Extending SCORM LOM

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Abstract

The purpose of this discussion paper is to examine approaches for extending the ADL SCORM standard with additional metadata based on ADL approved methods. An introduction to the ADL SCORM standard is presented followed by a description of the SCORM components. Examples of how SCORM is lacking LOM in the areas pedagogy, adaptive learning and learning assessment data are then discussed. According to ADL guidelines, there are three predefined methods to extend SCORM: (a) adding new metadata elements, (b) adding new vocabulary for elements, and (c) references to an internal or external XML files using the location element. Each extension method is examined in detail and then is followed by a discussion of the three approaches.

Keywords: SCORM, Learning Objects (LO), Learning Object Metadata (LOM), XML

Introduction

Wiley (2000) discussed connecting Learning Objects (LO) to instructional design theory via defining LOs and then examining the LO LEGO block metaphor. Wiley defined a LO as a new paradigm for internet learning that is a digital, reusable component (or building block) which can be aggregated into larger modules. The concept of reusability is based on the availability of metadata that defines the content of the LO. Wiley defined metadata as descriptive information about a resource (e.g. data about data). Neven & Duval (2002) compared the architectural features of numerous Learning Object Repositories (LORs) and Learning Object Metadata (LOM) to provide information to user groups to enable them to select appropriate LORs to store their LOs. According to Neven & Duval, Reusable LOs are quickly becoming the fundamental building blocks for eLearning courseware. Sicilia, Garcia-Barriocanal, & Sanchez-Alonso (2005) provided an architectural approach called SLOR using the semantic lifecycle of a LO to facilitate machine understandable metadata for LORs to improve the automated process of searching a LOR. Sicilia et al. defined the functionality for a LOR as a data repository that is responsible for the storage and management of LOs and the associated LOM. Because of the recent advances in eLearning LOM standards development, some LORs use the Sharable Content Object Reference Model (SCORM) Content Aggregation Model (CAM) standard (ADL, 2004).

In 1997, the Whitehouse co-sponsored a kick-off meeting for the Advanced Distributed Learning (ADL) Initiative (ADL, 2006). In 1999, the USA Department of Defense (DoD) was mandated by Executive Order 13111 to develop common standards and requirements for eLearning for both public and private sectors (ADL). The DoD embraced the ADL Initiative as a way to satisfy the mandate. In January of 2000,

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the first version of the SCORM standard (version 1.0) was released. One year later, an updated version (1.2) of the SCORM standard was released. In 2004, a milestone version of SCORM (version 1.3.1) added many improvements by including the IEEE Learning Object Metadata (LOM) 1484.12.1-2002 Final Draft standard. According to ADL documentation, the SCORM standard is based on information from a variety of contributors. However, ADL (2006) specifically credits the origins of the SCORM standard to four organizations:

- Aviation Industry CBT Committee (AICC)
- Alliance for Remote Instructional Authoring and Distribution Networks for Europe (ADRIANE)
- Institute of Electrical and Electronics Engineers IEEE and Learning Technology Standards Committee (LTSC)
- Instructional Management Systems (IMS) Global Learning Consortium, Inc.

As mentioned above, the ADRIANE and IMS projects that contributed to the LTSC Final Draft 1484.12.1-2002 are mentioned by ADL as significant contributors to SCORM. Figure 1 shows the evolution of LOM standards over the last 14 years and the diagram highlights the synergy that existed between the various LOM projects. Although the ADL SCORM standard was initially independent from the IEEE LOM standard development, ADL changed direction before the SCORM V1.3.1 standard was published by incorporating the IEEE LTSC LOM Final Draft 1484.12.1-2002 standard into the SCORM standard.

