A Learning Resource Metadata Management System Based on LOM Specification*

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Abstract

The rapid increase of learning resources makes it difficult for searching, managing and reusing. Using metadata is an efficacious way to solve this problem. With consistent descriptions of the characteristics of learning resources, searching becomes more specific and accurate, managing becomes more simple and uniform, and sharing becomes more efficient and in-depth. Learning Object Metadata Schema developed by IEEE P1484.12 is one of the most promising metadata approaches for describing learning resources, on which we developed a Learning Resource Metadata Management System (LRMMS). The system provides a platform for users to register, browse, search and evaluate learning resources. It is a decentralized framework with several metadata servers to provide services. The system supports distributed queries and evaluation loop of learning resources. Users can search resources from different points of view, especially educational needs. We also made the interface as user-friendly as possible.

1. Introduction

As the number of learning resources available on and off the Web continues increasing greatly, it has become difficult to find, access and reuse useful resources [5, 7]. In this case, we need a union catalog to locate and obtain the information on different sites, just as library uses catalogues to find books on shelves. A standard metadata set on learning resources and an interchange method for these metadata make the union catalog possible [5].

With the consistent description of the learning resources using standard metadata, focused search can be performed accurately and efficiently. Aside from the basic importance of metadata in searching, it also plays a fundamental role in managing, evaluating and sharing of resources. The Learning Resource Metadata Management System (LRMMS) developed by our research group at Tsinghua University adopted the Draft Standard for Learning Object Metadata (LOM) [1] launched by IEEE LTSC Working Group12. LOM schema was shaped out of the preceding metadata schemas of learning resources and received extensive attentions both from academic communities and enterprises. It fully describes the attributes of a learning resource as well as keeps itself general enough. This informative and uniform description, the coming metadata standard, will facilitate the sharing of learning resources and the development of many useful learning systems. The LRMMS is an instance of these applications, whose learning resource metadata are strictly conformed to LOM description model which will be expounded later in this paper. As a practice system of the LOM schema, we hope it can provide useful clues for the consummation of LOM standard and its localization in China. The system will be added the function of LOM schema conformance check, serving as the test platform of Chinese e-Learning Technology Standardization Committee (CELTSC, http://www.celtsc.edu.cn).

Currently, there are many systems which are intended to collect, share and reuse the dispersed learning resources and present the end-user a uniform interface to search, access and evaluate the resources, including the ARIADNE Knowledge Pool System[4], the U.S.-based Science, Mathematics, Engineering and Technology Education Digital Library (http://www.smete.org), the Educational Network Australia (EdNA, http://www.edna.edu.au), the Gateway to Educational Materials (GEM) digital library (http://www.geminfo.org), etc. The metadata structures of these systems are based on LOM schema or trying to base on it. The LRMMS is similar to these systems but has its own features. It supports all the LOM data elements which can provide various search methods; the learning resources are not restricted to a certain kind and the sharing of resources is

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more complete and efficient in a homogenous environment.

The LRMMS is a service provider between the users and learning resources, which provides metadata services including resource registration (i.e. providing metadata), metadata management, search and evaluation. Users (learners, teachers and resource providers) only interact with the metadata services. What they see is a large, uniform learning resources catalog and what they need to do is to complement this catalog or retrieve resource information from it conveniently. Teachers and resource providers afford metadata of their resources and get feedback from the students, while students browse, search and evaluate distributed resources at a single place. The learners and instructors are no longer to worry about where and how to acquire beneficial learning materials from the Internet which is filled with overwhelming information related and unrelated to their educational goals. Also the resource providers needn't put so much energy in making their products known to the end-users. Figure 1 illustrates the relationship among users, LRMMS and learning resources. The broken line in Figure1 means that the users can also be owners of the learning resources.

