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A multi-layer, metadata driven approach enhancing SCORM to support adaptive and mobile learning objects

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Abstract: - We propose a method to assist in the reuse of learning content- from interoperable content repositories- to respond to several learner needs
We introduce in this paper an approach that describes how to exploit the ADL Registry- an instance of CORDRA (Content Object Repository Discovery and Registration/Resolution Architecture) - to adapt SCORM (Sharable Content Object Reference Model) content to learner learning style and devise features. We have chosen SCORM [1] since it is the most prominent of the proposed learning object centred standards [6]. However, this reference model confines learners to a static pool of learning resources- which are the same for all learners in the course- [20]. In addition, it does not support content adaptation for different devises [5].
Our work is based on an extension of LOM (Learning object metadata) [14]. This extension aims to suggest a new kind of relation that is not supported by LOM and can exists between learning objects.

Key-Words: - SCORM, learning object, CORDRA, ADL-R, content adaptation, mobile learning

1 Introduction

Learning Object (LO) is the most recent entrant in the field of learning content authoring.
It becomes quite obvious and well accepted to structure content by means of LOs. Despite of this, there is no general LO definition.
Basing on different author's reflexion, we define the LO as: "The smallest digital learning unit that has a pedagogical sense and could be autonomous by it self. It can be also re-used in several contents to accomplish various needs. A LO can be a text, an image, a video sequence, an animation, a Power Point presentation, a Web page, etc.".
Considerable attention is being focused on the concept of LO as a mechanism to facilitate reuse of learning materials amongst educational communities [19] and to permit new approaches of content adaptation.
The researches in the field of LO's reuse have focused on LO repositories. There exists a diverse collection of both public and private content repositories and digital libraries containing these learning and content objects (e.g., [7, 12, 13, 15]). The effort, however, has remained at the course and single enterprise level. The need of common methods to find or discover content and make it accessible outside of the often *private* repositories associated with the content delivery and management environment has lead to the proposition of CORDRA (Content Object Repository Discovery and Registration/Resolution Architecture) [9]. The CORDRA is an open, standards-based model designed to support an interoperable federation of independent content repositories. It prescribes design, and implements software systems to enable content discovery, sharing, and reuse.
In parallel with the development of repositories and content adaptation approaches, a collection of core learning technology standards have been created. All of them aimed at increasing the reuse of LOs, reducing their development effort and providing interoperability of content across delivery and management systems. SCORM is the most prominent of the proposed standards. It combines selected standards into a common framework that has more reach and applicability than its individual components by themselves.
Nevertheless, many critics have been attributed to SCORM especially concerning content adaptation. SCORM confines learners to a static pool of learning resources-which are the same for all learners in the course- [20]. Hence, users are unable to access materials that respond to their individual needs.

In this paper, we propose a two phases architecture - design time and run time phases- that adapts SCORM content in order to costume it according to learner learning style and devise capabilities. Our proposal is based on ADL-R (Advanced Distributed Learning Registry) [10], the ADL instance of CORDRA -recently approved- and an extension of LOM- the standard used by SCORM to describe and catalog individual content objects-. Indeed, LOM does not provide necessary information to carry out the reached adaptation.
The remainder of this paper is organized as follows: section 2 introduces our definitions of Adaptive learning object and Mobile learning object. Our proposal is detailed in section 3.

2 Definitions

In this paper we introduce some useful definition of adaptive learning objects and mobile learning object.

2.1 Adaptive learning object (ALO)

By basing on current state of LO based content adaptation, we suggest that: "A LO is considered adaptive if it is able to be integrated in an adaptation process statically or dynamically. A static participation in an adaptation process is allowed by the appropriate description -metadata- that provides the required information to carry out adaptation. A dynamic participation of a LO is its ability to be modified dynamically (on Run Time) according to dimensions of adaptation related to a particular learning situation."

