



# Improving Learning objects reusability through automatic generation web services

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## **Abstract**

To support current needs of flexible e-learning environments, there is need for improved techniques to create, mix and find and compose user e-learning resources. These techniques need to take advantage of the existing web infrastructure and tools to further provide seamless integration with the Internet where most learning objects live. The main enabler has been standardization efforts built around the notion of metadata. However, this standardization effort is not naturally supported by the web infrastructure where e-learning operates. In this paper, we take advantage of the widespread adaptability of web services to provide flexible and composable learning objects as services. We automatically transform learning objects and expose them as services, thereby allowing Learning Management Systems (LMS) to take advantage of the inherent flexibility, agility and mature tools within the domain of web services.

**Keywords:** *web services, learning objects, re-use, e-learning*

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## **Introduction**

The flexibility, self-learning and non-linear nature of electronic media has made e-learning a viable means to provide learning content. E-learning offers several benefits as opposed to traditional learning including location and time independence, and availability of content even in remote places(Gottfried Vossen 2008). Moreover, with the continuing

unprecedented rate of mobile phone penetration, e-learning is yet to reach its peak. Key to e-learning systems is the need to re-use existing learning resources to build larger and improved learning resources. To support this need, researchers in e-learning technologies have focused on interoperability, transportability and re-use improvement powered by the evolution of metadata standards such as IEEE LOM and ADL SCORM. However, a number of critical issues still remain open that require further attention and in-depth research. First, is that the domain of e-learning has far too many standards creating a new interoperability challenge. Secondly, all these have not kept pace with developments in web infrastructure – the natural home and platform for e-learning. For instance, they do not incorporate modern Web 2.0 techniques where the web is seen as an interactive environment rather than a repository of static documents.

Currently, the re-use, growth and interoperability of e-learning is premised on the use of Learning Objects (LO) (Wiley 2000; Downes 2003; Elliott 2004). LOs have been defined by Wiley (Wiley 2000) as “any digital resource that can be re-used to support learning.” The essence of LOs is to have foundational building blocks for e-learning content that can be re-used in different contexts. Consequently, an LO is neither built for a specific context nor for a specific pedagogical design. This definition further indicates that anything done in learning such as content delivery, learner assessment, interactivity between learner and instructor, among others, can be supported by a learning object. The standard for Learning Object Metadata (IEEE 2002) developed by the IEEE’s Learning Technology Standards Committee (LTSC) defines a learning object as “any entity - digital or non- digital - that may be used for learning, education or training.

A common challenge with learning objects is that the cost of producing effective teaching and learning materials is time consuming (V. Ahmed 2007). There is therefore need to support maximum reusability to allow for the remixing of LOs. A common characteristic of learning platforms is that it is difficult for learners to find appropriate educational services such as courses, seminars, and web-based training applications. Corporate and independent learners aim to choose educational services from heterogeneous sources and of heterogeneous quality. However, since an electronic, world wide infrastructure for the mediation of educational service offerings is missing, learners’ choices of educational services are limited towards pre-selected catalogues. It is still very difficult to orchestrate a combination of learning objectives to deliver a bigger learning goal.

Web services provide a means of organizing services to utilize distributed capabilities. They support means to publish, discover and bind applications through well-defined interfaces. The set of standards include a standard specification for public registries known as Universal Description Discovery and Integration (UDDI 2004), a description language namely Web Services Description Language (WSDL 2007), a distributed object communication protocol called Simple Object Access Protocol (SOAP 2007) and a dynamic, self-defining information specification Language with semantic support known as eXtended Markup Language (XML). With this set of technologies, web

services provide an essential deployment environment to realize dynamic e-learning/e-business systems by facilitating application-to-application interaction. Web services can play a crucial role when it comes to the management of educational services. They can be used to announce and contract educational services, register learners, and feedback learning results. In order to combine educational services of different granularity levels, a workflow model is needed. For example, you may need to enroll into a specific assessment session before registering a course.

In learning objects repositories, online databases have been constructed by learning object developers that contain learning objects and their corresponding metadata or sometimes metadata only. Other online databases offer a centralized database containing metadata of the available learning objects on a single server and the learning objects are located elsewhere. Examples of such learning object repositories include Merlot, CAREO, POOL and NSDC (Downes 2003). In learning content management systems, a set of learning objects are integrated into one single package in such a way that other learning object developers are able to locate them and the learning content management systems are able to assemble the objects into standard compliant learning (Downes 2003).

