

Semantically-enabled Model Driven Course Composition

Mark Melia and Claus Pahl

School of Computing, Dublin City University, Dublin 9, Ireland
mmelia@computing.dcu.ie

Abstract. Modelling has been used in software engineering, for quite some time, as a tool to aid the development of complex software systems. In software engineering modelling is increasing in importance, becoming actual implementable artifacts in the software design process. Substantial infrastructure has been developed to allow models to become implementable. This infrastructure presents opportunities in other domains. Here, we investigate the use of modelling in the composition of learning objects into executable courses. Course creation is a very time consuming and costly activity, modelling combined with reusable Learning Objects may prove to alleviate some of the time and cost that is associated with course creation.

The use of semantics in models is also investigated. Ontologies allow for the formal expression of semantic information. This information can be used to validate models and even provide fixes for invalid models.

1 Introduction

The “reuse rather than create” paradigm has been successfully applied in the software engineering sector. The advent of new software frameworks such as component-based software and service-orientated architecture cuts the time and cost involved in creating complex software systems by providing ready-made solutions to particular business problems.

Learning technology systems have more recently seen a surge in the use of this paradigm. This is in order to reduce the time and cost involved in creating complex e-learning material. Course creators are looking to reuse and re-purpose learning material created by others to cut course development time and costs. With the advent of learning object repositories (LORs) this style of course development is becoming ever more popular.

Unfortunately, the reuse of existing Learning Objects (LOs) in course composition is not perfect. LO selection can be time consuming, and the pedagogy that would have been a primary concern of the course creator when developing the course from scratch tends to become secondary to that of locating relevant LOs.

We propose using a development framework from the software engineering domain to correct these problems. A type of Model Driven Development (MDD) will be used to encourage the course creator to consider aspects of pedagogy,

by creating a visual environment for setting course sequencing and navigational strategies. In software engineering, MDD raises the level of abstraction software developers develop at, by using precise, platform-independent models as software development artifacts [1]. Semantic Web technologies [2] combined with MDD technologies will also be used to allow for automated selection of learning objects, and validation of course models, reducing the course creators workload.

In this paper we outline how we propose an intuitive authoring framework based on modelling, which allows the course creator to compose courses and specify sequencing behaviour. Our framework also aids the course creator in locating, selecting and validating LOs. Our approach is complimentary to other Learning Technology movements, such as LORs and Learning Management Systems (LMSs).

2 Project Objectives

This project consists of four main objectives, these are:

- Create an intuitive modelling language to set out a course conceptual structure which provides the course creator with a simple way to embed learning objects into the course. This modelling language is also used to specify sequencing of LOs and course components.
- Models are mapped to learning interoperability standards using MDD technologies.
- We assume the uptake of semantically enabled LORs, containing LOs, which are semantically annotated. These semantics enable the validation of our models, ensuring that all LOs are suitable within the context they are placed. Semantic web technologies, particularly ontology technology, enable this functionality. We also investigate parallels between LO composition and software component/service composition using semantic web technologies.
- Semantic knowledge contained within a course model graph are used to locate suitable content in semantically enabled LORs.

3 Rational, Benefits and Innovation

With Learning Object Repositories becoming proliferate, course creators will reuse and re-purpose learning material available to them through repositories much more and only create original course content when no suitable existing content is available. This will cut the time and cost involved in creating courseware. Unfortunately it is not all good news, the course creator will now have to invest time in locating course content, evaluating it and integrating it with pedagogy.

Our project sets out to alleviate the problems associated with reusing LOs by providing an intuitive model-based environment to create courses and by semantically enabling the course creation tool providing for more sophisticated LO composition, discovery and validation.

Courses can be modelled both conceptually (in a hierarchical diagram) and pedagogically (in a flow diagram). The conceptual diagram outlines the course structure, while the pedagogical or sequence diagram allows the course creator to specify LO sequencing behaviour.

