Building Repositories of Learning Objects in Specialized Domains: The Chasqui Approach

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Abstract

In this paper we describe the Chasqui *approach to the construction of repositories of learning objects* (LO) *in specific knowledge areas. This approach is the result of our experiences in the virtualization of academic museums at the Complutense University of Madrid (Spain) as well as of some experiences in the virtualization of the campus of this university. This approach promotes a close collaboration between two kinds of actors*: domain experts (*e.g.* researchers *and* lecturers) *and* developers. *This collaboration results in* (i) *the definition of a suitable model for the* LO *in the domain of interest,* (ii) *the construction by developers of a domain-specific tool for authoring* LO *conforming this model, and* (iii) *the population of the repository by domain experts using this tool. The domain specific LO models and the domain specific tools based on these models facilitate the production and maintenance of the repositories and the exploitation of the educational potential of the resources used by the experts in their daily work.*

Keywords: *Repositories of learning objects, Authoring of domain – specific learning objects, Virtual museums, Virtual campuses*

1. Introduction

Many academic and research institutions have a great amount of pre-existing research resources that have been used/produced/maintained by different *domain experts* (e.g. lecturers and researchers) for years. Although the potential educational value of these resources is very high, this potential may be largely underused due to severe accessibility and manipulability constrains. Two paradigmatic examples are the museums and the documental archives maintained in many academic and research centers. Therefore, the *virtualization* of these resources, i.e. their representation as reusable *learning objects* (LOs) [8] able to be used in e-learning environments is, in our opinion, a key element for allowing the full exploitation of their educational value.

The *Chasqui*[1] approach establishes a set of guidelines for the construction of repositories of LO from pre-existing research resources in specialized domains like the aforementioned two. This approach promotes a virtualization of these resources carried out by the experts that use, and in many cases have produced, them. In addition, for experts, this virtualization should suppose a minimum of overload in their habitual work. For this purpose, the approach involves a community of *developers* supporting experts in this task. Experts and developers collaborate in the definition of an adequate model for the LOs in the domain. This model lets developers build a domain- specific application for authoring these LOs. Because this tool is specially adapted to the bodies of expertise and to the skills of the experts, the virtualization task is dramatically eased.

The *Chasqui* approach has arisen from our experiences in the virtualization of several academic museums at the *Complutense* University (Madrid – Spain) and also in the development of the virtual campus of this university. In this paper we describe the approach (section 2) and we exemplify it in the domain of the virtual museums (section 3). The paper finishes with some conclusions and lines of future work (section 4).

[1] *Chasqui* means *messenger* in *Quechua*, the language spoken in the *Inca Empire*. The name of the approach is due to the first application inspiring it (see section 3).

2. The Chasqui approach

In this section the construction of domain – specific repositories of LO according *Chasqui* is analyzed from three different perspectives. In subsection 2.1 the activities and products involved in the approach are described. Subsection 2.2 shows how these activities are sequenced. Finally, subsection 2.3 describes the responsibilities of domain experts and developers.

2.1. Products and activities

The products and activities contemplated in the *Chasqui* approach are displayed in Fig. 1.

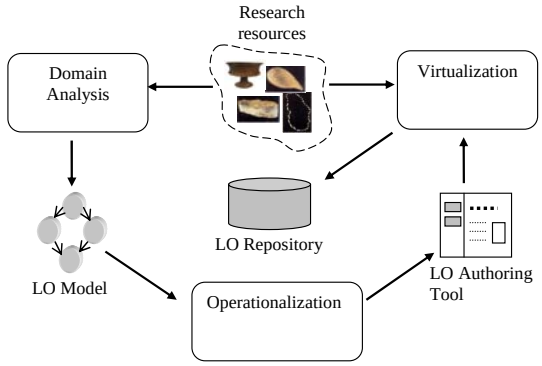

Fig. 1. Products and activities in Chasqui.

The goal of the *Domain Analysis* activity is the formulation of an *LO model* that makes the educational features of the *research resources* manipulated by the domain experts explicit. This model will be specific to the knowledge area of these experts and therefore it will closely mirror the nature of the actual resources managed by them (e.g. the LO model in the domain of archeology can differ from the one used in natural history, because each domain involves a different sort of objects). The domain-specific nature of the model is critical in order to increase its acceptance and usability by the domain experts. The model should be conceptually independent of existing LO technologies. While these technologies are very valuable from a developer's point of view, they wouldn't condition domain experts unnecessarily during the characterization process of the LO in their domains of expertise. On the contrary, this activity could be better based on techniques used in software engineering [1] and knowledge engineering [11] for the construction of domain models.

