ADVANCES IN TECHNOLOGY-BASED EDUCATION: TOWARDS A KNOWLEDGE BASED SOCIETY

Proceedings of the II International Conference on Multimedia and Information & Communication Technologies in Education

m-ICTE2003
www.formatex.org/micte2003/micte2003.htm

Badajoz, Spain, December 3-6th 2003

Edited by

A.Méndez-Vilas
J.A.Mesa González
J.Mesa González

ANALYSING THE REUSABILITY OF LEARNING OBJECTS IN A MULTI-LINGUAL E-LEARNING CONTEXT

H.WATCHORN AND R.O'CONNOR

School of Computing, Dublin City University, Glasnevin, Dublin 9, IRELAND.
E-mail: hwatchorn@yahoo.com, roconnor@computing.dcu.ie

This paper examines the current problems associated with creating, storing, searching, retrieving and reusing multi-lingual e-learning content in an emerging learning object economy. In particular, it examines the notion of reusable Shareable Content Object Reference Model (SCORM) Learning Objects (LO's) and highlights the need for the e-learning industry to adopt SCORM as the means to store, search, and retrieve LO's. The central focus of this paper is the design for a proposed web service that acts as a bridge between proprietary e-learning applications and online digital repositories which allows users to search for SCORM LO's stored on web servers which returns newly generated SCORM LO's. The design is based on open standards and is centred around a web service that allows disparate proprietary applications to interface with it. This paper also discusses test cases that validate the implementation of the web service and discusses its findings. Provisional results from these tests demonstrate that SCORM LO structures can be manipulated for commercial e-learning projects.

1   Introduction

The e-learning industry is at a crossroads in its development of products, services and content. Until recently the predominant mechanism for the delivery of e-learning content was via proprietary-based products. However, the growing acceptance of the World Wide Web (WWW) as a platform for delivering e-learning products and services, and the notion of pervasive e-learning have had profound effects on the mechanisms used for the delivery of e-learning content.

In this paper we outline current practices in creating e-learning content and describe the methodology that underpins a new way of creating e-learning content to enhance its reusability. We examine an emerging web-based e-learning standard that utilizes this methodology to create e-learning content. In addition, we analyse the reusability of this e-learning content by writing and testing an application that extracts selected e-learning units from it. We also outline the implications that current methods of storing, searching and retrieving multi-lingual e-learning content have on its reusability.

Of central importance to the emergence of a learning object economy is the development of reusable LO's. The main factors that affect a LO's reusability are [1]: 1) Granularity, 2) Effective and descriptive metadata and 3) Appropriate Content Packaging for distribution. In addition, there are two important facets of a LO that have to be considered when evaluating its reusability: semantic consistency and pedagogical quality. The core problem of developing reusable LO's is ensuring the separation of content from its narrative or pedagogical model. SCORM puts it another way: ensuring that the LO is context independent. More specifically, it is only when LO's are aggregated do they gain context, by themselves they have no context [2]. It has also been argued that that the development and deployment of LO's are mutually exclusive processes, and ensuring the separation of these processes will mean that LO's do not favour any particular instructional methodology [3]. It is worth noting that [4] claim that "this separation improves the possibilities of reusing a piece of learning content", but it is still no guarantee that an aggregation of disparate LO's are semantically consistent with each other.

This research has been conducted with the assistance of a leading international multi-lingual e-learning company, referred to as ABC Inc. (to protect the identity of the company), which is a leading player in the multi-lingual e-learning. In this paper, ABC Inc. has been used as a case study to explore the economic value of reusable multi-lingual e-learning content and how the findings of this research could be implemented to achieve improving the economic value of reusable multi-lingual e-learning content created by ABC Inc.'s product, MultiWorld. ABC Inc. is currently planning to extend its services to include multi-lingual content development and have developed an authoring tool component in their MultiWorld product, which enables them to develop e-learning content with reusable LO's thus reducing the overall time and cost of developing e-learning content.

