An integrated learning resource management system with web services

Yushun Li  Zheng Chen  Ronghuai Huang  Xiaochun Cheng  
School of Education Technology  
Beijing Normal University  
Beijing, China  
lyshun@bnu.edu.cn  
School of Computing Science  
Middlesex University  
London, UK  
xiaochun.cheng@gmail.com

Abstract—In recent years, there are some new directions in learning resource management and sharing research field, which mainly focus on innovative methods to promote sharing and reusing learning resource in modular manner, to create system with capabilities suitable for personalized learning and mobile learning. The feature of adaptive capability becomes more and more important in these systems. These requirements demand new generation e-Learning system. The paper introduces an approach to design new generation learning resource management and sharing system according to these requirements, which should be realized with bottom up design, and the system adopted this approach should be implemented with technologies of reusable Learning Object and Web Services, and furthermore, these technologies should be integrated inherently according to a integrated framework, and provide programmable learning resource management facilities. The design approach has been initially validated in the realization of a prototype system aimed to provide capabilities aforementioned.

Keywords: Learning resource management and sharing system; Learning Object; Web services

I. THE STATUS OF RESEARCH ON LEARNING RESOURCE MANAGEMENT AND SHARING

The sharing of learning resource is always basic requirement in e-Learning area, and with the maturity and prevalent deployment of Learning Management System from 1990’s, the management and sharing of learning resource become a leitmotiv of e-Learning, and there have some new directions in this research field:

The first is sharing and management learning resource in modular manner. The most obvious motivation is the economic interest of reusing learning material instead of repeatedly authoring it, and accordingly, new technologies, such as Learning Object technologies, have been proposed according to this demand. Today, the management and sharing of learning resource with Learning Object technologies has been agreed by most researchers in e-Learning communities.

The second is delivering learning resource according to requirements for personal learning, situated learning, contextual learning, etc. Motivations can be found in the pedagogical area since learner-centric teaching theories invite instructors to use a wide variety of didactic material, and accordingly, the capability for adaptive learning resource delivering should be provided by learning resource management and sharing system in personal, intelligent style.

The third is designing new learning resource model for mobile learning. Mobile learning has been the most promising learning method in learning science, and the way for integrating mobile learning into mainstream of education has been research topic of the field[1][2]. Compare to traditional educational technology, a lot of aspects in learning will be changed in mobile learning environment, such as learning devices, learning scenarios, new educational approaches etc., and accordingly, there have some new research topics appeared in mobile learning environment[3][4], and among them, new learning resource model and related management system has been the hot topic of mobile learning.

The forth is open education resource sharing. From the initiate of MIT OCW (Open Courseware) from 2002, the development of OER (Open Education Resource) has been greatly developed[5], and now, the idea of OER has been expanded to all over the world[6][7], and accordingly, these initiates strength the requirements for new generation learning management and sharing systems.

The fifth is construct infrastructure for learning resource management and sharing. Nowadays, the infrastructure of learning resource management and sharing in intra-organizations for regions or for a nation has been recognized as the foundation for knowledge society, and it is very important for learning resource sharing. There have some countries endeavoring in this direction, such as Australia[8], America[9], UK[10], etc.

Today, there have many research activities in all of these directions, but most of them just focus some aspects of the requirements, and research endeavors are scattered in these directions. Now, it is urgent to carry out more synthetical activities on the research of learning resource management and sharing, in which some groundwork for new generation learning resource management should be the emphases. The paper introduce our viewpoint on the necessity for research on learning resource with more integrated approach, the method for design integrated learning management and sharing system, and a prototype system has been developed for validation.

The paper is organized as follows: in section 2, the technologies for the new type learning management and sharing system are introduced, and an approach for creating integrated learning management system is considered. In section 3, a prototype system is introduced, which integrate technologies of Learning Object and Web Services inherently, details of the key features of the system is explained. Comparison between our research and some other similar efforts are presented in section 4. With the prototype
system, more research activities should be carried out for perfecting the system, and validating philosophy for the design approach, this plan is briefly introduced in section 5.