During the *Operationalization* activity a suitable authoring tool is constructed. This activity is driven by the LO model formulated during the *Domain Analysis* activity. Therefore, the resulting tool will also be domain specific. This activity can take advantage of the existing e-learning technologies. Hence, standard information models like IMS Content Packaging (IMS CP) [5] and IMS Learning Design (IMS LD) [6], and LO structuring proposals like ADL Shareable Content Object Reference Model (SCORM) [9] can be adopted in order to promote the interoperability of the resulting tools and the shareability and reusability of the LO produced. These technologies must be considered implementation mechanisms and as such they are hidden from the domain experts by the tools.

Finally, during the *Virtualization* activity, the repository of LO is populated with virtualizations of the research and learning resources. This virtualization is carried out using the LO authoring tool produced during the *Operationalization* activity.

2.2. Sequencing of the activities

The diagram in Fig. 2 shows the sequencing of the activities in *Chasqui*. Instead of proceeding sequentially, performing an exhaustive domain analysis, followed by exhaustive operationalization and virtualization, the three activities are interleaved in time. According to this iterative – incremental conception, the LO model and the associated LO authoring tool can be refined whenever new domain knowledge is acquired during virtualization.

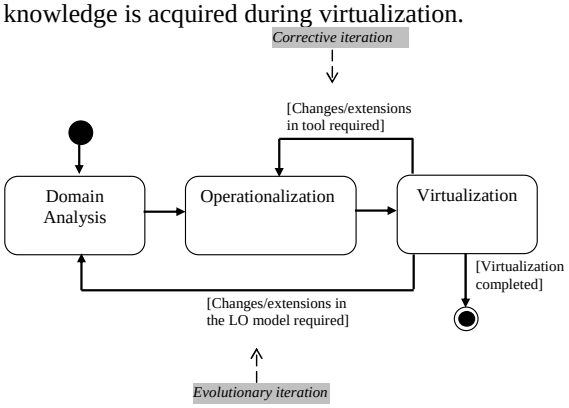

Fig. 2. Sequencing of the Chasqui activities

Chasqui introduces two types of iterations in the construction of the repositories, which are highlighted in Fig. 2. On one hand there are *corrective* iterations, which are related to the updating and fine-tuning of the LO authoring tool to accommodate it to the needs of the experts (e.g. by introducing an enhanced interaction style in its user interface). On the other hand, *Chasqui* also contemplates *evolutionary* iterations, which are related to the evolution of the LO model to capture new educational features of the virtualized resources (e.g. by considering a new kind of attributes for the LO). Both types of iterations can

be started during the *Virtualization* activity in response to the specific needs manifested by the domain experts.

During our experiences with the approach we have realized that continuous maintenance and evolution of the LO models and their associated authoring tools are mandatory to better accommodate them to the desires and changing expressive needs of the experts. This obligation supposes a heavy interaction between the experts and the developers of the applications, which can decrease overall productivity. To manage this interaction we are studying the application of our *document-oriented* approach proposed in [10] for the production and maintenance of content-intensive applications.

2.3. Actors and their roles in the activities

Domain experts and developers are the two main actors involved in the construction of LO repositories, as mentioned before. The different roles that they play in the three *Chasqui* activities are depicted in Fig. 3

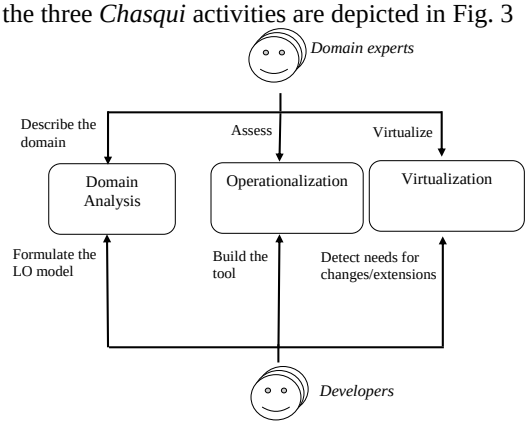

Fig. 3. Actors in Chasqui and their roles in the different activities.