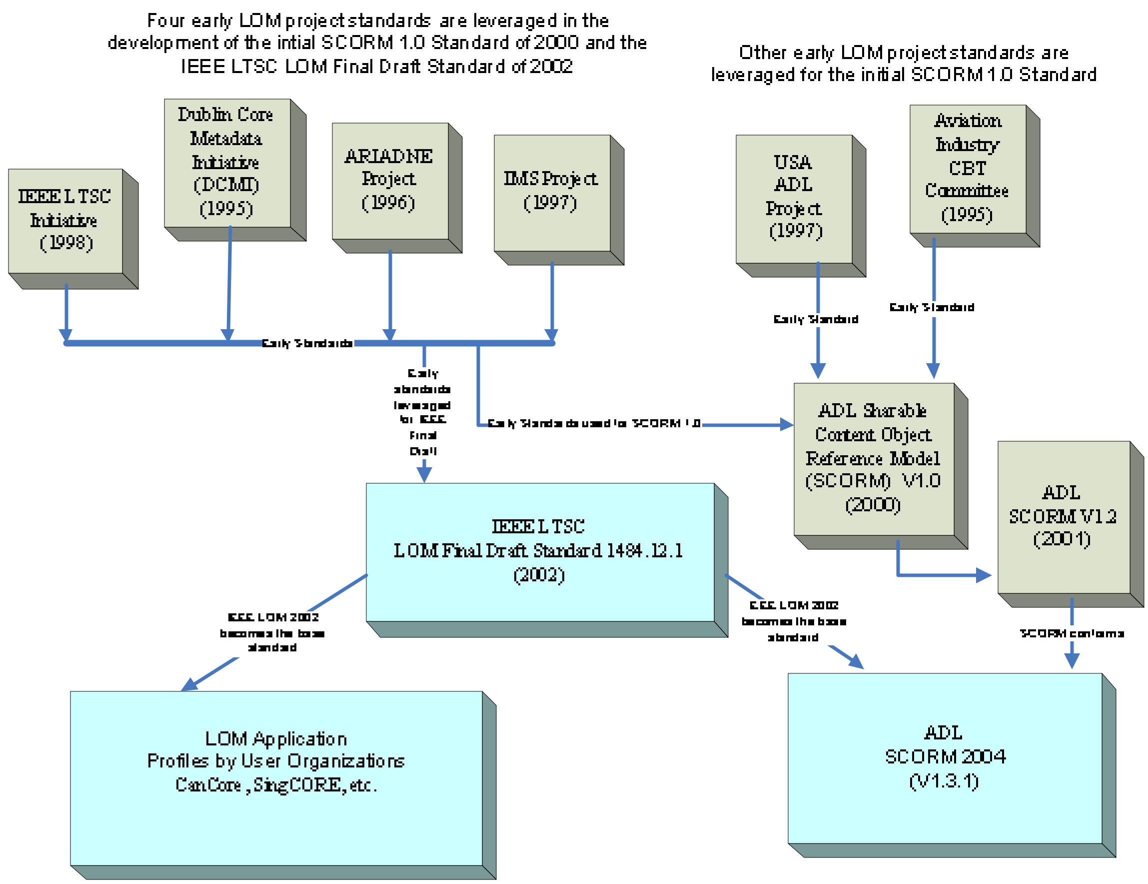

Figure 1: The evolution of the SCORM standard

Extending the SCORM Standard

The SCORM standard has limitations that are commonly discussed in the research literature. Mustaro and Silveira (2007) highlighted the fact that SCORM does not support the sequencing of LO components adequately to support adaptive learning. Adaptive learning is defined as a style of organizational learning that uses student successes as the basis for developing future learning directions while a student is participating in the eLearning course. Therefore, the researchers proposed the development of new eXtensible Markup Language (XML) structures to capture learning path LOM to facilitate LO component sequencing for adaptive learning. The Learning Object Educational Narrative Approach (LOENA) architecture was developed to use narrative-driven hypertext patterns to structure the sequencing of LOs beyond the simple sequencing that is offered by SCORM.

Huang, Webster, Wood, and Ishaya (2006) developed a context-aware eLearning approach by supplementing SCORM with pedagogy friendly data elements from the IMS Learning Design (LD) LOM standard. Huang, et al. noted that SCORM LOM does not adequately support the documentation of pedagogy. IMS LD LOM was developed using the Educational Modeling Language (EML). EML is offered by the Open University of the Netherlands and supports the modeling of LOM using both objectivist and constructivist learning approaches. Huang et al. suggested an intelligent semantic eLearning framework that would integrate a context model with semantic web technology and include an ontology/knowledge database. The Semantic Web is described by Huang et al. as the next generation of the World Wide Web (WWW) that will replace XML data communication with the use of ontology based data communication. Huang defines ontology as a formal representation of a set of concepts within a particular domain and the relationships between those concepts. Therefore, ontology is a step beyond conventional XML because it provides the relationships between data elements.

Earlier research by Sicilia (2006) defined ontological structures to capture and store LO design rationale within LOM. The Sicilia research supported the Huang et al. (2006) assertion by stating that there is consensus in the eLearning community that SCORM is inadequate for the documentation pedagogy. Sicilia proposed the development of a richer framework (e.g. extension to SCORM) that can capture the intellectual metadata for LO development to include the hypothesis, assumptions, and decisions made by LO designers. In other words, Sicilia believes that it is critical to offer LOM to document the thought process (heuristics) followed by LO designers during course material development. A large portion of Sicilia's research was focused on learning design theory and the analysis of two semantic frameworks.