II. THE DESIGN OF INTEGRATED LEARNING RESOURCE MANAGEMENT AND SHARING SYSTEM

The research of the paper focus on the approach and the way for the realization of integrated learning resource management and sharing system, which can provide an integrated solution for resource sharing in modular manner, for adaptive features demanded within various learning scenarios, such as for personal learning, mobile learning, etc.. With our research, the key for creating such kind system is to integrate technologies of Learning Object and technologies for realizing adaptive features of system together, furthermore, programmable facilities should be provided for dynamic and extensible function configuration of the system. According to our viewpoint, the technologies of Learning Object and Web Services should be the essential elements for realizing an integrated framework.

A. The Technology of Learning Object

The technologies of Learning Object have been developed continually in slow steps for a long time in e-Learning communities. After great effects on research and practices, the idea of Learning Object has been accepted widely in e-Learning area, and there have some known international effects, such as[12][13]. The separated e-Learning facilities (such as Learning Management System and Learning Content Management System) accelerate the acceptance of LO’s notion in e-Learning area, and now, it has been the essential element in e-Learning’s facilities.

The Learning Object is a small unit of instruction that can be reused in many lessons, typically a slide show, tutorial or a test. The IEEE Learning Technology Standards Committee (LTSC) defines a Learning Object as “any entity, digital or non-digital, that can be used, re-used, or referenced during technology supported learning”.[14] Some metadata specifications have been proposed for this purpose, and in order to be pedagogically relevant, researchers has agreed that the specifications for LO should also include specific educational elements. The LOM (Learning Object Metadata) standard includes such data elements. Consequently, Learning Object Repositories typically use this metadata for storage and retrieval of Learning Objects. A more defined view was expressed by Frank Farance at the LTSC meeting (on10th August, 1999) where he described Learning Objects as the result of the association of learning assets (reusable learning resources) with LOM metadata.

The standard of LOM has been accepted by research communities all over the world, and to reach the localization needs and interoperability of Learning Objects, many countries would adopt application profile approach, such as Canada CanCore, UK LOM Core etc. SCORM from ADL is also such an application profile, and it has been a de facto learning resource package standard, which has been adopted by many commercial e-Learning systems, includes Learning Management System and Learning Content Management System. On the other hand, the research on learning resource management and sharing is also carried in these communities, for example, there have some research work on the learning resource sharing based on SCORM specification, and CORDAR(Content Object Repository Discovery and Registration/Resolution Architecture) is such a research effort supported by DARPA of US, which aims to create distributed learning resource sharing infrastructure for learning resource conformed to SCORM specification[15]. In fact, there have some other research efforts on learning resource management and sharing with Learning Object technologies[16][17].

According to the research activities aforementioned, the emphases of them is on the sharing (reusing) aspects of learning resource with technologies of Learning Object, and therefore, they usually neglect or pay little attention to the mechanism for the realization of adaptive feature for such kind systems. Because of the absence of programmable facilities, the functions for realizing adaptive features in these systems could not be extended and deployed according to requirements (maybe appeared after system development phase). The technologies of Web Services can be used to solve the problem and create a more integrated learning resource management and sharing system.

B. The Technology of Web Services

In recent years, the development of Web Services is great [18], which supplies a kind of interface for communicating and sharing resources among independent platforms and realizes interoperation among these platforms. The World Wide Web Consortium defines web services as “a software application identified by a URI, whose interfaces and bindings are capable of being defined, described, and discovered as XML artifacts. A web service supports direct interaction with other software agents using XML-based messages exchanged via Internet protocols.” Web services expose the functionality of an information system and make it available through standard Web technologies. They build on a number of standards, in particular XML to tag data, SOAP to transfer data and WSDL for describing the services available. Web services is supposed to facilitate internal and external integration across platforms (inter- or intra). Services encapsulate functions with a high level of interdependencies (cohesion) and are at the same time highly independent from other services (loose coupling).

On accounting of the above features of web service, the paper tries to adopt the basic principles of Web Services to construct a new resources sharing mechanism and provide a unify facilities for extensible programmable and reconfiguration for dynamic operations on Learning Objects.

C. the Design of New Generation Learning Resource Management System

To summarize, the technologies of Learning Object are related to metadata schema and binded learning resources, while the technologies of Web Services can be used to create component and normalized mechanism for function realization of system, which provides the foundation for the realization of relax-coupled and extensible functions of
system. Therefore, the technologies of Learning Object can be used for learning resource sharing, interoperability in modular manner, and the technologies of Web Services can be used for the realization of functions for learning resource extraction, transformation, etc., and it is especially suitable for extensible and flexible capability of system, which make it suitable to be the underlying technologies for new generation learning resource management and sharing system. Thus, for new generation learning resource sharing system, these two kind technologies should be integrated together according to an integrated framework. This is the viewpoint of our research, and it also reveals the approach of our research for creating integrated learning resource management and sharing system.