2.2 Mobile learning object (MLO)

"A MLO is a LO adapted to characteristics of mobile device."
By characteristics, we mean device's hardware and software attributes. Hardware attributes include: size and resolution of screen, multilanguage capability, input possibilities (keypad, keyboard or pointer device), memory capability, processing power, cookies, supported media types and capabilities in presenting multimedia content, and so on. Software attributes include: operating system, compatible applications and so on. In [4], dimensions of adaptation in a mobile environment were synthesized. A general framework for the construction of adaptive systems in a mobile context were also proposed
Based on above definitions, we can affirm that a SCO (Shareable Content Object) is a LO but it is not adaptive and mobile, How to make a SCO adaptive and mobile? This question will be answered in the next section.

3 System architecture

3.1 Run Time adaptation architecture

Our proposal aims to add two adaptation layers to SCORM RTE (Run Time Environment) to support content adaptation to learner and his devise capabilities at run time. As illustrated in Figure 1, the adaptation architecture is divided into three levels: the learner adaptation layer, the API communication layer and the mobile adaptation layer. These layers aim to improve the SCORM RTE1.3.3 proposed by ADL [8] to make it able to deliver adaptive and mobile SCOs.
The main layers are the learner adaptation layer and the mobile adaptation layer. For the learner adaptation layer side, the appropriate selection of an adaptive SCO is based on an extended Learning Object Model. For the mobile adaptation layer side, adaptation technology is used to dynamically adjust content to meet the constraints of network bandwidth and device limitation. Each layer has several phases and will be detailed in the following sections.