During the *Domain Analysis* activity, the main role of developers is to formulate the LO model for the resources managed by the domain experts. In turn, domain experts must describe these materials to the developers, letting them perform an adequate conceptualization. The acceptability and usability of the resulting LO model will strongly depend on the participation of domain experts, because they know the actual resources, they can describe these resources to the developers, and they can help them in the elicitation of the possible educational uses of this material.

During the *Operationalization* activity, the main responsibility is for the developers. They must construct the LO authoring tool. During this construction, they are driven by the LO model and they can also be assessed by the domain experts regarding different aspects not contemplated in this model (e.g. presentation and edition styles).

Finally, during the *virtualization* activity, domain experts use the LO authoring tool to populate the LO repository. In this activity developers can react to the needs manifested by the experts and start new corrective and/or evolutionary iterations when required.

3. A case study: the domain of the academic museums

This section exemplifies *Chasqui* in a case study: the virtualization of academic museums with educational purposes. We have successfully applied *Chasqui* principles in this domain during the virtualization of two different museums at *Complutense* University of Madrid: the museum of archaeological and ethnographical material maintained at the *Department of American History II* (the *Antonio Ballesteros Archaeology museum*) and the museum of history of computing at the School of Computer Science (the *José García Santesmases Computing museum*). Subsection 3.1 outlines the domain analysis carried out in these experiences. Subsection 3.2 briefly describes the architecture of the LO authoring tools produced. Finally, subsection 3.3 reports some details of the virtualization activity.

3.1. Domain analysis: virtual objects

Academic museums are a paradigmatic application domain for *Chasqui* because they contain huge collections of *real* objects that can be directly chosen as the most suitable candidates for conversion in LO. In this domain it is natural to distinguish between such real objects and their virtual representations. These virtual representations will be called *virtual objects* (VO) because they come from the virtualization of real objects with educational purposes (Fig. 4). The VO model was formerly proposed in [3] in relation with the archaeology museum but it has also been used in the computing one, although with different concrete features.

In Fig. 4 the structure of a VO is outlined. That way a VO is characterized by a set of *data*, a set of *metadata*, and a set of *resources*:

- The *data* in a VO represent all the features of the real object that are considered useful for its scientific study and its pedagogical use. Examples of data are the *dimensions* of a piece in the archaeology museum or the *model* of a computer in the computing one.

- The *metadata* are the information used to describe and classify the VO from a pedagogical point of view. Examples of metadata are the *name* of the VO's author or its *version number*. The different features covered by metadata are chosen from existing exhaustive metadata schemas like the IEEE LSTC Learning Object Metadata (LOM) [4].

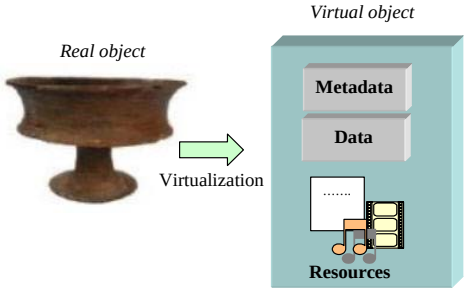

Fig. 4. Real and virtual objects.

- The *resources* are the other informational items associated with the VO. These are further classified in *own*, *foreign* and *VO* resources. The *own resources* of a VO are the multimedia archives resulting from the virtualization of the real objects (e.g. the photograph of a ceramic vessel or a video with the operation of an analogical computer). The *foreign resources* are references to resources of other VOs. Finally, the *VO resources* are references to other VOs in the repository.

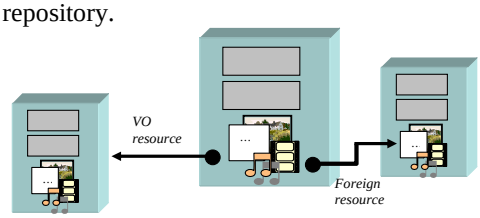

Fig. 5. Virtual objects can be related using foreign and reference resources.

Foreign and VO resources allow the establishment of basic relationships between different VOs (Fig. 5). Indeed this mechanism can be used to build new VOs based on existing ones. These resulting composite VOs don't need to correspond to real objects in the virtualized resources, but they represent the new constructed knowledge that arises during the virtualization process.