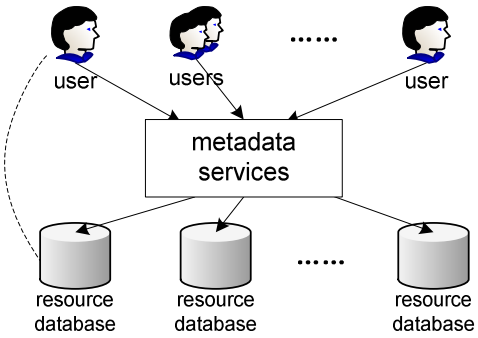

Figure 1: Metadata Service

2. Metadata Standard

Metadata is defined as information about information. To use and benefit from metadata of learning resources, we need a common format for expressing it which should be designed to be machine-readable. One simple but significant metadata schema is the Dublin Core [3]. The DC facilitates the discovery of online resources in a networked environment. The current metadata set consists of 15 elements, every of which is optional and repeatable: Title, Creator, Subject, Description, Publisher, Contributor, Date, Type, Format, Identifier, Source, Language, Relation, Coverage and Rights. Many other organizations such as IMS (Instructional Management System), ADL (Advanced Distributed Learning), CEN/ISSS (European Committee for Standardization/Information Society Standardization System), and IEEE LTSC (Learning Technology Standards Committee) are also concerned with metadata schema of learning resources.

Now, one of the most promising metadata schemas is the Learning Object Metadata Schema developed by IEEE Working Group P1484.12. It was mainly influenced by the work of IMS and ARIADNE (Alliance of Remote Instructional Authoring and Distribution Networks for Europe). There are already editors and free software for it [2]. The LOM standard specifies a conceptual data schema that defines the structure of a metadata instance. The schema contains every category of the Dublin Core and extends it to a minimal set of attributes which can adequately describe a learning resource.

The LOM schema has several features: 1) allowing for linguistic diversity of both learning resources and the metadata instances that describe them; 2) the separation of semantic model and its bindings; 3) consistent description ensured by the recommended vocabularies of some metadata elements; 4) accommodating extension mechanism for localization; 5) and so on. The definition of LOM divides the descriptors of a learning resource into 9 categories, each of which is relatively independent and characterizes the resource from a separate aspect. Figure 2 shows the 9 categories in brief.

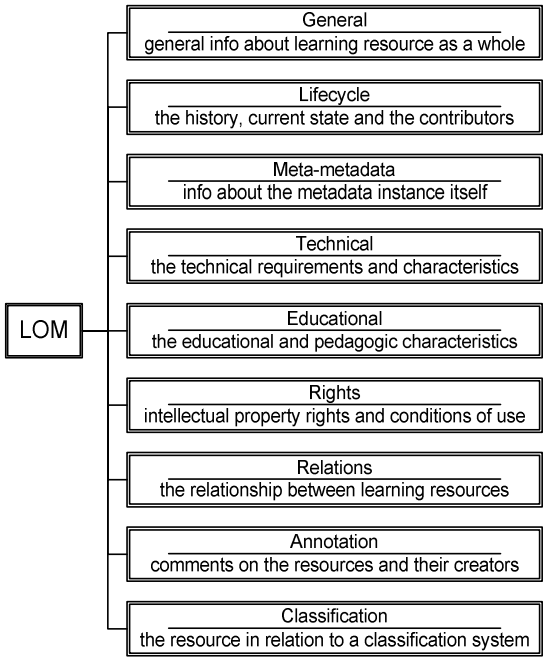

Figure 2: Categories of the LOM Schema

In the LRMMS, we used LOM schema to describe the attributes of learning resources. The vocabularies recommended by LOM standard were adopted to get further interoperability of the metadata. The current system supports two languages: Chinese and English, that

is to say, the metadata information can be written in both Chinese and English. And the binding language of LOM schema is XML.

3. The LRMMS

3.1. Services

When we designed the LRMMS, the motivation behind could be divided into two sides: 1) giving practical support for the LOM schema and exploiting it in as many aspects as possible; 2) giving users a space for announcing, searching, evaluating and accessing learning resources. According to the two objectives, the system was developed completely based on LOM standard and provides the following services for users to

- Publicize their learning resources by providing metadata in two ways: filling out metadata forms online or uploading metadata XML files.
- Manage their metadata provided before, including update, delete and download (the metadata XML file).
- Search learning resources online by different query conditions: keywords, learning resource type, learning resource classification, etc.
- Browse the metadata information of a learning resource. Thus, users can decide whether it is wanted, and then locate it or examine other related learning resources.
- Annotate a learning resource online and view the annotations made by other users.

3.2. Design Issues

While designing, we took both the technical and educational issues into account. The following things were got more attentions because we considered them important from the perspective of instruction, users and data exchange.