The focus of this paper is to define transformation rules and develop a platform that can be used to transform LOs into web services. Given that web services are typically represented by WSDL files, we shall show how a LO object described in the LOM standard can be mapped into a WSDL element. We also describe how the new LO expressed as a service can take advantage of BPEL, an execution language for web services to create larger combinations of LOs.

## **Related Work**

Existing literature (Simon 2003; Devedzic 2004; Jose-Manuel et al., 2006) indicates that there is a concerted effort to support reusability and easy construction of learning objects. Beyond efforts in standards, (IEEE 2002; Downes 2003), there is general trend that sees web services to be the ultimate solution for the current incompatible standards in the e-learning domain.

In (Saddik et al., 2003), they propose a Web services oriented framework for e-learning systems aimed at providing a flexible integration model in which all the learning components and applications are well defined, effectively discovered and loosely connected. In (Gonzalo et al., 2006), BPEL is proposed to bring orchestration and collaboration of services.

Despite several efforts, we are not aware of attempts to auto-generate web services from learning objects. In our work, we introduce the notion of generic operators and also extend to composition of learning objects based on web service standards.

## **Re-use in Learning Management Systems**

Much as a number of such learning objects standards exist, for example, IMS content packaging standard, IEEE LOM standard, Dublin Core standard, among others, these

*Part 6: Improving Learning objects reusability through automatic generation web services* 505 standards provide a common data structure for defining the metadata of the learning object (Downes 2003). According to (Downes 2003) and (Cebeci and Kara, 2008), this common data structure includes the following;

Attribute	Explanation
Lifecycle	the history and current state of this learning object
General	description of the learning object as a whole
Meta-Metadata	information about the metadata instance
Technical	technical requirements and technical characteristics
Educational	educational and pedagogic characteristics
Rights	intellectual property rights and conditions of use
Relation	the relationship with other learning objects
Annotation	comments on the educational use of the learning object
Classification	relation to a particular classification system

The IEEE LOM standard requires that the learning object's metadata be stored in a single XML file and then be made available for the purpose of easy discovery and retrieval of learning objects from the repositories (Downes 2003). Due to this requirement, this standard is divided into two parts; the first part, called IEEE LOM Data Model standard (1484.12.1) specifies a conceptual data schema that defines the structure of a metadata instance for a learning object. The second part called IEEE LOM XML Binding standard (1484.12.3) describes an XML binding to enable the exchange of LOM instances between conforming systems that implement the 1484.12.1 data model.

### **Learning objects as Web Services**

In this section we show how learning objects can be automatically transformed into services. Consider the example in Listings 1, below of typical LO expressed in LOM.

**Listings 1: Extract of LOM representation**

```

<lom xmlns="http://ltsc.ieee.org/xsd/LOM"
  xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
    xsi:schemaLocation="http://ltsc.ieee.org/xsd/LOM http://
ltsc.ieee.org/xsd/lomv1.0/lomLoose.xsd">
  <general>
    <identifier>
      <entry>lo_repo/content/1296294053.xml</entry>
    </identifier>
    <title>
      <string language="en">photosynthesis</string>
    </title>
      <language>en</language>
      <description>
        <string language="en">description of photosynthesis</string>
      </description>
      <keyword>
        <string language="en">plants</string>
      </keyword>
    </general>
    <educational>
      <description>
        <string language="en">1</string>
      </description>
      <language>
        <source>LOMv1.0</source>
        <value>final</value>
      </language>
    </educational>
    <technical>
      <format>web page</format>
      <location>http://www.wiki.com/plants</location>
    </technical>
  </lom>

```

It can be observed that description at the basic level, a learning object should have three major parts summarized in the table below.

Section	Description
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Introduction	Which introduces the learner to the content presented in the LO. This could be a simple page that gives a summary about the LO.
Body	Which is the actual content of the LO for the learning process. Here the content presented in the body of the LO largely depends on the pedagogical method used by the designer. For example, the designer might choose to divide it into three parts namely; Engagement, Apprehension and Comprehension
Application	which is where the learner applies the knowledge gained from the LO, say, through a quiz

Similar to learning objects, a key component of web services is how they are described. Web services are generally described by an XML description document, expressed in the Web Service Description Language (WSDL). Given then that both LOM and WSDL are XML documents, the transformation process reduces to definition of mapping between the elements in the different documents.

### Transformation rules

The transformation of LOM to WSDL is supported by the commonality of tags. The table below shows the LOM elements (also known as tags) , and their corresponding WSDL component transformations. To enable quick searching, some of the description elements are mapped onto operations. For instance, the General.Language tag can be mapped to both the Definition.Documentation tag as well as new operation called `getLanguage()` that can be called on the service. As a convention, the dot notation is used to denote nested tag elements.