3.2. Operationalization: web-based authoring tools for virtual objects

The VO model has led us to develop web-based authoring tools for the two aforementioned museums (Fig. 6).

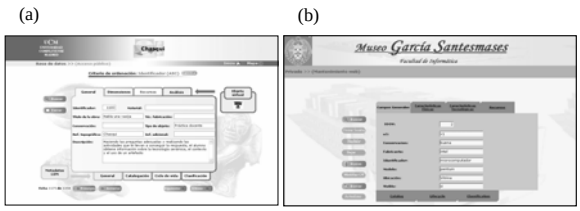

Fig. 6. Snapshots of the *Chasqui* tools for (a) the museum of archeology, and (b) the museum of computing.

These tools share a common architecture that is depicted in Fig. 7. According to this architecture, the repository of VOs is supported by a relational database. The tools include pre-established web interfaces tailored to the museums being virtualized. In addition, these tools also include programmatic interfaces accessible via *web services* [2]. Web services facilitate the interoperation with other repositories, enable different accessing mechanisms (e.g. mobile devices) and even permit the use of other authoring tools with alternative interaction styles. As suggested in Fig. 7, this architecture is entirely implemented using open source technologies.

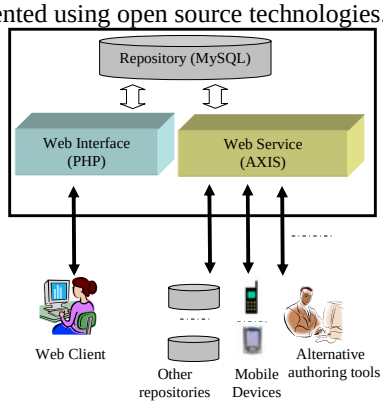

Fig. 7. Architecture of the *Chasqui* Web Based Authoring Tools used in the Virtualization of Academic Museums

To enable interoperability, the tools incorporate importation and exportation facilities of content packaged in accordance with the IMS CP specification. This way, VOs can be packaged according to this specification and can be exported to other IMS-aware systems. Direct importation is also possible between repositories associated with museums sharing a common VO model. More complex importation processes can be also automatically achieved by connecting the appropriate adapters to the web service.

3.3. Virtualization

The tools described in the previous section are being used in the virtualization of the aforementioned

museums. While the virtualization of the computing museum is in its initial stages, the virtualization of the archaeology one is in an advanced state. Currently, the resulting virtual museum, using a prototype version of the tool, contains more than 1500 VOs and the virtualization process continues to be active [7].

(a) (b)

Fig. 8. (a) Unpublished ceramic vessel neck from *Proyecto Esmeraldas* that was re-recovered during the virtualization process, (b) A resource of the VO associated with a work assignment for undergraduate students.

The tool for the archaeological museum is proving very valuable to reviving unpublished archaeological material for research and pedagogical purposes (Fig. 8a). This is indeed the case with several finished projects at the Department of American History II: *Chinchero*, *Incapirca* and *Esmeraldas*. The tool has also been used in several pedagogical experiences with undergraduate and Ph.D. students. Indeed, work assignments for undergraduate students have been introduced in the system as new VOs (Fig. 8b). In turn, Ph.D. students have been actively involved in the virtualization process.

4. Conclusions and Future Work

The *Chasqui* approach described in this paper lets domain experts create repositories of LO. For this purpose domain-specific LO models are formulated and supporting authoring tools based on these models are developed. These tools are used by the experts to produce the repositories. We have realized that the approach is very valuable to exploiting the educational potential of otherwise underused and/or access-limited research materials. We have also realized that the approach allows the creation of new knowledge as reusable composite LOs.

In the archeology domain, we are currently experimenting with the publication of the material as this is recovered in the excavations. We are finishing the first stage in the virtualization of the computing museum, and we are also starting several virtualization experiences regarding the virtual campus of the *Complutense* University of Madrid. As future work we are planning to undertake the virtualization of other museums at this university in order to refine the concept of VO. We are also planning the use of our document-oriented approach [10] to improve the maintenance of LO authoring tools.

5. Acknowledgements

This work is supported by the Spanish Committees of Science and Technology (TIC2002-04067-C03-02, TIN2004-08367-C02-02) and of Industry, Tourism and Commerce (PROFIT, FIT-350100-2004-217).

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