As learning resources grow rapidly, metadata information becomes huger and huger. These vast data are too heavy for a single server to run efficiently. So we need a decentralized framework that contains several metadata servers placed in different sites to disperse the load. Users can connect to the nearest server to minimize the response time. Otherwise, the system is more robust as if one server goes down, the others still can provide metadata services.

By utilizing metadata for the learning resources, searching can be performed more specifically and efficiently. The system provides various search methods, allowing users to retrieve resources from different views, especially their educational needs. The details about searching in the LRMMS will be illustrated later.

The evaluations of learning resources are important both for the teachers and for the learners. A Student consults the comments made by others to estimate the value of a learning resource and obtain guidance on how to use it to good purpose, while a teacher needs the comments to know what the advantages and disadvantages are of his material and then try to enhance it. The system provides a mechanism for the users to give their annotation freely online, which will be explained later in this paper.

When a user searches or browses a learning resource, showing information on other related learning resources should be an effective way to give the user a comprehensive understanding of this resource and to expand learner's curiosity about other fields [8]. The seventh category of LOM schema which describes the relationship of learning resources makes it possible. In LRMMS system, when users view the metadata of a learning resource, the information of the related resources is presented in the form of hyperlink if their metadata have already been in the metadata server. If interested, users can get the metadata information easily by a click.

How to design a user-friendly interface was also what we concerned. We tried to make the system easy to use through different ways: language selection, input simplification and user personalization.

Finally, we chose XML as the file format to import and export metadata files. XML technology has been widely applied in the area of data exchange. We hope we can interoperate with other systems by XML metadata files, at least as an interim file format. We temporarily use the self-ordained XML binding method of LOM schema. Figure 3 is part of a XML metadata file.

```
- <lom>
 - <general>
  - <title>
   - <langstring>
    - <string lang="en">Draft Standard for
              Learning Object Metadata</string>
    - <string lang="zh">学习对象元数据草案</string>
   - </langstring>
  - </title>
  ……
 - </general>
 ……
-</lom>
```

Figure 3: Part of a XML Metadata File

3.3. Architecture

The LRMMS is a distributed, Web-based system, as Figure 4 shows. The main components are several metadata servers whose front-end are web servers connected by Internet. The metadata servers can exchange data using HTTP. The data exchanged include search requests, query results and metadata files. That means a web server can perform distributed queries and retrieve

metadata records from all the metadata servers, whether it is local or remote.

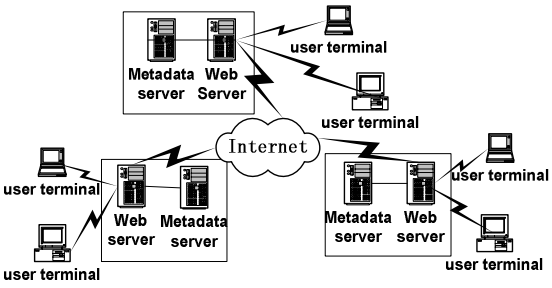

Figure 4: System Structure

3.4. Distributed Query

After a user logs on one of the web server and submits a search request, the titles of the learning resources which satisfy the conditions are retrieved from the local metadata server first and presented to the user. If the user wants to acquire more qualified learning resources, then the web server queries the remote metadata servers one by one through a local configuration file until all the servers are requested or the user thinks the information is enough. This file can be configured by the system administrator.

```
<?xml version="1.0" encoding="gb2312"?>
<!DOCTYPE config SYSTEM "config.dtd">
<Config>
   <Server>
      <Id>1</Id>
      <Ip>localhost</Ip>
      <Dbname>LOM</Dbname>
      <Collection>cLOM</Collection>
      <Schema>lom</Schema>
      <IsLocal>yes</IsLocal>
      <Weight>0</Weight>
   </Server>
   <Server>
      <Id>2</Id>
      <Ip>166.111.137.121</Ip>
      <Dbname>LOM</Dbname>
      <Collection>cLOM</Collection>
      <Schema>lom</Schema>
      <IsLocal>no</IsLocal>
      <Weight>0</Weight>
   </Server>
   ……
</Config>
```

Figure 5: Part of the Configuration File

Figure 5 shows part of the configuration file. The XML format makes it easy to extend and to understand. By this file, one web server knows where the other servers are and the names of the metadata databases from which to get the query results. The web server also can retrieve metadata XML files from remote servers using HTTP protocol.