Baker (2006) suggested improving the interoperability of LOM by removing ambiguity from metadata standards and proposed future directions for LOR tools. Baker stated that SCORM does not support the ability to document pedagogy. As Baker explains, SCORM is inadequate to document the interaction between LO stakeholders during the design process and SCORM does not offer the ability to capture the thought processes of LO designers. To resolve these two issues, Baker recommended extending SCORM to support the richer documentation of learning content by adding an ontological framework that would capture information about stakeholders and the pedagogical decisions that are made during the design process. In addition, Baker recommended the creation of new tools and services using Service Oriented Architecture (SOA).

Chang, Hsu, Smith, and Wang (2004) document the lack SCORM LOM for learning assessment data. SCORM version 1.3.1 provides assessment LOM for:

- User interaction
- Tracking of student learning progress
- LO component difficulty

- Semantic level
- Interactivity level
- Typical learning time required to complete a LO component.

However, Chang et al. notes that SCORM fails to provide LOM for cognition level, discrimination, distraction, and instructional sensitivity. The researchers suggested an extension to SCORM called the Metadata Information Model (MINE) that would provide additional LOM to support assessment data within SCORM.

Chang et al. (2004) defined an assessment data category for MINE that decomposed into four high level data elements: Cognitive Level, Question Style, Individual Test, and Exam. Each of the four high level elements decomposed into many subordinate data elements. The Cognitive Level data element consisted of six subordinate data elements that originated from the Taxonomy of Educational Objects defined by Bloom (1956) as knowledge, comprehension, application, analysis, synthesis, and evaluation.

The remaining data elements defined the components for the documentation of questionnaires, tests, examinations, quizzes, and include indices for discrimination, distraction, and instructional sensitivity. For future work, Chang et al. proposed extending SCORM to:

- Support additional question types
- Support multimedia assessment
- Support a question and answer authoring software application.

Researchers have been extending SCORM when they considered the data to be necessary to support new features for LOs.

SCORM CAM Component Details

According to ADL (2004), the SCORM Content Aggregation Model (CAM) standard was designed to:

- Describe the learning components for a learning experience (e.g. course materials).
- Describe a packaging method for the exchange of components between systems.
- Define a method for sequencing information within the components.
- Provide metadata that can be used for search and discovery of component content.

Therefore, SCORM CAM supports labeling, storage, packaging, exchange, and discovery of learning content (ADL). There are two major components of SCORM CAM, a Content Packaging Model (CPM) and a Metadata Model. The SCORM CAM CPM describes the learning resources that are assembled to create a learning experience. The development of the SCORM CAM CPM standard was heavily influenced by the IMS Content Packaging (CP) specification.

The IMS CP specification was developed by the IMS Global Learning Consortium (2006) to describe data structures, XML binding, and to provide guidance for the interoperability of Internet based content that is shared across Learning Management Systems (LMS), run time environments, and content design applications. A LMS is an independent computer system that manages and delivers course content to students via a web interface (Broisin, Vidal, Meire, & Duval, 2005). Since the SCORM standard can be extended with external LOM, early versions of the IMS CP standard where incorporated into the SCORM CPM standard. IMS continues to refine the CP specification and recently published the v1.1.4 final draft in 2006 (IMS).

The SCORM CPM standard is composed of assets, sharable content objects (SCO), (learning) activities, content organization, and content aggregation (ADL, 2004). Assets are the fundamental building blocks of learning resources and include electronic media that can be rendered within a LMS environment. For example, an asset can be a HTML page or graphic image. A SCO is a grouping of one or more assets, and is conceptually equivalent to Learning Objects that are described in the research literature. Unlike an asset, a SCO has the ability to communicate with a LMS using the IEEE ECMA Script Application Programming Interface (API) for Content Runtime Services Communication standard. Content Organization provides a mapping between content items and learning activities. Content Aggregation facilitates the structuring of assets and SCOs together to form a content package.

A Content Package represents a complete unit of learning (e.g. at least one SCO) that can be stored in a LOR or communicated to a LMS. A Content Package is composed of two primary components, a XML manifest file that contains information that describes the learning content and learning content data files (ADL, 2004). A XML manifest file is composed of four major sections:

- Metadata
- Organizations
- Resources
- Subordinate manifests

Metadata is information that describes the package content. Although not required, ADL strongly recommends that the metadata schema that is included in the manifest file follow the IEEE LOM Final Draft Standard 1484.12.1-2002 (ADL, 2004).