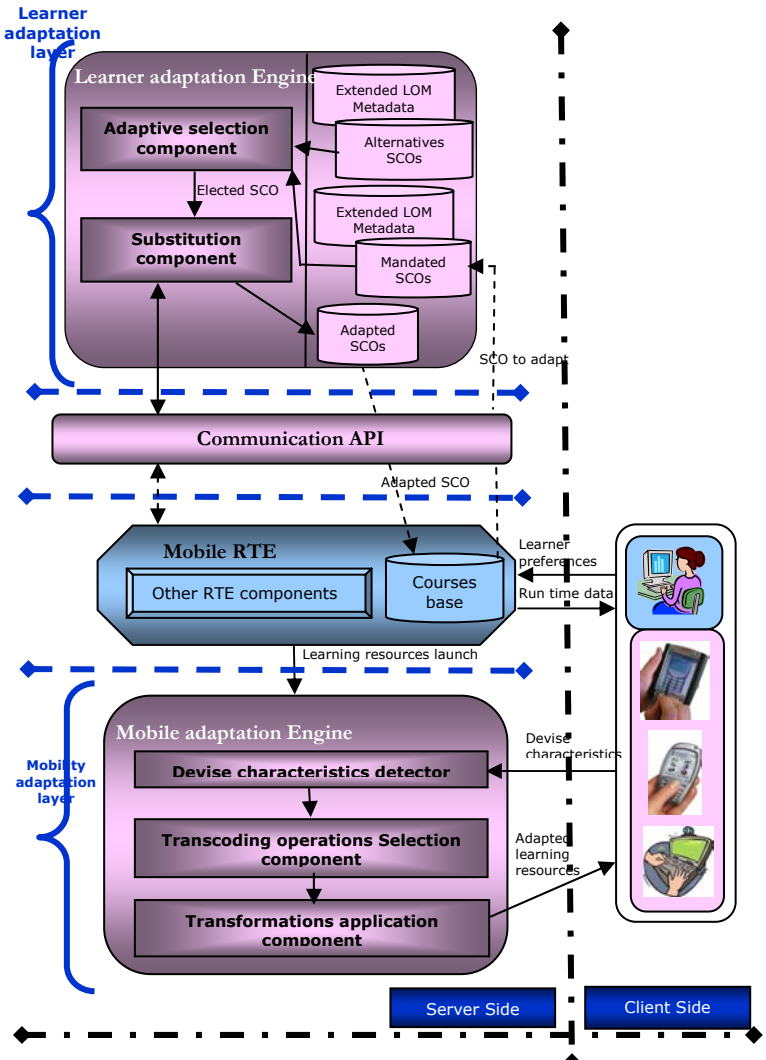

Fig.1: Run Time adaptation architecture

3.1.1 Learner adaptation layer

The learner adaptation engine (LAE) is activated by the communication API each time a deliverance action to a learner is identified. The learner adaptation process starts if the mandated SCO (referenced in the manifest by the activity identified for delivery) does not meet learner preferred style.
This engine has to choose the most appropriate SCO (the elected one) according to the learner preferred learning style and to substitute the mandatory SCO (referenced in the manifest by the activity identified for deliverance) by the elected SCO. The communication API layer manages all data exchange between the RTE and the LAE, thing that ensures independence between the LAE and the RTE and makes our LAE reusable and interoperable across SCORM 2004 Conformant LMSs (Learning Management System) [3].
There are two major components that are included in the LAE which are the selection component and the substitution component. These will be detailed in the next two subsections.

Adaptive selection component

The role of this engine is to choose among the alternative SCOs the most appropriate one that ensures the same content as the mandated SCO and reaches more the learner preferred learning style.
In order to achieve this adaptive selection respecting to the learner learning style criterion, the SCO has to be adaptive (See definition of ALO). Unfortunately, the current LOM elements used to describe the SCO do not allow this adaptability. In fact, the SCO needs to be aware of all styles that it support, but, the current version of LOM's specification do not support psychological factors for instance learning styles [17]. Moreover, a SCO must be conscious of his alternative resources.
The LOM relation category allows to define relationships between a LO and other LOs. But, the kinds of relationships supported does not allow to express that a LO is an alternative of another LO.
Extending the Learning Object Metadata
We propose two extensions:
The first extension adds an element to educational category to introduce leaning style. A SCO may fit numerous learning styles but not with the same proportion, so the new element may contain multiple supported learning styles with their corresponding Confidence Values. Table 1 illustrates our proposed extension to educational category.

Element name	Explanation
5 EDUCATIONAL	Describes the educational characteristics or philosophies of the resource.
5.5 Learning Styles	**It describes the learning styles supported by the resource.**
5.5.1 Type	**It describes one style supported by the resource. For example: visual. The values of this element will be selected from a vocabulary containing possible styles corresponding to a given theory of learning style**
5.5.2 Confidence Value	**It describes the confidence value of a learning style type supported by the resource.**

Table1: Extension of educational category

The second adds a new vocabulary [token] **"CanBeSubstitutedby"** to the set of tokens defined by ADL to express the possibility of substitution of one LO by another. This allows a SCO to know his alternative SCOs.

Element name	Data types
7 RELATION	It's a container
7.1 Kind	Vocabulary The set of tokens defined by IEEE is: • ispartof • haspart • isversionof • hasversion • isformatof • hasformat • references • isreferencedby • isbasedon • isbasisfor • requires • isrequiredby The token we add is: •***CanBeSubstitutedby***
7.2 Ressource	It's a container

Table2: Extension of relation category

The advantage of specifying these aspects in the LOM standard is to accurately select suitable SCO from alternative SCOs for any individual learner for any kind

of learning system built on the metadata specification.

Substitution component

The substitution component attributes to the elected SCO, the same URL as the mandated SCO when it is ready. Then, it orders to the communication API to replace the mandated SCO in the RTE course folder in order to be launched instead of it. So, the change will be transparent to the RTE and the learner.

After elected SCO launch, the communication API must put a copy of the mandated SCO in its original place in the course folder maintained by the communication API.

The substitution component must maintain the list of SCOs adapted for each learner studying the course. When a learner request at another time the same mandated SCO, it will be served directly without application of the adaptive selection if the learner doesn't modify his learning style preferences.

3.1.2 Mobile adaptation layer

Current SCORM learning resources were designed for desktop computers and high-speed network connections. It is not efficient to develop new learning resources for mobile learning environments by discarding large amounts of them. It is a challenge to deliver such learning resources to various devices with limited capabilities over low-speed wireless network.

This layer intends to dynamically adjust learning resources to be adapted to learner device capabilities; it is also placed between the RTE and the client and performing after the launch of resource to a learner.

To do this, we propose to use transcoding. It's the process of converting a media file or object from one format to another. But it is also used to fit HTML files and graphics files to the unique constraints of mobile devices and other Web-enabled products. These devices usually have smaller screen sizes, lower memory, and slower bandwidth rates. In this scenario, transcoding is performed by a transcoding proxy, server or device, which receives the requested document or file and uses a specified annotation to adapt it to the client [11]. In our case, we use proxy based adaptation.