LOM	WSDL
<b>General</b>	
General.Definitions	Definitions
General.Identifier (a globally unique label that identifies this LO)	-Targetnamespace = uri
General.Language (the primary human language used within this LO to communicate to the intended user)	-Definition.Documentation -portType.Operation= getLanguage()
General.Description (a textual description of the content of this LO)	-Definition.Documentation
Metadata (describes the metadata record itself rather than the LO)	-Message (an abstract, typed definition of the data being communicated.)
Technical (describes technical requirements and characteristics of the LO)	Binding (a concrete protocol and data format specification for a particular port type.)
Technical.Format (technical datatypes of this LO)	Types (a container for data type definitions using some type system (such as XSD).)

LOM	WSDL
Technical.location (a string that is used to access this LO e.g. url)	Port (a single endpoint defined as a combination of a binding and a network address)
Educational (describes key educational characteristics of the LO)	Message (an abstract, typed definition of the data being communicated.)
Educational.Context (The principal environment within which the learning and use of this learning object is intended to take place)	Service (a collection of related endpoints)
Educational.description (Comments on how this learning object is to be used)	-Defintion.Documentation -PortType.Operation = getEducDescription()
Educational.language (The human language used by the typical intended user of this learning object)	Defintion.Documentation -PortType.Operation = getEducLanguage()

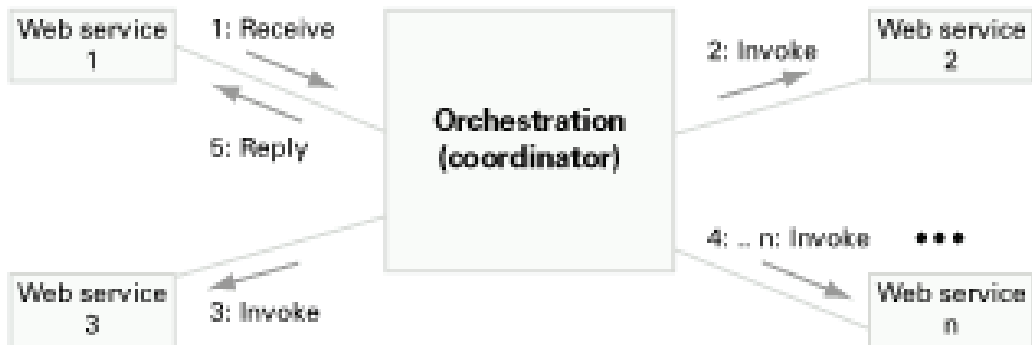
### Generic operations

To address the different types of learning objects, we introduce the notion of generic operations during the transformation process. For instance, an LO whose content is a video clip needs to be supported by operations such as play, pause, preview, resume, view and so on. Below is a table of the operations supported.

Content Type	Operations
Video	Play, Preview, Resume, Pause
Audio	Play, Resume, Pause
Text	Read, View, Bookmark

### Flexible Composition of Learning Objects

BPEL is focused on the orchestration of SOAP web services and based on XML, so it facilitates the interchange formats and brings interoperability. It provides a relatively easy and straightforward way to compose several web services into new composite services called business processes. BPEL, therefore, extends the Web Services Interaction model, enabling support for business transactions. Business processes can be described either as executable, whereby the actual behavior of a participant in a business interaction is modeled, or as abstract, whereby descriptions specify the mutual message exchange behavior between parties without revealing their internal behavior (BPEL 2007). LOs can be exposed as web services, and described in an abstract manner, allowing for them to be easily integrateable, and reusable (as Figure 1 below illustrates) (BPEL 2007).

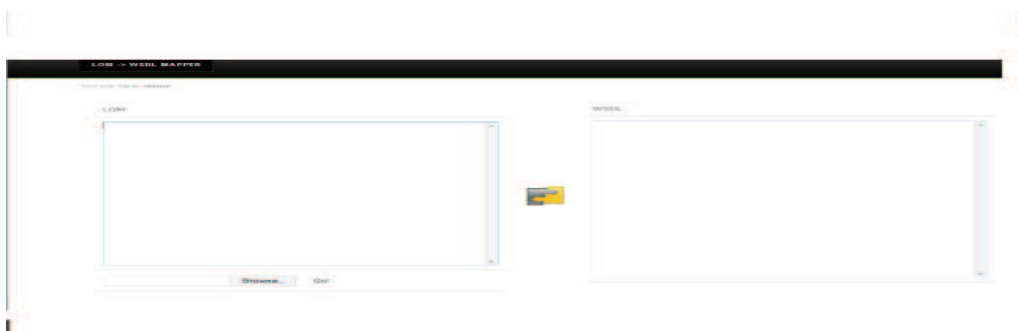
**Figure 1: Web service orchestration**

One of BPEL's design goals is to define processes that interact with external entities through webservice operations defined using WSDL. This fits the use for LOM element transformation to web services. Each LO is exposed as a webservice, and the BPEL process specifies the exact order in which the services should be invoked.

