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On Reusability and Interoperability for Distance Learning

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Abstract

Distance learning has taken root, but it will take a big push to get to the next level. A key is to make courseware reusable in creating other courseware and interoperable across a wide variety of platforms on which the courseware is to be presented. In fact, reusability and interoperability are the cornerstones of the emerging distance learning standard called the Sharable Content Object Reference Model (SCORM). In this article, we examine reusability and interoperability for distance learning as embodied in the SCORM specifications. We also outline some important research projects related to SCORM.

1 INTRODUCTION

Distance learning, also called e-learning, cyber education, etc., is the delivery of instructions using network and multimedia computer facilities, and has become an important part of modern education for universities and corporations by complementing traditional in-class education. One of the challenges for distance learning is the creation of high quality course materials (lecture notes, references, tests, etc). While intelligent technology is still under development to automatically aggregate sufficient course materials, it is important to share and reuse well-developed learning objects (i.e., decomposed reusable objects as a course material) to reduce the load on instructors, and to make them available across a wide variety of platforms. Thus, the concepts of reusability and interoperability in distance learning are an interesting issue for education professionals, system developers, and learners. (note: In this article, we use the term "course materials" to refer to lecture notes, tests, references, presentations, etc, of distance learning in general. When discussing reusability, we use the term learning object to refer to a decomposed part of course materials.)

In order to achieve reusability and interoperability, standards are needed. The Advanced Distributed Learning (ADL) initiative (http://www.adlnet.org/) first proposed the Sharable Content Object Reference Model (SCORM) standard in 2000. Main

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contributors to SCORM include the IMS Global Learning Consortium, Inc. (http://www.imsglobal.org/), the Aviation Industry CBT (Computer-Based Training) Committee (AICC) (http://www.aicc.org/), the Alliance of Remote Instructional Authoring & Distribution Networks for Europe (ARIADNE) (http://www.ariadne.eu-org/), and the Institute of Electrical and Electronics Engineers (IEEE) Learning Technology Standards Committee (LTSC) (http://ltsc.ieee.org/). SCORM addresses the following four high-level requirements (http://www.adlnet.org/):

- **Reusability:** the flexibility to incorporate course materials in multiple instructions.
- **Interoperability:** the ability to take course materials developed in one location with one set of tools or platform and to use them in another location with a different set of tools or platform.
- **Accessibility:** the ability to locate and access course materials from one location and deliver them to many other locations.
- **Durability:** the ability to withstand technology changes without redesign, reconfiguration or recoding.

Reusability and interoperability are of interest for the purpose of this article. Reusability can be achieved by using SCORM-compliant authoring tools, which can be used to produce course materials that may be decomposed, shared, and reused among different lectures. Interoperability can be achieved by using a SCORM-compliant Learning Management System (LMS), which also includes a sequence engine to control user interactions.

The SCORM 2004 (also known as SCORM 1.3) specification consists of three major parts: the Content Aggregation Model (CAM), the Run-Time Environment, and the Sequencing and Navigation.

- **The Content Aggregation Model (CAM):** Learning objects are divided into three categories (i.e., Assets, Sharable Content Objects (SCOs) and Content Organizations – these will be explained later). The contents of the learning objects are described by metadata. In addition, CAM includes a definition of how reusable learning objects can be packed, delivered, and used.
- **The Run-Time Environment:** In order to deliver learning objects to different platforms, a standard method of communication between the learning management system (LMS) and the learning objects is defined.
- **The Sequencing and Navigation:** Interactions between users (i.e., students) and the LMS are controlled and tracked by the Sequencing and Navigation definitions. This also serves as a standard for defining learner profiles, as well as a possible definition for intelligent tutoring.

2 REUSABILITY

In order to make a learning object reusable, a standard representation of its content and its structures must be observed and enforced. CAM provides such a standard. It consists of three parts: the Content Model, the Metadata, and the Content Packaging. The Content Model defines the hierarchy of learning objects, that is, how a learning object is organized in terms of smaller potions at different levels. The Metadata describes the Content Model and provides an efficient mechanism for content search. The Content Packaging is a definition that allows the content model and structure to be packed into a standard exchangeable file, known as the Package Interchange File (PIF). The PIF (see Figure 1) allows learning objects to be exchanged in a standard form across different platforms on which these learning objects are presented.

There are several categories (called, somewhat imprecisely, "levels" in the SCORM specification) of learning objects in the Content Model:

- **Assets:** basic contents, such as text, images, sound, web pages, assessment objects or other pieces of data that can be delivered to a Web client.
- **Sharable Content Objects (SCOs):** a collection of one or more Assets. An SCO represents the lowest level of granularity for course materials that can be tracked by the LMS in the SCORM Run-Time Environment.
- **Learning Activities (Activities)**: an instructional event (such as a pretest, a lecture, and a final test) or events embedded in a learning object or as an aggregation of learning objects.
- **Content Organization:** a map (content structure) that can be used to aggregate learning objects into a cohesive unit of instruction (e.g. course, chapter, module, etc.)