Approaches for Extending SCORM LOM

There are three permitted approaches to extend LOM within a SCORM manifest file: (a) new metadata elements, (b) new vocabulary values, and (c) the reference of an internal or external XML file using a location element (ADL, 2004). A XML namespace is a mechanism for uniquely naming elements when merging multiple XML schemas together. There are two options when using namespaces: (a) define a namespace using the syntax xmlns:<prefix> within the root node of a XML element, or (b) define a namespace in a XML element without a prefix. If the second option (e.g. without a prefix) is leveraged, then all subsequent child elements are assumed to be from the namespace. The SCORM CAM standard supports the addition of LOM at different locations within a manifest. For example, LOM can be inserted to describe:

- Content Packages (overall, high level)
- Content Organizations
- Activities
- SCOs
- Assets

ADL (2004) offers three validation (binding) methods for SCORM XML:

- Strict schema validation
- Custom schema validation
- Loose schema validation

Binding is defined as a set of rules that are applied to data prior to creating metadata instances and these rules exist in XML Schema Definition (XSD) files. Although the IEEE LOM standard considers all elements to be optional, SCORM classifies some elements as mandatory. Therefore, if the mandatory elements are provided in the metadata and the XML passes validation, then the XML can be classified as SCORM conformant. The risk of using non-conformant SCORM XML is that it may not be accepted by many applications (LMSs). Strict schema validation does not support the validation of SCORM extensions and therefore is not relevant to this research on extending SCORM. The custom schema validation method supports the extension of new elements and new vocabulary. Custom schema validation enforces uniqueness constraints for elements that are required to have only one value at a time, verification of vocabulary values (the second SCORM extension method described below), and new elements incorporated into the LOM using a different XML namespace (the first SCORM extension method described below). The customized approach allows a developer to leverage the SCORM validation tools provided by ADL. However, ADL warns that this approach will not allow for semantic interoperability between different organizations (e.g. external groups), therefore vertical communities must work together to build a consensus on new elements and vocabulary.

The loose schema validation, as the name implies, provides very little validation of the data prior to creating the metadata instance (ADL, 2004). Therefore, in addition to semantic interoperability issues with different organizations, the data within the XML may have syntactic (data errors) interoperability problems (Park & Ram, 2004). Unlike the custom schema validation, loose schema validation does not:

- Validate uniqueness
- Verify vocabularies

Therefore, loose schema validation requires the development of external validation tools to ensure that the XML data is correct. Loose validation can result in non-conformant SCORM XML. Therefore, ADL strongly recommends that researchers and developers do not use the loose schema validation approach for obvious reasons.

First SCORM extension approach

The first SCORM extension approach involves the addition of metadata elements to the LOM categories that are defined within the IEEE LOM Final Draft Standard 1484.12.1-2002. If this extension mechanism is applied, ADL insists that the semantics (meaning) of the new elements not be the same as the existing elements in the base schema and therefore not replace any of the existing elements (ADL, 2004). In addition, ADL requires that the new elements should not be defined as aggregate data elements, and that extended elements must retain the permitted values (value space) and the data type of the parent element. Aggregate LOM elements are defined as a repeating group of subordinate elements, such as a group of 50 test questions.

Zhu (2007) provides an example of extending the SCORM CAM LOM by adding two new elements to the general element (category) of the IEEE LOM Final Draft Standard 1484.12.1-2002. The new SCORM <Requirement> element describes the characteristics and functions of a service requested by an Open Content Object (OCO). An OCO is a software module (object) developed by Zhu that can provide services or request services via message passing. The new SCORM <Service> element describes a method name and the functionality of the method provided by an OCO. The fundamental premise of OCO is to facilitate message passing between applications using a LMS as a scheduling center. Zhu noted that by extending SCORM, his research enabled LO designers to use containers of OCO to aggregate learning contents and organize learning sequences by using the relationships between OCOs. Future work will include the extension of the OCOs to improve the flow of control when sequencing LOs (Zhu).

Ip and Canale (2003) provide another example of extending the SCORM CAM metadata by adding 26 new elements to the general element (category) in support of collaborative learning activities. Ip and Canale state that collaborative learning involves multiple learners that can communicate either synchronously or asynchronously using peer-to-peer network communication. Ip and Canale proposed SCORM LOM elements that provided:

- Course administrator contact information
- Course message content
- Instructor contact information
- Student session details
- Collaborative learning data formats

The researchers outline a revised development and activation model for SCOs that contains collaborative learning activities with six steps:

1. Subject Matter Experts (SMEs) create SCOs that may be composed of solo and/or collaborative learning activities.
2. Instructional designers assemble the SCOs into a course.
3. Course administrators install the course into a LMS environment.
4. Learners begin interacting with most of the course content asynchronously.
5. Group learners are arranged into study groups by instructors prior to beginning the collaborative learning activities.
6. Learners are assisted by instructors with the collaborative learning activities.

Ip and Canale concluded their research by stating that LO reusability was not compromised by adding new elements to SCORM and that one of their goals was to encourage other researchers to pursue SCO development for collaborative learning activities.

