusions and suggest future work.

2 RELATED CONCEPTS

In this chapter, we introduce some concepts relevant to our work. Our intention is not to provide a comprehensive description of the topics involved, but to give a short overview. An interested reader is invited to review (Fallon and Brown, 2003), (Noy and McGuiness, 2001), (Aamodt and Plaza, 1994).

2.1 Educational Contents Modelling

e-Learning is defined as "any learning, training or education that is facilitated by the use of well-known and proven computer technologies, specifically networks based on Internet technology" (Fallon and Brown, 2003).

An important part of the e-Learning process involves the educational platform. The actual situation involves propriety design platforms with their own contents, making interoperability and interaction between models in use by different institutions a difficult and considerable task. The re-use of previous content presents further difficulty and expense. To rectify this situation, metadata-based educational standards have been developed.

We believe that important information can be rendered invalid, or not to be taken into account. Such information is not directly stored in databases, and is closely approximated to what we understand as 'user experience'

2.2 Semantic Technologies

In this work, we use ontology modelling for its inference capabilities and to support our architecture from a knowledge engineering point of view.

There are many possible definitions to describe what ontology is. In the Computer Science domain, the widely accepted definition states that "an ontology, is the explicit specification of a conceptualization" (Gruber, 1995), or in other words an ontology is a description of the concepts and relationships in a domain of study.

The main characteristic of an ontology based solution is its capacity to semantically infer newly derived information. Such information is not explicitly specified by the user and in order to obtain it modern inference engines and reasoners, like Racer or Pellet (Sirin et al., 2007), are used.

2.3 Case Based Reasoning

CBR is a problem solving technique based on two tenets: (*i*) the world is regular, so similar problems have similar solutions, and (*ii*) types of problems an agent encounters tend to reoccur (Leake, 1996).

CBR does not use generalized rules as a knowledge source, but a memory of stored cases recording specific prior episodes (Leake, 1996). New solutions are generated by retrieving the most relevant cases from memory and adapting them to fit new situations.

We believe that by mixing CBR and Semantic technologies the strong points of both techniques can be leveraged to the users advantage

3 PROPOSED SCHEMA

In this work we propose an open and extensible architecture that combines Semantic and CBR techniques to enhance the CCD process.

Our architecture is divided in five layers (see Figure 1): (*i*) the *User Layer*, (*ii*) the *Knowledge Layer*, (*iii*) the *Experience Layer*, (*iv*) the *Information Layer* and (*v*) the *Data Layer*.

From bottom up, the fist layer is the *Data Layer*. This layer contains the data repositories that define the different CCD conforming elements (e.g. objectives, competences, courses, etc). The components of the *Data Layer* are not necessarily standardized; they are just bits of data that can be used for a CCD.

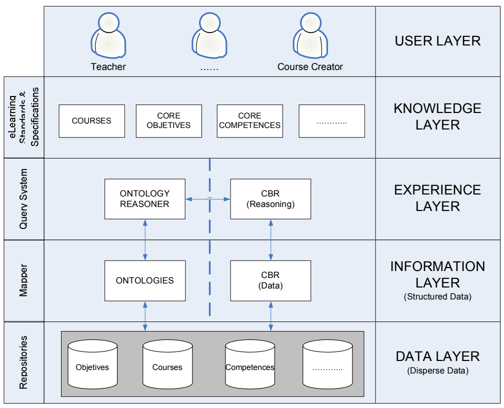

Figure 1: Architecture.

The *Information Layer* (above) contains two parts, (*i*) the ontologies and (*ii*) the CBRs.

The ontologies are constructed using a domain model that can be fed from the *Data Layer*. This means that these domain ontologies build their individuals upon the data available in the first layer.

The CBRs are the second component of this layer and they are a set of Case Systems (rules) that use the data of the first layer as a feed.

It is interesting to note that the available data is not necessarily used in both components and moreover that some data collected is resultless (revealing an opportunity for data model reduction). At this level it can be argued that the data has become usable information.

To convert the data into information a mapping tool is needed. Such a mapping tool is implemented based on the requirements of the domain model and the CBR and it must be implemented inside both components in a semi-automatic framework where possible.

The information produced enters the *Experience Layer* through a query system. Such a system performs a series of queries over the ontologies and the CBRs.

At the ontology level, the answers to the queries are obtained using an ontology reasoner.

At the CBR level, the traditional CBR cycle acts as the reasoner (based on rule logics and a statistical analysis). Both the CBR and the ontology reasoner are use to share information in a cyclic process. When the information is processed it can be argued that experience is obtained.

In the *Knowledge Layer*, the elements that constitute the curricular plans are modelled, using e-Learning standards.

Finally, in the *User Layer* several user types (e.g. course creator, the teacher, etc.) are used to adapt the system to particular cases.

4 CASE STUDY

Our case study is an application of the presented architecture following the Spanish Ministry of Education and Science (MEC) guidelines for vocational education.

The domain was modelled based on the unit-project composition of courses, following the recommendations of our R&D project partner who is a recognized expert in the field of CCD in Spain.

To explain the functionality of the prototype, it must be mentioned that we implemented a use case where the Course Designer user creates a course for a non-existing competence .