For instance, a picture illustrates that a machine architecture can be stored in a JPEG file, with an HTML file to specify its location and other associated descriptions. The HTML file can be regarded as an aggregation, while the JPEG image file is an asset. An asset does not maintain communication with the SCORM run-time environment. However, with additional control programs, such as Java scripts, learning objects can be packed into an SCO, which follows a communication protocol and interacts with the SCORM run-time environment. A learning activity is a collection of instructional events, with or without references to an SCO. For instance, the instruction can specify a pretest, a lecture, and a final test in an activity for a particular session of a class. Content aggregation is a mechanism which is used to gather different portions of course materials. Aggregation is described in an XML file (see Figure 1) which is read by the SCORM Run-Time Environment when the associated learning object starts.

Figure 1: The SCORM Content Packaging (adapted from SCORM 2004 Specification in http://www.adlnet.org/)

For an instructor to find suitable contents for reuse, a search mechanism is necessary. Course materials may contain pedagogical properties, which may not be found by ordinary search engines. One of the remaining challenges for the SCORM specification is the design of a reasonable set of metadata which can be used to precisely and easily describe course materials.

According to IMS (http://www.imsglobal.org/), a content package (i.e., a representation of course materials) includes two parts: an XML document which describes the organization of a course object, and a set of physical files which contain learning objects. Usually, each physical content file is associated with an XML file which has the metadata. A few control programs which maintain the communication between a learning object (e.g., SCO) and the SCORM run-time environment are also included in a content package.

3 INTEROPERABILITY

The same learning object must necessarily be available on different computers and software platforms. The specification of SCORM run-time environment provides a standard protocol for learning objects to talk to its underlying Learning Management System (LMS), which is a machine and OS independent platform. The specification of SCORM run-time environment includes the procedures and responsibilities for learning objects to communicate with the LMS, a set of standard application program interfaces (APIs) for communication, and a data model which describes the messages passed between learning objects and the LMS. A sample client-server architecture for the implementation of the LMS is illustrated in Figure 2.

Typically, the LMS is installed in a central server, where all of the learning objects and student profiles are stored. Since students login to the server from the client side, it is necessary to install an instruction delivery system on a client computer. The decentralized installation avoids service traffic overload when the computation power of the central server is limited. The procedure for viewing a learning object starts with a launch process by the LMS. After that, controls are passed to the learning object (i.e. an SCO). An initialization is issued by the SCO, followed by a series of invocations to the API, which is handled through an API adapter on the client computer. In some cases, Java scripts are used in the SCO to enable interactions between the user and the learning object. The Java scripts call proper API functions, which check the status of the learning process. Before the SCO is closed, it calls the termination API function to terminate communication with the LMS. While the learning object is presented, the associated multimedia data are retrieved and presented by a Web browser on the client computer.