Completed courses can be validated using an ontology describing the learning process in a similar way software compositions can be validated using software process ontologies [3]. Validation ensures, firstly that the learning object context fits within the lesson context, and second, the learner has the necessary pre-requisite knowledge in order to comprehend the learning object at the point he or she must engage with it.

Should a model be deemed invalid, the semantics contained within the models provide sufficient information to allow for the automated discovery of LOs, which when added to the model will validate the model. For example, if a knowledge gap is found in the sequencing, where the learner will not have the necessary pre-requisite knowledge for a desirable LO, the semantics within the models can be used to search a LOR for a LO which will provide the learner with the necessary knowledge in order to fulfil the pre-requisite requirements of the desired LO.

4 Research Methodology

The ultimate goal of this project is the development of an intuitive course composition methodology and a software framework that supports this methodology.

We firstly investigate similar component composition methodologies, such as those found in the software engineering domain. We investigate how these methodologies can be applied course composition.

We then investigate modelling notation, which allow the course creator to intuitively manipulate a course composition and can be translated into a learning interoperability standard such as SCORM [4]. There are three possible ways for doing this:

- Develop a UML profile that is intuitive enough that it will gain acceptance from course creators. This would be the simplest solution as an XML binding for UML is available (XMI) and can be mapped to learning technology standards. UML has been used to model course creation methodologies before, but only at a superficial level [5].
- Look at how future standards such as the Business Process Modelling Notation (BPMN) [6] could be used to model course composition, and investigate possible XML bindings.
- Investigate the creation of a new modelling notation for course composition, although this would be the most difficult it may be necessary in order to gain acceptance from course creators.

As a proof of concept, we will extend an existing tool, such as Reload [7] with the new model based course composition framework, and test it with course creators.

Semantic Web technologies that originate from the software engineering domain will be used to validate the course composition. This will allow for the validation of the LO context, insuring that each LO fits within the context of the course and is in harmony with the course as a whole. We will look at a few ways of doing this, one possible way is to investigate automated composition of complex software services using process modelling ontologies [3] and how it can be applied to course composition.

Our framework will also recommend solutions for an invalid course using semantic information captured within the modelling notation to automatically generate LOR queries. We hope this will minimise manual work carried out by the course creator.

5 Related Work

5.1 The Reload Editor

The reload project is a JISC funded project, managed by the University of Bolton [7]. The project aims are as follows:

- to facilitate the course creator in sharing learning objects
- to allow the course creator to encapsulate pedagogical information in lesson plans.

The Reload editor allows the course creator to create a SCORM package at a higher level of abstraction, abstracting the knowledge needed to use the implementation technologies, needed to create a SCORM package. Although some of the lower level implementation details are abstracted away, the course creator must still understand how to implement the SCORM technologies at a higher level.

We see our framework as the perfect companion to Reload and tools like Reload. Reload allows course creators to create courses, and to add sequencing information, but in less intuitive way than specified here. Adding our framework as a plug-in to Reload would empower the less technical course creator to develop courses that make use of explicit LO sequencing.

5.2 My Online Teacher (MOT)

The “My Online Teacher” (MOT) system [8], developed at the Technical University of Eindhoven, allows course creators to create adaptive courses using the LAOS model system of layered models [9]. In the LOAS model there are two types of models - static and dynamic.

Similarities between our approach and that of LAOS can be noted. LAOS contains a domain map, which is also implicit in our approach as LOs pre-requisites and post-requisites reference a domain model in order to share a common semantic space. On top of the domain map in LOAS a goal and constraints map contains pedagogical information. In our approach the author is in effect setting a goal and constraint map when he or she set out sequencing paths and sequencing strategies using models.

5.3 Sequencing Objects

Su et. al. recognised the steep learning curve faced by the course creator in SCORM 2004 compliant courses, and suggest using an Object Orientated Methodology (OOM) in [10], to simplify the creation of SCORM compliant courses. Using the OOM, complicated sequencing rules are encapsulated into objects, known as a sequencing object.

The course creator must add learning content to sequencing objects, and then joins the sequencing objects together to create a course. This course is then translated into a SCORM 2004 package using the “Course Sequencing to Content Package” (CS2CP) algorithm.