The advantage of using the first SCORM extension approach (adding elements) is that the new elements are integrated directly into the LOM (inline) and therefore are immediately visible to the metadata consumer within an organization. Also, the element extension approach is supported by the ADL custom schema validation method and therefore allows developers to leverage the ADL SCORM schema validation toolset (ADL, 2004). The disadvantage of adding new elements is that the new elements may not fit within the ADL guidelines if they are added below a lower level element within the base schema. In the Zhu (2007) and Ip and Canale (2003) examples, new elements were added at the <general> element level that is a high level category element (parent element) with few restrictions. The only restriction for Zhu, Ip and Canale using this high level element was to avoid introducing duplicate elements into the base schema. However, when dealing with lower level elements that may not have a clear content definition within the LOM, the task of verifying duplicate elements can be challenging and laborious (Godby, 2004). Godby compared and analyzed 29 international LOM application profiles to provide useful guidelines for user groups that chose to develop their own application profiles.

ADL also insists that extended elements must retain the permitted values (value space) and the data type of higher level data elements within the schema. The data types for new subordinate elements may not be compatible with higher level elements. Therefore, the new elements may have to be adapted to fit the higher level data type and permitted values (e.g. the process of putting a square peg into a round hole). ADL also prohibits the insertion of new aggregate elements with existing elements at lower levels. This ADL restriction can be especially troublesome for new elements that require repeating subordinate elements. An example of an aggregate element is a repeating group of 50 test questions.

Second SCORM extension approach

The second SCORM extension approach involves the addition of vocabulary beyond the defined element vocabulary values of the IEEE LOM Final Draft Standard 1484.12.1-2002 (ADL, 2004). To leverage the vocabulary extension approach, ADL recommends the use of custom validation methods that are detailed in the CAM documentation. ADL provides instructions for defining additional schema definitions that can be incorporated into the custom validation process. ADL warns that extending the vocabulary value set may reduce the semantic interoperability of the XML, thus it should be aligned with other vertical user communities. Elements that have a data type of “Vocabulary Type” will have additional information that is provided by the SCORM CAM documentation on whether or not the vocabulary is restricted or best practice vocabulary. A restricted vocabulary type means that that the value for the element must use the predefined vocabulary from the IEEE 1484.12.1-2002 standard.

For example, the <structure> element is classified as a restricted vocabulary element and therefore the <value> for the element must be one of the following five predefined values: atomic, collection, networked, hierarchical, or linear. Best practice vocabulary elements allow for addition of new vocabulary values, however ADL suggests that users adhere to the IEEE 1484.12.1-2002 standard as much as possible to avoid interoperability issues. An example of a best practice vocabulary element is the <role> element which has the suggested vocabulary <value> of creator or validator. However, the SCORM standard will permit a new value of inspector to be used for the value. Therefore, the XML for the new value would appear as: <value>inspector</value>.

The Zhu (2007) research as described above, suggested the addition of a new vocabulary value of “oco” for the resource type attribute. Normally the SCORM resource type attribute will only accept the resource type attribute values of “sco” or “asset”. Thus, Zhu extended the possible values of the resource attribute to include “oco” by using a new list of resource type values in a separate XML file that included: sco, asset, and oco. Using a namespace, Zhu merged this new list into the SCORM XML, thus replacing the current list provided within the LOM.

Rey-Lopez, Fernandandez-Vilas, Diaz-Redondo, Pazos-Arias, and Bermejo-Munoz (2006) suggested extending the SCORM CAM metadata vocabulary by adding adaptive learning vocabulary. Similar to what Zhu suggested for a resource type of OCO, Rey-Lopez et al. suggested defining a new type of SCO called a self-adaptive SCO. In addition, the researchers suggested adding a new category element called <adaptation> that contains subordinate elements to the SCORM <manifest> category element. The <adaptation> category element could be a child element of the <organizations> element. This new adaptation element would allow for the capture of adaptive data values, such as a student’s preferred sport.

Adaptive learning is explained in this research as a self-adaptive SCO that is capable of adapting to each student based on a student’s participation, a student’s preferences, and a student’s educational background (Rey-Lopez, et al., 2006). This new SCORM CAM metadata vocabulary would provide an Intelligent Tutoring System with the ability to use inference rules for Interactive Digital TV that personalizes course content on a per student basis. Rey-Lopez et al. provide two examples of how the inference rules are applied to user model characteristics to infer a value for a particular student’s preferred sport. Rey-Lopez et al. explained that this research was part of a much larger research effort to create an Intelligent Tutoring System (ITS) for T-learning education over Interactive Digital TV. T-learning is the convergence of two technologies, television and computer technologies, to create an interactive environment for training and educational activities (Aarreniemi-Jokipel, 2005). The Rey-Lopez et al. project was called the **M**ultimedia

Adaptive **E**ducational **S**ys**T**em based on **R**eassembling TV **O**bjects (t-MAESTRO). The researchers suggested that future work would consist of automating the gathering of user profile data from LMSs.