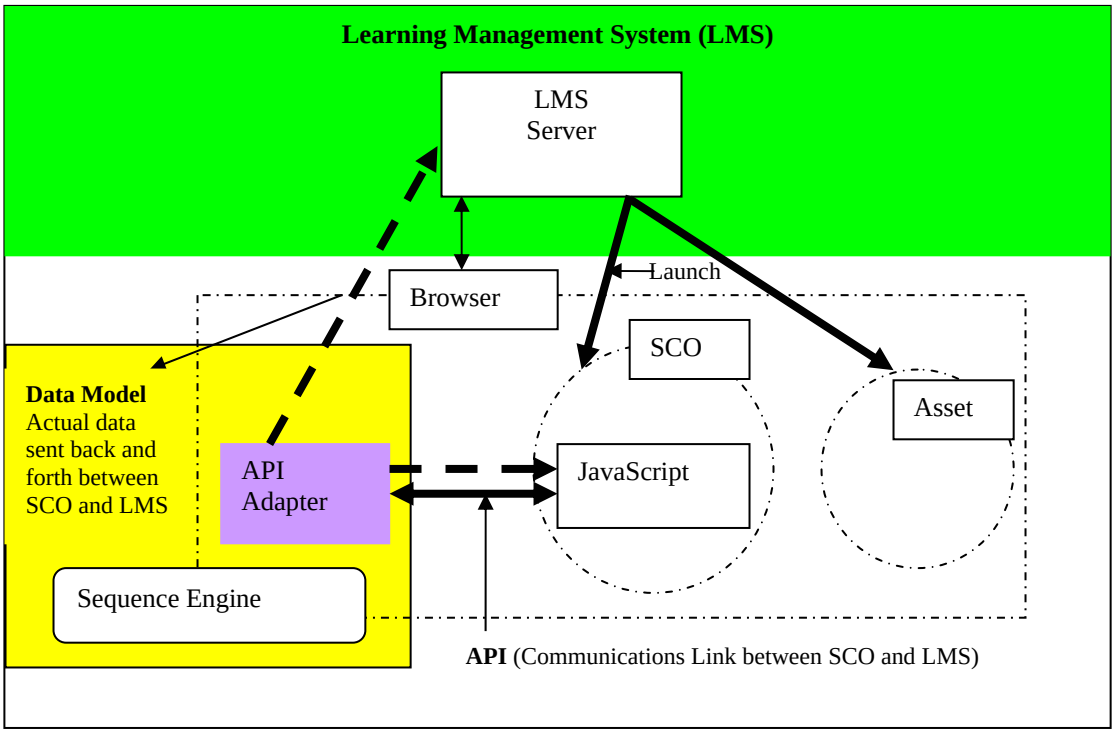

Figure 2: The SCORM Run-Time Environment (adapted from SCORM 2004 Specification in http://www.adlnet.org/)

4 PROJECTS RELATED TO SCORM AND IMS SPECIFICATIONS

A product directory (http://www.imsglobal.org/direct/getproducts.cfm) summarized by IMS provides information on SCORM-compliant and IMS specification related projects. We briefly discuss projects related to SCORM and IMS specifications below.

Authoring Tools

- A template-based authoring tool for creating learning and testing experiences was developed by the Blackstone Multimedia Corporation (http://www.blackstone.ca/).
- The *SCOmaker* (developed by the Boxer Technologies, http://www.scomaker.com) allows MS Office documents, such as PowerPoint and Microsoft Word files, to be transferred to SCORM 1.2 learning objects.
- The *CourseKeeper* is a LCMS (Learning Content Management System) developed by the Boxer Technologies (http://www.coursekeeper.com).
- The *Canvas Learning Author* provides an extensible, cross platform QTI (Question and Test Interoperability) development environment, which is developed by the Canvas Learning (http://www.canvaslearning.com).
- The *Learning Designer* (developed by the CyberMbA Corp, Korea, http://english.cybermba.com/main/e_main_omin.htm) is a progressive program for making e-Learning courses by generating course materials suited to SCORM.
- The *MINE SCORM Authoring Tool* (http://www.mine.tku.edu.tw/scorm) is a CSCW-like collaborative environment, which supports important issues of SCORM 1.3 specification, such as sequence rules, metadata definitions, and user definable templates. The authoring tool was developed by Tamkang University, Taiwan (http://foreign.tku.edu.tw).
- The *RELOAD Editor* (by the Joint Information Systems Committee, http://www.reload.ac.uk/) is a graphical tool for creating and previewing valid IMS Content Packages. The tool is freely available under the MIT Open Source License and is written in Java.
- The *IMS Assesst Designer* (by xDLSoft, http://www.xdlsoft.com/ad/) is an assessment creation tool, which follows the IMS Project Question and Test Interoperability (QTI) Specification.

Learning Management Systems

- The Aesthetic Technologies (http://www.mmizone.com/enlight) developed an LMS which enables seminars and manual evaluation of learner performance on Web browsers.
- The *Canvas Learning Player* provides a flexible cross platform QTI player, suitable for browser-based or stand alone delivery, which is developed by Canvas Learning (http://www.canvaslearning.com).
- The *CLI Virtuoso* (developed by the Cisco Learning Institute, http://www.ciscolearning.org) is designed to provide a complete, scalable, Web-based, e-learning platform with focus on collaboration, interactivity and personalized feedback for organization-wide e-learning.
- The *In.Form@* is the first Italian AICC and SCORM 1.2 LMS certified platform developed by the DIDAGROUP (http://www.didagroup.it).

- The *Digitalbrain plc* provides a powerful virtual learning platform, based on IMS content packaging and IMS metadata (Digitalbrain plc, http://www.digitalbrain.com).
- The *Learn eXact* is based on SCORM 1.3. The product supports authoring, packaging, and delivery of SCORM-compliant learning experiences on multi-devices. The *Learn eXact* is developed by the Giunti Interactive Labs (http://www.learneXact.com).

5 CONCLUDING REMARKS

SCORM 2004 is not widely accepted yet. One of the reasons is its complexity, which is more than 700 pages long and still expanding. The complexity should be hidden from the end users through automated tools and solutions. With the reusable and interoperable course materials, course material developers will be able to design and exchange course materials easily, and students and instructors will benefit from higher quality distance learning.

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