We note that in this paper, we are interested in adapting SCORM content; presentation adaptation is not our concern here. To have more details in this issue, the work presented in [5] can be consulted. In addition, the ADL RTE as it is does not allow connection of mobile learners. A mobile RTE or LMS must be implemented to consult SCORM content from mobile devises. We adopt an approach like [18] to implement a mobile RTE.

The mobile adaptation engine integrates three main components:

Devise characteristics detector: it must detect the learner devise characteristics in order to decide the suitable transformations that must be applied.

Transcoding operations Selection: it uses the learner devise and the learning resource characteristics to decide which operations will be applied from the available operations.

Transformations application component: it applies transcoding operations specified by the previous component.

The proposed architecture to adapt content at run time can't be realized without some design time adaptation. This is the subject of the next section

3.2 Design Time adaptation architecture

To realize run time adaptation, some activities must be done at design time allowing:

- Analyzing a SCO learning styles
- Determining alternatives SCOs for a given SCO
- Filling automatically added metadata elements- described in the previous sub section.

Current SCORM conformant authoring tools like Reload Editor [16] does not provide these functionalities. Thus, we suggest adding them as an authoring tool enhancement. It is depicted in figure 2. The process described by the figure is applied for each SCO to make it adaptive.

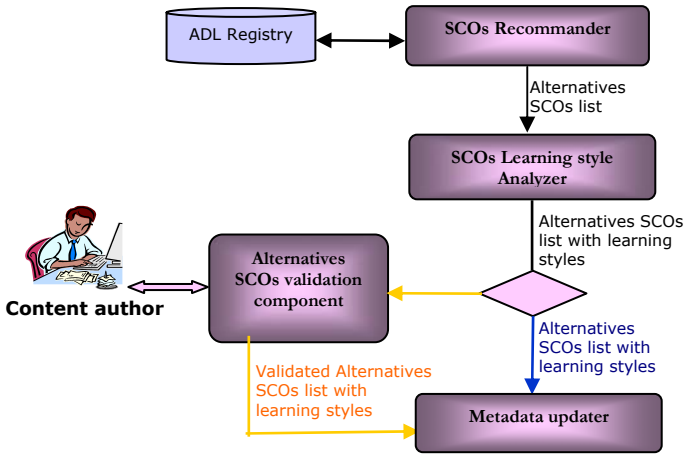

Fig.2: Design time adaptation architecture

3. 2. 1 SCOs Recommander

The researches in the field of LO's reuse have focused on LO repositories. There is a diverse collection of both public and private content repositories and digital libraries containing these learning and content objects. The effort, however, has remained at the course and single enterprise level. The need of common methods to find or discover content and make it accessible outside of the often private repositories associated with the content delivery and management environment has lead to the proposition of CORDRA.

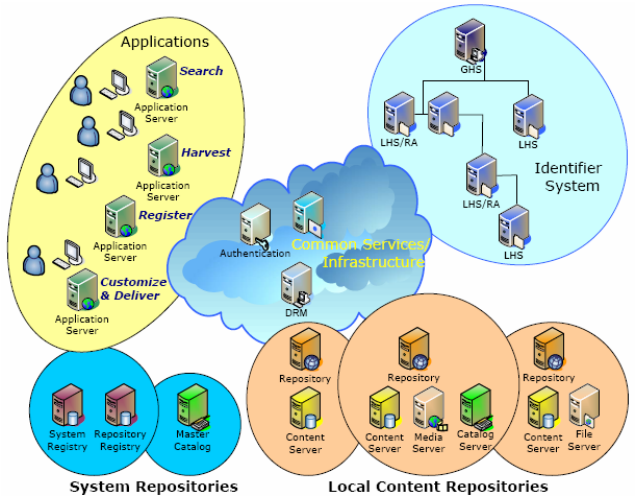

Fig.3: CORDRA Overall modal [9]

The overall CORDRA model and environment is illustrated in figure 3. Key components of the model are: [9]

- Content Repositories: Local repositories for learning content (content objects, assets, etc.) and associated data (local catalogs, metadata, etc.).
- System Repositories: CORDRA system repositories for system data, models, registries, etc.
- Identifier System: Infrastructure for object identification, registration and resolution.
- Common Services Infrastructure: Core technical and administrative services used throughout a CORDRA implementation (authentication, rights management, rule processing, etc.).
- Applications: Application systems and interfaces (search, discovery, authoring, personalization, customization, delivery, etc.) used to manage and deliver learning content and content objects to end users.