The advantage of using the second SCORM extension approach (new vocabulary) is that it allows additional data values to be accepted by an application without altering the fundamental structure of the SCORM LOM. Also, the vocabulary extension approach is supported by the ADL custom schema validation method and therefore allows developers to leverage the ADL SCORM schema validation toolset (ADL, 2004). As Zhu demonstrated, a new resource type of OCO enabled LMSs to use a new software module that provided message passing between applications. In the Rey-Lopez et al. example, additional inference rule processing was made possible by adding a new data element that contained new vocabulary values to the SCORM LOM.

The disadvantage of the second SCORM extension approach is that a researcher must develop new validation schemas for use by the custom validation method based on ADL instructions. Applications that use the extended SCORM XML will need to be altered to interpret the new vocabulary or at least be able to ignore the new vocabulary if it is not relevant to the application functionality. Also, as described above, a developer may encounter elements with a Vocabulary Type that is restricted and therefore will not be able to add new vocabulary for the element.

Third SCORM extension approach

The third SCORM extension approach establishes a reference to a standalone XML file using the ADL <location> element. The XML file can be internal or external to the primary file server (ADL, 2006). This extension approach is an alternative to placing the extension information in-line within the SCORM XML file (extension approaches one and two). This approach is leveraged to attach additional LOM and/or other asset files that are used by a package. XML Base is an optional construct used to explicitly specify the base Uniform Resource Identifier (URI) of a document in resolving relative URIs (partial URIs) for links to files. The partial URI value contained in the XML Base attribute is used as a prefix to subsequent location elements that are found throughout the manifest. The use of this attribute is a shorthand method to reduce the amount of URI text contained within each location element and therefore provides a fast method of changing the URI structural information at a high level from one central place within the XML. Internal and external references may be absolute or relative in the imsmanifest.xml file. Relative URIs, in the absence of xml:base attribute, are relative to the package root (the root is the location of the imsmanifest.xml file). If an xml:base attribute path is specified, relative URIs in the location element are relative to the path specified in xml:base attribute. A sample of the XML syntax for a relative internal location using the <location> element that uses the ADL namespace of adlcp is shown below:

<adlcp:location>/course/metadata/my_metadata.xml</adlcp:location>

In the example shown above, if an xml:base attribute was provided, then the base value would be prefixed to the internal location information. However, if an xml:base attribute was absent, then the root directory of the package would serve as the prefix for this location. Absolute URIs that specify a complete URI address to an external location are not altered via the xml:base attribute or the root directory.

Sicilia, Garcia-Barriocanal, Aedo, and Diaz (2005) provide an example of using the <location> XML element to extend the content package metadata of the <resource> element for an ontology that defines link types. The addition of a link type XML schema defines source and target internal relationships (links) between content package SCOs. This type of link was not defined within the IEEE LOM Final Draft Standard 1484.12.1-2002 or SCORM CAM, thus an extension to the LOM was required (Sicilia et al.). The researchers are assisting in the effort to build the Semantic

Web by defining LOM with a more precise mechanism to support the definitions of relationships (links). Sicilia, et al. (2005) defined a fourth type of learning resource called a Sharable Link Object (SLO) based on Fuzzy Set Theory to facilitate the links between SCOs. Adding a new resource type of SLO is similar to what the Zhu (2007) research accomplished two years later when adding a new resource type of OCO. Fuzzy Set Theory is defined by Sicilia et al. as a mathematical framework that can deal with imprecision or vagueness of the characteristics of a learner, thus a link (relationship) can be described in an abstract manner.

The major disadvantage of using the third extension approach with external files is that SCORM XML instances will not be considered conformant. As mentioned above, non conformant XML may or may not be accepted by application (LMS) administrators for installation. ADL prefers that all files including content for a package are grouped together in one directory structure. Then, all of the files can be bundled together within one zip file, thus making the XML package self contained. Another disadvantage to using this approach is that URIs that link to an external file server may have to be encoded (or escaped) according to the Request for Comments (RFC) 2396 World Wide Web Consortium (W3C) standard. Therefore, capturing a URI for an external file source is not an intuitive process for a developer. Another disadvantage to using the location element is that the external file must be accessible whenever the SCORM XML is used by an application. This requirement may place an unfair burden on the external file server on which the XML file resides.