2   Multi-lingual E-learning Content Issues

Until recently, the e-learning industry has been creating proprietary systems, products and content. With the introduction of SCORM, the industry is slowly transforming its content development practices. However if the industry is serious about creating reusable LO's, and by extension a learning object economy, it must utilise SCORM's features as a means to standardise storage, search and retrieval of LO's. At present SCORM is rarely used for these functions and proprietary functionality is implemented instead. The remainder of this section will

deal with the issues of storage, search and retrieval of LO's. The main problems associated with current storage practices of LO's are:

- LO's are generally stored as indexed assets in a database
- LO's may be generated at runtime by an application
- SCORM Packaging Interchange Files (PIF's) are not being widely used as a storage format

ABC Inc.'s product MultiWorld is built on top of a content management system and currently saves the LO's as indexed raw assets that get assembled at runtime. This is an important issue because it binds LO's to proprietary systems, thus reducing the possibility of scaling local learning object economies up to a global learning object economy. This paper addresses the issues of the inconsistent storage of LO's across different systems by investigating the use of SCORM PIF's as a storage format. The main problems associated with searching for reusable SCORM LO's are:

- No metadata
- Low quality metadata
- No semantic inferencing
- Proprietary search tools

In order to search for reusable LO's, the LO's must have metadata associated with them at their various levels of granularity. Currently search engines employ syntactic search algorithms rather than semantic search algorithms; search engines do not 'know' what they are searching for and cannot make inferences when searching [5]. The current version of ABC Inc.'s MultiWorld product does not have a feature to search for LO's. This is an important issue because LMS's and digital repositories typically bind users to proprietary search tools that have a relatively local search scope. Therefore users have to use different search tools to access different LO content repositories. This paper addresses the issues of proprietary search tools by creating a non-proprietary search tool for both local and global learning economies. The main problems associated with retrieving SCORM LO's are:

- Different file formats
- No metadata associated with the LO for further reuse outside of its current environment
- No simple access to the LO component files for updates or localisation work

LO's become reusable outside of their original development environment because SCORM encapsulates all the data related to a LO in one PIF. There is nothing inherently wrong in returning LO's as an object compiled at runtime, or as a URL pointing to the LO, or the LO in any other format. However problems may surface when attempts are made to export these LO's outside of their original environment, such as to translation companies or online digital repositories because they do not have their metadata bundled with them. The current version of ABC Inc.'s MultiWorld product cannot retrieve a LO because there is no LO search facility. This paper addresses the inconsistencies of how LO's are returned to the user by utilising SCORM PIF's. The main problems associated with LO's in a multi-lingual context are:

- High quality, consistent metadata translations
- Localising metadata may not map directly to other languages
- LO's not stored in language domains
- Extended character support

The quality of the metadata translations should be of a sufficiently high standard to locate the LO. Problems may surface when there is not a one-to-one translation of metadata terms from one language to another. Multi-lingual LO's should be stored in language domains within these content repositories. This aids search engines and ensures that LO's are not overwritten if called the same name. This paper addresses the issue of storing LO's in language domains to aid search tools, however LO translation issues themselves are not the focus of the research.

3 Proposed Web Service

It is the proposition of this paper that what is required by the e-learning industry for the successful creation of reusable multi-lingual LO's in a SCORM context is a web service that acts as a bridge between proprietary e-learning applications and online digital repositories. The authors have devised an open-source, standards-based solution as outlined above. Initially this has been implemented in the context of ABC Inc.'s MultiWorld product, but can be extended to any LMS, database, or online digital repository. Figure 1 outlines the high-level architecture plan for the proposed web service.

The proposed architecture for this web service proposes to create different language directories (domains) on a number of web servers. Language directories are named according to the ISO 639-1 language code naming convention. The SCORM PIF may contain a complete e-learning course with any number of LO's or it may contain just LO's. The solution utilises the so-called SCORM Registry file (scorm_registry.xml) which is a

registry-type file. It is written in XML and it lists the URL of each web server, the language and location of each SCORM PIF for each web server. The web service parses this file to search for SCORM PIF's.
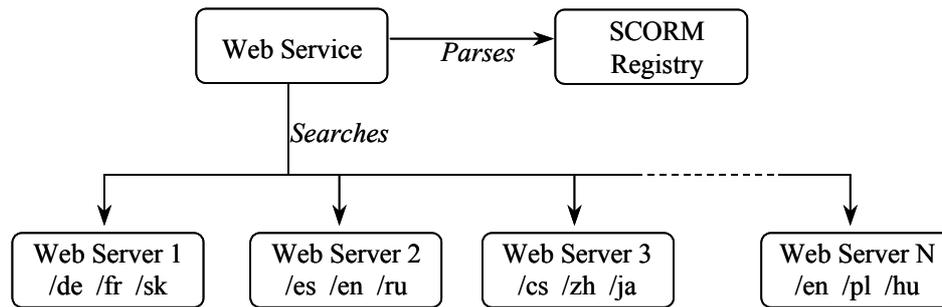