III. THE INITIAL REALIZATION OF THE SYSTEM

In our research, the approach aforementioned has been initially validated in a prototype system. For system realization, a metadata schema for mobile learning, personal learning etc. is designed firstly, then, the metadata schema is realized into Fedora\textsuperscript{[16]}, which is a open source project for managing rich content, and Fedorad is modified and extended for realizing the integrated learning resource management and sharing prototype system. The technologies of web service are inherently integrated in the system, and can be used for realization of dynamic features for learning resource sharing system. The approach for the system design is introduced in the following paragraphs.

A. Integrated Model of the design

According to the orientation of our research, a special metadata schema is proposed, in which some metadata elements are selected from the specifications of Dublin Core, IEEE LOM, etc., which is selected especially for educational requirements, and other elements are extended for semantic relationship and mobile learning requirements, and Learning Object described by this metadata scheme is called ULO (Ubiquitous Learning Object) (refer to figure 1). The elements in this metadata schema is classified into two levels, the upper level is related to the whole features of ULO Learning Objects (refer to figure 2), and the lower level is used to described medias binded to a special ULO (refer to figure 3). Details explain of these elements in the schema can refer to the literature\textsuperscript{[20]}.

Then, the metadata schema is realized into Fedorad, which is implemented through modify the data model of Fedora system, and the work is carried based on the source code of Fedora. The data model of Fedorad is displayed in the left part of figure 4, which is made up of four parts, and they are Digital Object identifier, Reserved Datastreams (used for key object metadata), Datastreams (used for aggregate content or metadata items), Disseminators (used for provide web service function). In the model, the part of Reserved Datastreams is modified according to our proposed metadata schema, which is displayed in the right of figure 4. This is the uniform framework referenced by the prototype system.

In the prototype system, the technologies of Web Services are inherently embeded. The Fedora service framework facilitates the integration of Web Services with the Fedora, and it takes a service-oriented architecture approach to adding new functionality around a Fedora data object repository, allowing new services to be built around the core repository as stand-alone web applications that run independently of Fedora. Besides, the power of Fedora lies in its ability to associate the data in a digital object with special web service to produce dynamic disseminations.

The programmable facilities for flexible and extensible functions in the prototype system is described in figure 5, which is realized with Web Services technologies and inherited from Fedorad. In the system, the operations on a ULO can be extended and reconfigured with web service, which is implemented with two kinds of Fedora data object. These two kinds of Fedora data object are Behavior Definition object and Behavior Mechanism Object, and they are special data object in Fedora. Among these two kinds of data objects, \textit{Behavior Definition (\textit{bDef})} object is a digital object used as a template for client-side functionality, defining a set of abstract operations (methods) and their
client-side arguments. Behavior Mechanism (bMech) object is a digital object that registers within Fedora with the capability of web service to perform the operations defined by a specific bDef. This registration includes defining service binding metadata encoded in the WSDL (Web Service Description Language) and also a data profile of the bMech. The data profile defines the types of inputs that are considered compatible with the service. These two kinds of special Fedora objects are stored in Fedora repositories. The set of all bDefs represents a “registry” of all the kinds of abstract services supported by Fedora data object repositories. Other digital objects make references to bDefs and bMechs as the way of providing extended access points for digital objects (i.e., dynamic content disseminations), and this is done by adding a special component to a digital object known as a Disseminator. Disseminator is a component added to any digital object that ties together a bDef and a bMech in the context of that digital object to produce extended service-based functionality for that digital object.

![Figure 4. Extend data model of Fedora to ULO model](image)

With the flexible and extensible programmable facilities by Web Services technologies, the functions(operations) on a ULO can be extended and reconfigured in flexible means, which is important for the realization of adaptive features of learning management and sharing systems, and now, according to our research, the web service in the prototype system has been planed into three categories, one is used for realization of adaptive features suitable for e-Learning (on the medias of a ULO), the second is used for the operation on Learning Object relationships (semantic relationships), and the third is used for general Learning Object operations.