The process of distributed query is transparent to the users. The query results are showed to the users in a sequential way. To the users, all the resource metadata appear to be in local. With distributed query, there is no need for a user to register on several metadata servers in order to gain more resource information. The number of query result can be controlled by the user, that is to say, it is a progressive search: the user needs more, then the system searches more. It can reduce the response time to the user and save the computing resources.

3.5. Resource Access

It is noticed that the system doesn't deal with the learning resource itself. It is only concerned with the management of the metadata which is the basis of several kinds of services. The reason why to do in this way is that: 1) the system is a practical application of the LOM standard, so the metadata is the emphases, not the learning resource; and 2) different users have different requirement to share their resources. Some learning resources may be accessed freely, while others may have various restrictions such as payment. The system leaves the access problem to the users who provide the learning resource. However, the metadata contains entry information of the resource. It can be a URL or a paragraph of text description. In the LRMMS, the former is made into a hyperlink that links the learning resource and its metadata together, the later is a text description about where and how to access the learning resource.

3.6. Focused Search

As the Internet grows and learning resources increase, it is a vain hope to bridge the gap between people and the resources they need through a general-purpose search engine [5]. The reasons can be summed up as follow:

- General-purpose search engines are mostly text-based and use keyword-matching techniques [5, 6]. Many resources are not text-based, such as audio, video and software.
- Unwanted search results are not filtered because users have no way to express specific enquiries about learning resources such as resource type, author and so on.
- Important resources are excluded due to the failure to access the significance of the resources.
- Many of the resources are not documented because people won't do it or don't know how to do it. Encouraging people to document resources and make them accessible to search engines are crucial.

The shortcomings of the general-purpose search engines can be compensated by utilizing metadata on learning resources. It makes the search more reliable and

efficient and allows the users to search for their educational needs. The LRMMS provides a tool for the users to document their learning resources and update the metadata information after the metadata database has been built up.

The metadata in LRMMS are strictly conformed to LOM set and its recommended vocabularies. This consistent description of the resource attributes makes possible more precise and purposeful queries. To learners and teachers, they are more likely to search resources from instructional perspective, for example, the context in which the learning resource used, the difficulty level of the learning resource, besides general properties such as title, author and so on. On the basis of LOM schema, we developed quite a few search methods that we hoped can search learning resources from diverse points of view. It includes general information, educational information, technical information, classification information, etc. Table 1 summarizes the search methods and the corresponding data elements employed in LOM schema. The methods which can be realized on LOM schema are not restricted to the following list. Many other helpful search methods, such as the semantic level of the learning resource, can be added to the system effortlessly.

Table 1: search methods and the data element used

Search Method	Data Element in LOM
By Keywords The keyword can be contained in field of title, description or keyword.	1.2 title; 1.5 description; 1.6 keywords
By Structure of the learning resources	1.8 structure; 1.9 aggregation level
By Contributor's name The contributors can be those who make contribution to the learning resource and its metadata	2.3 contribute 3.3 contribute
By Format and Size of the learning resource	4.1 format 4.2 size
By Technical Requirement of the learning resource, mainly including OS and Browse requirement	4.4 requirements
By Resource Type	5.2 learning resource type
By User Type that the learning resource is concerned with	5.5 intended end user role 5.6 context
By Classification of the learning resource	9.1 purpose 9.2 taxonpath

3.7. Evaluation Procedure

Metadata of learning resources can be supplemented during the evaluation procedure by different types of users. After the resource providers or teachers initially supply the metadata, the end-users who may ask the system to find learning resources for their needs through the system's interface can comment on them online. What evaluation information is provided is up to the user. The user's evaluations on the resources are added to the metadata file and stored in the database, all of which later can be retrieved by other users. Also, the providers or teachers might access to the evaluations as feedbacks so that they can improve their learning resources in the future. Figure 6 shows the evaluation procedure.