The first task is to create a new competence using the stored previous experiences (elements contained in the *Information Layer*). For such purposes, the user introduces the master guides of the new competence that they are interested in. Following these guides, the system launches a CBR process on the data repositories containing the competences. By doing so, they obtain a set of similar competences stored in the repositories, which are at this point in the *Experience Layer*. Those competences will help them in new competence generation. If necessary, it is possible to launch a new CBR process changing the guidelines. When finished, the new competence (that is now in the *Knowledge Layer*) is saved (to the repositories of the *Data Layer*) and becomes a part of the stored cases.

Once the new competence is created, the user can decide if they want to assign a collection of courses for the created competence, or finalize the process and return to the competence creation task.

If the chosen option is to assign courses, an ontology reasoner infers which are the most relevant courses of the new competence based on a semantic reasoning process performed over the stored courses (these courses are in the *Information Layer*). With this collection of suggested courses (and individual units and projects, all of which are in the *Experience Layer*), the user is able to design the new course. At this point, the user can launch more CBR processes to obtain new complete courses, or to obtain new individual units and projects. The results obtained are added to the course creation *Experience Layer*.

When the course contents are defined (in the *Knowledge Layer*), it is necessary to establish a common objective for the competence and the course. The system shows the available objectives (again from the *Information Layer*), and the user chooses an available objective or creates a completely new one. After this assignment, the new course including its objective is stored in the repositories of the *Data Layer*.

Finally, the user chooses between assigning other course to the same competence or to end the process.

The *User Layer* filters the content displayed depending on user type. In this use case, there is only a user type, so there is not explicit implementation of the layer.

4.1 Implementation Issues

The core language used to implement the prototype was Java, using Swing and AWT libraries for Graphical Interfaces. Competence, Course, Project and Unit repositories were created and managed with mySQL databases. The set of ontologies that model the domain were written in OWL-DL, using the Protégé ontology editor. For the query system, we used Protégé OWL API (Knublauch, 2006), and the chosen reasoner was Pellet (Sirin et al., 2007). For the CBR implementation, we used jColibri2 (Díaz-Agudo et al., 2007), developed by the GAIA group at Complutense University of Madrid.

5 CONCLUSIONS AND FUTURE WORK

In this work, we presented an architecture to address some common problems encountered in CCD. Specifically we focused on the re-use of available information. Our approach uses a mix of Semantic and CBR techniques in order to enhance a real world, factual industry problem. A case study implementation of our architecture was presented for using the design of a mid-level vocational education course that complies with the Spanish normative as a demonstration sample.

As future work we intend to extend our implementation in two different directions, one being related to the collaborative aspect of our work (e.g. many users modifying the same resources at the same time). The other direction we wish to explore will focus on the possibility of enhancing the system with experience in using SOEKS techniques (Sanin et al., 2007) used in other domains with positive results (Toro et al., 2007).

REFERENCES

Aamodt, A., Plaza, E., 1994. Case-Based Reasoning: Foundational issues, methodological variations, and system approaches. In *AICom – Artificial Intelligence Communications, 7 (1) pp. 39-59*. IOS Press.

Diamond, R.M., 1998. *Designing & Assessing Courses and Curricula*, Jossey-Bass. San Francisco.

Díaz-Agudo, B., González-Calero, P.A., Recio-García, J.A., Sánchez, A., 2007. Building CBR systems with jCOLIBRI. In *Science of Computer Programming, 69 (1-3) pp. 68-75*. Elsevier.

Fallon, C., Brown, S., 2003. *e-Learning Standards. A Guide to Purchasing, Developing, and Deploying Standards-Conformant e-Learning*, St. Lucie Press. Boca Raton.

Gruber, T.R., 1995. Toward principles for the design of ontologies used for knowledge sharing. In *International Journal of Human-Computer Studies, 43 (5-6) pp. 907-928*.

Högskoleverket, 2008. *E-Learning Quality: Aspects and criteria for evaluation of e-leraning in higher education, Report 2008:11 R,* Swedish National Agency for Higher Education.

Knublauch, H., 2006. *The Protégé-OWL API.* Webpage: http://protege.stanford.edu/plugins/owl/api/index.html (Last visited, 17 November 2008)

Leake, D., 1996. CBR in Context: The Present and Future. In *Case Based Reasoning: Experiences, Lessons and Future Directions, pp. 3-30*, AAI/MIT Press. Menlo Park.

Noy, N.F., McGuiness, D.L., 2001. Ontology Development 101: A Guide to Creating Your First Ontology. In *Stanford Medical Informatics Technical Report SMI-2001, 880.*

Rubio Oca, J., 2006. *La Política Educativa y la Educación Superior en México, 1995-2006: Un balance, Page 81*, FCE. México.

Sanin, C., Szczerbicki, E., Toro, C., 2007. An OWL Ontology of Set of Experience Knowledge Structure. In *Journal of Universal Computer Science, 13 (2) pp. 209-223*, Graz University of Technology. Graz.

Sirin, E., Parsia, B., Grau, B.C., Kalyanpur, A., Katz, Y., 2007. Pellet: A Practical OWL-DL Reasoner. In *Journal of Web Semantics, 5 (2) pp. 51-53*, Elsevier.

Toro, C., Sanín, C., Vaquero, J., Posada, J., Szczerbicki, E., 2007. Knowledge Based Industrial Maintenance Using Portable Devices and Augmented Reality. In *KES 2007. Proceedings, Part I. LNCS 4692, pp. 295-302*. Springer Berlin. Heidelberg.