The advantage of using the third approach is that it provides a means of referencing an external file while the SCORM XML is evolving. The SCORM XML may be changed during development and unit testing phases of a development project. If the unit testing results prove to be favorable, the external file can be moved to an internal location on the file server prior to the later testing phases of system testing, user acceptance testing, and the distribution to third party testers/users. Therefore, within a volatile development environment where the external XSD file may be constantly changing on a daily or hourly basis, this approach will allow the last version of the external file to be used during unit testing process.

Extending SCORM from a pedagogical perspective

Critics state that the SCORM pedagogy is simplistic and is more appropriate for training than for education (Abdullah, Bailey, & Davis, 2004). SCORM version 1.3.1 provides simple sequencing that allows a learner to progress forward through the learning material or to be routed backward to remedial material. However, simple sequencing falls short of personalized e-Learning as described by the adaptive learning community. Abdullah, et al. proposed a method of dynamically extending SCORM by adding adaptive links to a SCORM manifest to leverage predefined learning materials. Abdullah, et al. indicated that further research would include the development of a link authoring tool and an adaptive engine. As mentioned previously, Mustaro and Silveira (2007) highlighted the fact that SCORM does not support the sequencing of LO components adequately to support adaptive learning and therefore they developed the LEONA architecture to supplement SCORM. Mustaro and Silveira indicated that future work would include the development of an object-driven interface to convert abstract script conception into SCORM-compliant XML data. Moving forward, Mustaro and Silveira can use the first, second or third extension approach to extend SCORM. After a pedagogical decision is made to extend SCORM (e.g. with narrative sequencing data in this example), then choosing a SCORM extension approach becomes a technical decision that best accommodates the new metadata and the supporting software infrastructure. As mentioned previously, the third extension approach provides the most flexibility for extending SCORM by allowing the insertion of a XML file with no restrictions. With any of the three extension approaches, the major challenge for the researcher is the development of new software to process the additional metadata.

Conclusion

SCORM is a LO packaging standard that was developed by ADL (2006) that recommends using the IEEE 2002 LOM standard as the internal metadata standard. Various researchers state that SCORM is lacking LOM in the areas of pedagogy, adaptive learning and learning assessment data. SCORM can be extended by the three approaches of adding new metadata elements, adding new vocabulary for metadata elements, and references to an internal or external XML file using the location element. A SCORM package that is being deployed to an LMS that uses URIs to external files is considered non-conformant by ADL. Non conformant SCORM XML may be rejected by a LMS administrator. However, the use of the location element with an internal XML file link is considered to be a best practice by ADL (Sicilia, et al., 2005). Either method of using an internal or external file may require the development of supplement software to validate the new XML file as SCORM conformant.

A location element link to an internal file provides the two advantages because the link reduces the amount of clutter that is included within the SCORM XML file and the link avoids the issue of Internet network latency. Network latency is defined as the amount of time required to retrieve a file from a remote file server via a file transfer protocol. Since Internet network traffic is unpredictable, latency can become a major consideration for LMS administrators that want to manage the LMS performance. As mentioned previously, ADL prefers that all the LOM and content for a particular SCORM package is bundled into a zip file from an internal directory structure. External file references may be useful during the early development phase of unit testing. Changes that are made to the external XML file on a remote server can be immediately referenced in the SCORM XML for unit testing purposes.

The use of extension approaches one and two are also relevant to extending SCORM XML. For small amounts of LOM that will not clutter the XML package, this approach may be beneficial because the extensions are displayed inline with the XML. Therefore, consumers of the SCORM XML can easily identify the extensions when reviewing the file. Provided that a researcher follows the SCORM extension guidelines from ADL, then the SCORM validation toolset will be able to validate the XML. The decision to use a particular extension approach is dependent upon the quantity and complexity of LOM that will be added to the SCORM XML.

References

Aarreniemi-Jokipel, P. (2005). T-learning model for learning via digital TV. *16th European Association for Education in Electrical and Information Engineering Conference*, 1-6.

Abdullah, N. A., Bailey, C. P., & Davis, H. C. (2004). Augmenting SCORM Manifests with Adaptive Links. *Fifteenth ACM Conference on Hypertext and Hypermedia 2004*, 183-184.

Advanced Distributed Learning. (2004). *Sharable Content Object Reference Model (SCORM) Version 1.3.1 - Content Aggregation Model (CAM)* [Data file]. Retrieved March 26, 2007, from http://www.adlnet.gov/scorm/history/2004/documents.cfm.

Advanced Distributed Learning. (2006). *Introduction to SCORM and the ADL Initiative*. Message posted to http://www.adlnet.gov/aboutadl/index.cfm.

Baker, K. D. (2006). Learning objects and process interoperability. *International Journal on ELearning, 5*(1), 167-172.