To a learner, the evaluations from other end-users (teachers and students) are valuable for him to decide if it fits his needs. Useful comments can also help the learning resource to complete its instructional purpose. To a teacher, good comments give him evidence why to choose such a learning resource for his students and also provide him with feedbacks from the students. The evaluation loop is beneficial both for the educational process and for the quality of teaching materials.

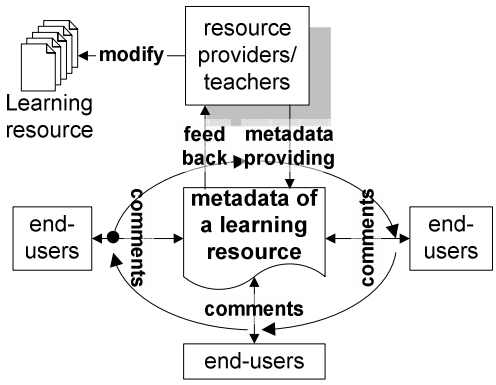

Figure 6: Evaluation Procedure

3.8. System Interface

The LRMMS interface is Web-based which we tried to make as user-friendly as possible. As part 3.2 said, the system is easy to use in three ways: multi-language support, easy metadata input and personalized user interface.

The system now supports two languages: English and Chinese. Users may choose their preference language to view the metadata information. The vocabularies of metadata elements are also presented to the users in the form of Chinese-English comparison. In the LRMMS, a problem we faced is the input of the metadata which, to be frank, is a troublesome task if a user decides to provide

online. The LOM metadata set covers several fields and contains many data elements. Users may feel tedious if they should fill in one by one. To alleviate the burden of input, the values of many data elements are enumerated for the users, especially the data elements with recommended vocabularies. What the user has to do is to choose one or more from the options. Moreover, for some attributes, the system provides default values. We hope this can simplify the data input farther. In order to give users an individual space, the system maintains two lists for each user on the left side of the interface: one is the titles of learning resources the user provided; the other is the titles of learning resources the user interested in. Figure 7 shows the interface of the system. After a user registers a learning resource, its title is added to the first list as a hyperlink. This list is used to facilitate the owners to manage the metadata of their learning resources. When a user finds an interested learning resource, he can add its title to the second list as a hyperlink. By clicking the title, user can conveniently retrieve the metadata information later. These two lists form the personalized interface of the LRMMS.

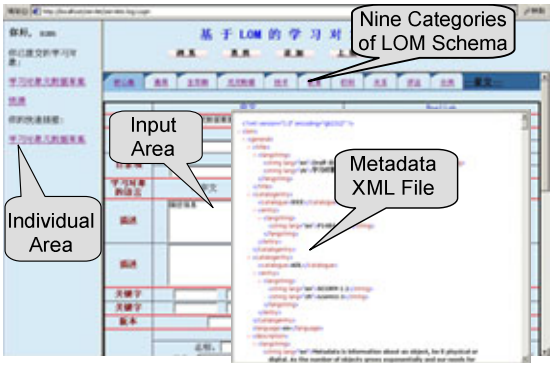

Figure 7: System Interface

4. Conclusion and Outlook

The LRMMS provides several metadata services totally based on the LOM schema developed by IEEE P1484.12. Being an application of LOM schema, the system wants to examine its data elements to find out which are most/least useful and whether the structure of the attributes is proper, therefore, offering information for the next version of LOM standard. We hope this system can make contributions to the evolution process of the standard and its localization in China.

The system will be improved in several ways: increasing new functions, designing more user-friendly interface and making the system more reliable and security. In the near future, we plan to add the following new services. One is the metadata browsing by the classification of learning resources. With seemly classification, users can locate a resource quickly. But the problem is that there has not been a universal classification yet and it is difficult to establish one suitable to all types of resources. The second is to realize conformance check to LOM schema. After the user uploads a metadata XML file, the system tests if this metadata instance is conformed to the LOM standard. If not, give the user some correct suggestions aside from the test result.

In future work, we will make some investigation in building semantic networks out of single metadata descriptions. We hope we can develop new applications when we regard all the metadata of learning resources as a whole, not discrete metadata instances. By digging the relationship among the resources with their metadata, extracting the high-level semantic is a good way to guide the learning procedure of users. It is not always easy to provide the adequate information, even for the author. Authoring tools should be able to automatically generate many metadata values and offer user-friendly ways to make the metadata integrated.

5. References

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