Figure 1. High-level Architecture of Storing LO's on Web Servers

The web service has five main tasks:
1. It validates user input.
2. It parses the SCORM Registry file to get the URL of each registered web server and the location(s) of the appropriate language version SCORM PIF's.
3. It extracts and parses the SCORM manifest file and metadata files from each SCORM PIF looking for keyword matches.
4. It extracts LO's from their parent SCORM PIF and generates new SCORM PIF's containing these LO's.
5. It stores new SCORM PIF's on web servers and returns the URL's to the user.

There are four components that make up the web service: storing LO's, searching for LO's, retrieving LO's and the web service interface.
- SCORM PIF's containing single or multiple LO's were stored on disparate web servers
- Syntactic keyword searches are implemented on LO metadata files
- The information contained in a PIF's manifest file is used as the basis for extracting a LO from it's parent PIF.
- Proxy interface classes are generated from the web service that allows client applications to interface with it.

The overall design forces MultiWorld and LMS's to use SCORM PIF's as they were intended – as a means to transport LO's within an intranet or on the WWW. It also provides a stepping stone towards doing semantic searches for LO's on the Semantic Web.

4   Prototype Design, Implementation and Deployment

The design was based on a Service-Oriented Architecture (SOA) architecture. The web service was installed on a locally installed web server that connected to all known web servers containing servlets listed in the SCORM Registry file. The business logic was contained in these classes and their associated helper classes. The SCORM PIF's were stored on web servers. It was was based on deploying a SOAP messaging engine as a servlet on a web server. The web service made Java calls to a helper servlet that was installed on each web server. The helper servlet extracted, searched and regenerated the SCORM PIF's on each web server. The work was delegated to this servlet to improve overall performance of the design.

An issue that has been observed during this research is the inconsistent storage of LO's. SCORM PIF's were designed for transportation on the web; by extension they can be stored there. This design proposed to store SCORM PIF's on web servers in a predefined directory structure. The newly generated PIF's containing singular LO's were also stored on web servers in a predefined directory.
The main problems that arose in the implementation phase involved:
- **Phrases** - Keywords that contained spaces or extended characters caused the servlet to crash because the parameters posted to the servlet were then misinterpreted. This was resolved by encoding all keywords using the URLEncoder class before posting them as parameters to the servlet.
- **Extended Characters** – Keywords that contained extended characters caused XML parsing errors. The problem was caused by the character-set implemented by the client machine, mismatching what the character-set implemented in the software and XML files. This problem was not resolved despite many workarounds.

- **HTTP Tunnelling** – The servlet helper classes created an ArrayList object of newly generated URL objects. Ordinarily servlets return primitive data types to client classes. HTTP Tunnelling resolved this problem because it made serializable objects available to the client by using the ObjectOutputStream class.

The system was subjected to a period of trial usage period to obtain feedback in relation to the systems functionality. The validation process was broken down as follows:

- Test data was downloaded from the ADLNet website as these were publicly available SCORM-compliant PIF's. The data was uploaded to the appropriate web servers in different language directories to simulate a multi-lingual environment. It must be noted that all the test data was in English.
- Each test case used different search strategies. The test cases covered the spectrum of queries that can be made of the web service.
- Newly generated PIF's were manually examined to ensure that they displayed correctly in a browser.
- URL's to these PIF's were tested on web servers to ensure that each PIF hyperlink opened correctly.
- The PIF's were tested to ensure that they were SCORM compliant.

The SCORM 1.2 Conformance Test Suite is a framework to test different components of the SCORM: the LMS Runtime Environment, the SCO Runtime Environment, Metadata and Content Packages. The Content Package conformance test component was used by the validation process.