Bloom, B. (1956). Bloom_Taxonomy.pdf [Data file]. Available from http://www.first2.org/resources/assessment/Bloom_Taxonomy.pdf

Broisin, J., Vidal, P., Meire, M., & Duval, E. (2005). Bridging the gap between learning management systems and learning object repositories: Exploiting learning context information. *Proceedings of the Ad-*

vanced Industrial Conference on Telecommunications/Service Assurance with Partial and Intermittent Resources Conference/ E-Learning on Telecommunications Workshop, 478-483.

Chang, W. C., Hsu, H. H., Smith, T. K., & Wang, C. C. (2004). Enhancing SCORM metadata for assessment authoring in e-learning. *Journal of Computer Assisted Learning*, 305-316.

Godby, J. (2004). What do application profiles reveal about the learning object metadata standard? *Ariadne, 41*. Retrieved from http://www.ariadne.ac.uk/issue41/godby/

Huang, W., Webster, D., Wood, D., & Ishaya, T. (2006). An intelligent semantic e-learning framework using context-aware semantic web technologies. *British Journal of Educational Technology, 37*(3), 351-373.

Ip, A., & Canale, R. (2003). Supporting collaborative learning activities with SCORM. *EDUCAUSE Australasia*, 669-678.

IMS Global Learning Consortium. (2006). (Version 1.1.4). imscp_sumcv1p1p4.html [Data file]. IMS Global Learning Consortium, Inc. Available from http://www.imsglobal.org/content/packaging/cpv1p1p4/imscp_sumcv1p1p4.html.

Mustaro, P. N., & Silveira, I. F. (2007). Learning object educational narrative approach. *Issues in Informing Science and Information Technology, 4*, 561-571. Retrieved from http://proceedings.informingscience.org/InSITE2007/IISITv4p561-571Must378.pdf

Neven, F., & Duval, E. (2002). Reusable learning objects: A survey of LOM-based repositories. *Proceedings of the Tenth ACM International Conference on Multimedia*, 291-294.

Park, J., & Ram, S. (2004). Information systems interoperability: What lies beneath? *ACM Transactions on Information Systems (TOIS), 22*(2), 595-632.

Rey-López, M., Fernández-Vilas, A., Díaz-Redondo, R. P., Pazos-Arias, J. J., & Bermejo-Muñoz, J. (2006). Extending SCORM to create adaptive courses. *European Conference on Technology Enhanced Learning*, 679-684.

Sicilia, M. A. (2006). Semantic learning designs: Recording assumptions and guidelines. *British Journal of Educational Technology, 37*(3), 331-350.

Sicilia, M. A., García-Barriocanal, E., Aedo, I., & Díaz, P. (2005). Using links to describe imprecise relationships in educational contents. *International Journal for Continuing Engineering Education and Lifelong Learning (3rd ed.), 14*, 260-275.

Sicilia, M. A., Garcia-Barriocanal, E., Sanchez-Alonso, S., & Soto, J. (2005). A semantic lifecycle approach to learning object repositories. *Advanced Industrial Conference on Telecommunications/Service Assurance with Partial and Intermittent Resources Conference/E-Learning on Telecommunications Workshop* (AICT/SAPIR/ELETE'05), pp. 466-471.

Wiley, D. A. (2000). *Connecting learning objects to instructional design theory*. Retrieved, 2006, from http://reusability.org/read/chapters/wiley.doc

Zhu, X. H. (2007). Extending the SCORM Specification for references to the Open Content Object. *Educational Technology & Society, 10*(1), 248-264.

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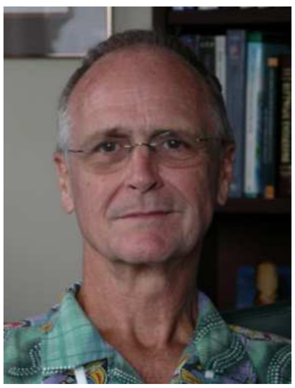
Bob Mason is completing his Ph.D. dissertation in Computer Information Systems at Nova Southeastern University (Ft. Lauderdale, FL). The subject of his research is Interoperability Gap Challenges for Learning Object Repositories & Learning Management Systems. He has a MBA with an emphasis in Computer Information Systems (CIS) from the University of North Texas (Denton, TX).

Bob has been employed for the last 24 years by various large corporations such as Cigna, Oracle, American Airlines, Frito-Lay, JCPenney, Qwest Communications, Dish Network (Echostar), Northrop Grumman, Electronic Data Systems (EDS), Lockheed Martin, Emery Worldwide (shipping), Computer Consultants of Australia, and Air New Zealand (Auckland, NZ), within CIS in the areas of database administration and software development.



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