The process receives a request, say for a specified education service, invokes the involved services, and responds to the request. For example, to compose a LO combining video and audio content types (services) together, the learner invokes the process by specifying the name of the content they wish to study. The BPEL process will then invoke the respective services for the audio and video content asynchronously and return the results to the learner, who will then choose the operation to be undertaken next. This defines a new composite/larger service built from existing services. It also gives the learner an opportunity to choose educational services that are from heterogeneous sources, and therefore quality.

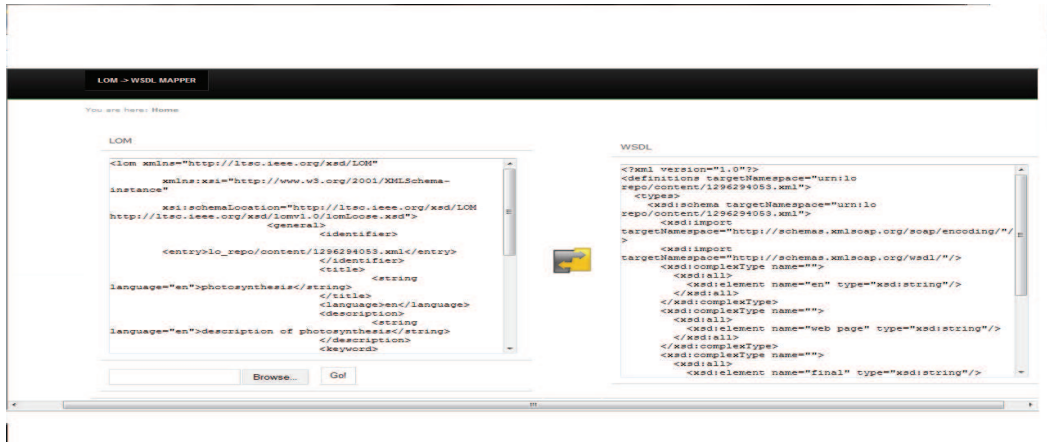
## Implementation

The implementation allows for automatic conversion of LOs to services and auto-generation of the WSDL document that describes the service. Figure 2, shows the user interface where the user can browse and load XML representations of the LOs. Once the XML is loaded, the middle button is then pressed to show the corresponding service on the right.

**Figure 2: LOM to WSDL user interface**

During conversion, it is very easy to check the original XML against the new WSDL document, given that both are displayed side-by-side as indicated in Figure 3. Once the web services are generated, they are stored in a repository, where they can be searched for for re-use using web service standards.

**Figure 3: LOM to WSDL transformation**



## Improvements

The LO to WSDL transformation brings with it all the advantages that web services offer, which can therefore be extended to the LOs, including, among others:

- The ability to engage and integrate other learning objects, also presented as web services and of different granularity levels, in order to compose larger objects and consequently achieve more comprehensive learning objectives.
- The learning objects, stored as web services, are able to inter-operate with other applications that are also based on open standards.
- The learning objects are then rendered more scalable, making it easier and cheaper to add features and other learning components, facilitating easy customization and enhancing reuse.
- Also, since the transformed webservices are stored in an online repository, they can be accessed at any time, from any location and provide an electronic infrastructure for mediation of education services.

## Conclusion

In this paper, we defined transformation rules and developed a platform that can be used to transform LOs into web services. Further, we have described how flexible composition is achieved when LOs are expressed as services. The use of BPEL allows for innovative orchestration of learning resources with interoperability that is inbuilt into service-oriented architecture. As part of future work, we shall extend automated conversion of services to cover other LOs standards other than LOM.

We conclude by mentioning that a service-oriented approach to developing e-learning objects opposed to the conflicting and incompatible standards that has been the case in the past, is inline with general developments in web infrastructure, specifically web 2.0 that focuses on easy re-use, growth and interoperability of e-learning components.

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