The high level test cases and their objectives are as follows:

- To test web service validation.
- To test keywords (single-word) where there are known matching internal and external metadata files on a single web server.
- To test keywords (single-word) where there are no matching metadata files on a single web server.
- To test keywords (single-word and phrases) where there are known matching internal and external metadata files on multiple web servers.
- To test keywords (single-word and phrases) where there are no matching internal and external metadata files on multiple web servers.
- To test keywords (single-word and phrases) that contain extended characters where there are known matching internal and external metadata files on multiple web servers.

The purpose of the test phase was to assess user feedback on the web service tool. This was done by asking users to implement each query and to provide verbal feedback. Validation of the results was completed using version 1.2.3 of the SCORM Compliancy Test Suite as well as empirical checks of the LO's. The overall findings of the test phase were not very positive but very instructive.The web service proved that SCORM PIF's can be disaggregated into separate LO's for further reuse. It proved that SCORM PIF's contained important metadata information to aid reusability. It proved that a web service could be developed quite easily to handle such complexity.

5 Conclusions

This paper has addressed the following problems: LO's were stored as SCORM PIF's on web servers using pre-defined language directory structures. A web service was developed to parse the manifest file and LO metadata files of each PIF to search for the appropriate LO's. The web service disaggregated the relevant LO from its parent PIF and returned a newly generated LO in PIF format. These new PIF's were also stored on web servers. The solution used the data stored in SCORM PIF's, namely the manifest and metadata files, as the means to store, search and retrieve LO's. The solution also generated client proxy classes for applications to interface with the web service, such as ABC Inc.'s application, MultiWorld. In the absence of any LO search and retrieve functionality, MultiWorld could interface with the web service API.

This paper highlights the importance of the e-learning industry adopting SCORM as its de facto standard. It found that SCORM can be used successfully as the means to store, search and retrieve LO's in a standardised format, namely as SCORM PIF's, in addition to its more recognised role of structuring e-learning content. The paper also raised the importance of developing reusable LO's and drew attention to the economic impact of using reusable LO's in a localisation context.

Further research needs to be carried out to determine if a web service can act as a bridge between local learning object economy systems such as LMS's and global learning object economy systems such as online digital repositories. Further research is also required on algorithms to search SCORM metadata. At a broader level, an examination of SCORM and the speed and scale of its implementation will provide an important insight into its overall success. Using SCORM for tasks other than wrapping e-learning content should contribute to its future success. Another aspect is the importance of assessing how much time and cost can be reduced by using reusable LO's in a multi-lingual context.

It is the proposition of the authors that both SCORM and LO's will be the future of e-learning. It accepts that there are many problems that have to be solved to reach that point. Further for SCORM and LO's to become globally used, the e-learning industry must implement non-proprietary tools that are inherently bound to both SCORM and LO's. The research presented in this paper demonstrates that SCORM PIF's can be easily stored, search and regenerated using XML and web service technologies. It raised issues about the performance of the implementation and provided a roadmap of future research.

References

1. O.Conlan, D.Dagger and V.Wade. "Towards a Standards-based Approach to e-Learning Personalization using Reusable Learning Objects". In. ELearn 2002, World Conference on E-Learning in Corporate, Government, Healthcare & Higher Education, October, 2002.
2. P.Dodds, (ed.). "Advanced Distributed Learning Shareable Content Object Reference Model Version 1.2: The SCORM Overview", 2001. [Online]. Available from: <http://www.adlnet.org>
3. P.R.Polsani. "Use and Abuse of Reusable Learning Objects", 2003. Journal of Digital Information. Vol. 3 (4).
4. O.Conlan, V.Wade, C.Bruen and M.Gargan. "Multi-Model, Metadata Driven Approach to Adaptive Hypermedia Services for Personalized eLearning". In. Second International Conference on Adaptive Hypermedia and Adaptive Web-Based Systems, May, 2002.
5. P.Shabajee, A.McFarlane and G.Conole. "The design of multimedia database systems, for use as multidisciplinary, cross-sector and cross-cultural educational resources". In. Computer Assisted Learning 2003 Conference: 21st Century Learning, April, 2003.