All these services can be integrated with Fedora framework easily, which can be integrated with two kind methods: First, Dynamic content delivery: any special web service can be associated with any of the data streams in a ULO object. As a result, a ULO object can deliver dynamic content: the output of a web service processing data in the object. Second, Management and Access APIs: ULO object repository runs as a service within a web server, and all of its functionality and all features of its ULO object model are accessible through well-defined REST and SOAP interfaces. Thus, the functions of the prototype system can be easily integrated into a variety of application environments with different user interfaces.

![Figure 5 mechanism for function extend in the system](image)

With the aforementioned design approach, an integrated learning resource management and sharing system can be created, which is different to existing system for learning resource management. With the approach, the functions from Learning Object technologies, adaptive capability produced from the operations on Learning Objects can be integrated in an integrated framework, and programmable facilities are provided for the environment, which are realized by technologies of web service for abstract operation definition, implementation, and dynamic binding.

### B. The Realization of the Prototype

The proposed idea for integrated learning resource management and sharing has been initial validated in a prototype system, which is called SULOMS (Semantic-oriented Ubiquitous Learning Object Management System) (refer to figure 6), and the functions has been the foundation for more advanced learning resource sharing environment, which mainly focus on the support for mobile learning. Now, the integrated functions for learning resource management and sharing have been implemented in the prototype system, which can be used for ULO object creating, ingesting, storing, and adaptive delivering for varied learning contexts, and specially, the operations on ULO object can be reconfigured and extended according to adaptive features required by different learning contexts.

At present, some core modules of SULOMS system have been developed (refer to figure 6). They are ULO module, adaptive module, mobile terminals module, and course structure management module, etc. (1) ULO module is provided to enable resources providers (such as teachers, curriculum experts, etc.) to package learning resources in the way of ULO. Fedora uses Dublin Core to describe Learning Objects by default, and it has been expanded by our research team to our proposed metadata schema. After that, the system can support creating, adding, deleting and modifying ULO objects. These functions have been implemented now; (2) Adaptive module can be used to choose appropriate ULO and its binded learning resources dynamically for learners according to terminal characteristics, learner preferences and learner styles. (3) The course structure management module can be used to provide convenient access for teachers or resources providers when they build their own course structure and create ULOs under the course structure.
Figure 6. the architecture of the prototype system

To summarize, the prototype system provide a integrated, flexible learning resource management and sharing system that facilitate to uniformly store, manage, and deliver all their existing learning resource with adaptive capability, and also it can accommodate new functions that will inevitably arise in the future.

IV. COMPARISON

There have some similar efforts within the research filed of our research. In literatures [21-23], learning resource encapsulated in Learning Object can be delivered to mobile devices (such as PDA), which is realized with different approaches and technologies. In literature [21], WSORA (Web Services Oriented Rendering Architecture) was proposed, which has three modules, modified version of the IEEE LOM, LOM Editor, and Device-independent LO generator. In these three modules, LOM Editor with published web services is used to make a device-independent m-learning gateway between different mobile devices and the learning objects available on the WWW. In literature [22], mobile learning course scenario model is proposed, and the module can be built or linked with basic atomic learning objects. In literature [23], an architecture was proposed to support m-Learning process, which mainly focus on implementing learning object repository for mobile devices, and learning objects are stored in the repository, which include study guidelines, summaries and auto-evaluation tests. Although these efforts aim to create learning resource with Learning Object technologies and some web service technologies, they are different to our approach, because programmable facilities for dynamic binding between special Learning Object and various web services are realized in our system. There are also some other research efforts, such as in literatures [24-27], which focus on the revolution of e-Learning systems with web service technologies. Compared to these research efforts, our approach emphasize on the capability of integrated, extensible and flexible web services with Learning Object model, which is more general and more basal for Learning Content Management.

V. THE DIRECTION OF FURTHER RESEARCH

Now, based on the realized functions in the prototype system, and more advanced work has been carried out in the system, which include creating more advanced learning resource sharing system based on semantic technology, developing learning resource sharing functions for querying, subscribing and delivering, designing adaptive engine for various terminals in mobile learning environment. Semantic operation API (implemented with web service) should be provided. The research has planed to integrate all learning resources in a course (English learning) into the prototype system, and to conduct a preliminary application in undergraduate students in our University. All these work aims to verify and improve the design method of the prototype system, and further validate the system approach.

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