The Advanced Distributed Learning Registry (ADL-R) is an implementation of the Content Object Repository Discovery and Registration/Resolution Architecture (CORDRA). It began to be operational since December 2005. The main purpose of the ADL-R is to provide a DoD-wide means and infrastructure to search, discover, and expose learning content [10].

The ADL-R is a searchable index of content metadata that can be resolved to content located in distributed repositories. Figure 4 shows how ADL-R retrieves learning objects.

We suggest that the SCO recommender accesses to ADL-R search service and enter search metadata to obtain alternative resources. It uses a metadata template to enter search metadata. The search criteria defined in the template is the 1.3 Keyword LOM element. The SCO recommender fills the template with values taken from the metadata of the SCO for which it looks for alternatives.

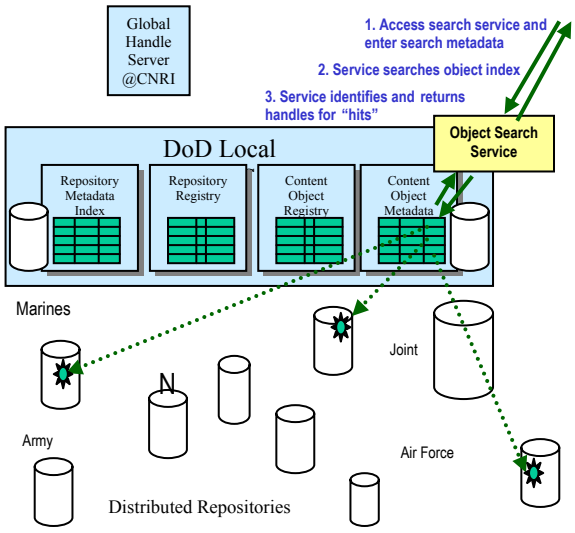

Fig.4: Retrieving an object [10]

3. 2. 2 SCOs Learning style Analyzer

This component imitates a pedagogical expert in analyzing a resource and identifying its supported Learning styles. This analyzer use rules based on metadata description of a SCO and on Felder Silverman learning style theory features [21]. Details concerning this component are out of the scope of this paper. It will be more explained in a future paper.

3. 2. 3 Alternatives SCOs validation component

This component allows a content author to validate the list of alternative SCOs proposed by the SCO recommender. This intervention will certainly ameliorate the final list of alternative SCOs. The author is not obliged to do this validation.

3. 2. 4 Metadata automatic update component

Numerous critics of LOM were stated for the huge number of elements that the author must fill. To solve this problem, some approaches to automatically fill LOM elements were proposed such as [23]. Since, it is not our concern here; we propose a component that automatically updates the elements that we had added to LOM. The role of this component is to:

- Update the added element 5.5 and its sub elements using information given by SCOs Learning style Analyzer.
- Define for each SCO a relation category; choose in 7.1 element the added token "CanBeSustitutedBy" and list in the 7.2 element each identified alternative SCO for the SCO subject of the description.

4 Conclusion and future work

In this paper, we presented a two phase proposal (design time and run time) based on the reuse of existent LOs to adapt SCORM to support adaptive and mobile LO.
The first phase concerns the use of ADL-R to find alternative resources for those used in the SCORM content. The second is a multilayered architecture that adapts SCORM content at run time to suit it to the learner learning style and his device features. Both phases are based on an extension of LOM elements. We are now carrying out several tests for our proposal using Reload editor 2004 [16] and the ADL RTE.
Future work includes achieving the experimentation of our proposal and ameliorating it based on the obtained results.

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