Sequencing objects are excellent examples of how models can be used to elivate some of the complexity involved in creating a SCORM sequencing. Sequencing objects use a self-defined notation, and are not standardised, and therefore do not reap the advantages of the automated transformation processes developed for standardised modelling languages such as the UML.

5.4 Visual Online Authoring Tool (VOAT)

Yang et. al. identifies difficulties with reusing and repurposing LOs in [11], and has created a suite of tools which aim to aid the course creator in the creation of courseware.

There are three components of Yang’s course creation tool suite, Ontology-Based Outline Authoring Tool (OBOAT), the Visual Online Course Authoring Tool (VOCAT) and the Visualized Online Simple Sequencing Authoring Tool (VOSSAT). The course creator uses OBOAT to create a conceptual map of the content of the course to be created. The construction of this conceptual map is very much guided by a domain ontology.

Once a conceptual map has been created it is loaded into the VOCAT, which is used to add and assemble Learning Objects and Content Packages to the course.

The final tool in the suite is the VOSSAT, which allows the course creator to specify LO sequencing information. Sequencing information is specified through a form based user interface. Once sequenced the course is exported into SCORM and can then be used by learners on a SCORM-compliant LMS.

6 Conclusion

The main goal of our work is to aid the course creator in the course creation process. We do this by providing the course creator with an intuitive environment in which to allocate and sequence LOs in courseware. We also provide a way for the course creator to check that his or her course adheres to basic pedagogical principles. Courses are validated based on these principles. If a course has been deemed invalid, the framework can recommend a remedy to validate the course. Once the course is valid it can be exported using one of the learning technology interoperability standards, and delivered on a standards-compliant LMS.

References

1. Frankel, D.S.: Model Driven Architecture. Wiley Publications, Indianapolis, Indiana (2003)
2. Daconta, M.C., Obrst, L.J., Smith, K.T.: The Semantic Web: A Guide to the Future of XML, Web Services and Knowledge Management . Wiley Publications, Indianapolis, Indiana (2003)
3. Pahl, C.: Ontology Transformation and Reasoning for Model-Driven Architecture. In: Proceeding of the International Conference on Ontologies, Databases and Applications of Semantics (ODBASE05), Springer-Verlag LNCS (2005) 1170–1187
4. Advanced Distributed Learning: SCORM 2004 Overview (2004) Available from <http://www.adnet.gov/scorm/index.cfm>.
5. Hu, S.C.: Application of the UML in modeling SCORM-conformant Contents. In: Proceedings of the IEEE International Conference on Advanced Learning Technologies (ICALT03), IEEE Computer Society (2005)
6. White, S.A.: Introduction to BPMN. Technical report (2004)
7. The RELOAD Project: (The RELOAD Metadata and Content Packaging Editor) Available from: <http://www.reload.ac.uk/editor.html>.
8. Cristea, A.I., Smits, D., de Bra, P.: Writing MOT, Reading AHA! - converting between an authoring and a delivery system for adaptive educational hypermedia. In: Proceedings of The Third International Workshop on Authoring of Adaptive and Adaptable Educational Hypermedia at AIED05. (2003)
9. Cristea, A.I., de Mooij, A.: LAOS: Layered WWW AHS Authoring Model and their corresponding Algebraic Operators. In: Proceedings of The Twelfth International World Wide Web Conference (WWW03), Alternate Track on Education, ACM (2003)
10. Su, J.M., Tseng, S.S., Weng, J.F., Chen, K.T., Liu, Y.L., Tsai, Y.T.: An Object Based Authoring Tool for Creating SCORM Compliant Course. In: 19th International Conference on Advanced Information Networking and Applications. Volume 1., IEEE (2005) 209–214
11. Yang, J.T.D., Chen, W.C., Tsai, C.Y., Chao, M.S.: An Ontological Model for SCORM-Compliant Authoring Tools. Journal of Information Science and Engineering **21**(5) (2005) 891–909