Sharing Learner Information through a Web Services-based Learning Architecture

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Abstract. This paper presents architecture for the exchange of learner's model information between e-learning systems on the Web. The present work is part of a current project intended to present an adaptive content associated to a particular student profile, the AdaptWeb® Project. The Web Service technology is used since it allows the easy communication between Web applications through the HTTS protocol. Our goal with this work is provide a standard communication allowing different e-learning systems to cooperate in order to gather a set of learner information, richer than that found in a standard e-learning system. As a result, the course content, in any federated e-learning system is adapted and presented to students, according to each student's program, cognitive characteristics, and navigation preferences in the same way. Once the student profile is determined all the courses will be offered using the same profile.

1 Introduction

Due to the Internet worldwide distribution, several researchers investigate the use of it's the Web resources to create e-learning systems. Such systems deal with important management issues related to learning courses content, learner stored information, and learning resources in general. In this paper we are particularly interested in investigating how learners' information can be shared among different e-learning systems in the Internet.

Often, new learners of an e-learning system are required to update his/her personal information before proceeding in one of the offered courses. Some systems are able to adapt its course content presentation using some techniques that discover the learner's preference [1], level of previous knowledge [2], and cognitive style [3]. However, this important learner information is not shared among different e-learning system, which forces the learner to fill cumbersome forms in each new system, and also forces each new systems to analyze and process new learner behavioral information. In consequence, current systems do not collaborate with each other in order to enrich the information related to users of several different e-learning systems. With richer learner information shared among a federation of e-learning systems a better course content adaptation may be attained.

Currently, international bodies (such as IEEE, IMS, and ADL) are working on the standardization of e-learning information defining metadata for learning objects, learner model, learner assessment, among others [4,5]. For example, LIP (IMS Learner Information Package) [5] allows the description of learners based on the personal information, interests, or activities. However, LIP does not define any method to exchange such information among different e-learning systems.

In this paper we propose a Web Service based solution to exchange learner information described following one learner model. The use of Web Services is justified as they provide a well defined mechanism that allows inter-application communication on the Web. We expect that a federated e-learning systems will implement a Web Service that will be able to export the internal learner information. Thus, other systems that require learner information can retrieve it accessing the Web Service implemented by the e-learning system that holds such leaner information. The federated e-learning systems will be able to share a larger amount of information on the cognitive learner's abilities. It is clear that some legal citizen privacy defense mechanism, specific for the e-learning environment, must be offered before such a proposal may be accepted.

An e-learning system may store the personal data of a learner in a database while other e-learning system will store some information about the cognitive style of the same learner. Using Web Services it is possible to make a search for this federated data (personal data + cognitive style) in each of the participant system in the environment. A third participant may use this information to improve its learner model. To make this exchange possible, an interchange standard must be created to identify data through the different participant, a learning environment, allowing that all federation participants can "understand" in the same way the fragments of stored information. In this work the information in the learner model is composed of two parts: information supplied by the learner and information collected through the learner's behavior using the e-learning system. The more data the system obtains from the learner, the more personalized functionalities it can offer to this learner. Based on this idea, the learner model depicted in this work follows the idea presented at the SeLeNe [6] project, which joins some of the categories defined by the PAPI standard with some of the LIP standard categories. The reason for this union is the fact that some categories are included and richer in one specific standard while other categories are better detailed in the other. In addition, some extremely important information for the adaptation work is not contemplated in any standard such as, for example, the cognitive style and the learning style of each learner.

This paper is organized as follows: Section 2 presents the main learner model standards existent. This section also provided a short presentation of related work and describes the technology of the Web Service. Section 3 describes our architecture and the learner model used at this work. Section 4 concludes the article and presents the plans for future researches.

2 Background

This section presents the definitions and standards associated to this work. The Web Services technology used in this work for communication among e-learning system is describes in section 2.1. Section 2.2 presents the existing learner model standards. Section 2.3 describes research projects that present solutions for the sharing of information between different e-learning systems, which are basically concerned about the reusability of the educative material.

2.1 Web Services

The Web Services technology [7] can be described as an architecture that possesses platform-independent components, allowing applications interoperability. For this reason, Web Services are being used for exchange of data and messages between applications through a Web protocol-based infrastructure, such as HTTP, SMTP and FTP.

W3C owns some groups that deal with the standardization of Web Services and other related technologies such as SOAP, WSDL and UDDI [7]. The SOAP (*Simple Object Access Protocol*) protocol defines a way of communication between applications very similar to the RPC (*Remote Procedure Call*), however with the ability to flow through different administrative domains. SOAP basically encapsulates a procedure call into an XML structured request and returns the result of the execution. The procedure call, the data passed as parameter and the return value are also structured in a textual format through XML.

WSDL (Web Service Description Language) [7] is a standard that describes a Web Service through XML, allowing client applications to access and validate the Web Service in a well-defined way. Besides this, it is possible to publish the description of a Web Service. Once the description is published, the applications can look for it dynamically, download the description and then create a client in execution time. The UDDI (Universal Description, Discovery and Integration) [7] standard is one of the most frequently used standards for this purpose.

A solution that involves data distribution and communication on an unsafe network structure requires an efficient security mechanism. Web Services allow implanting various security related services, such as authentication, access policies and cryptography, which can be used isolated or together. The users accessing the service must be identified in order to establish roles, permissions or access levels and therefore restrict the access to data and services offered.

Although solutions that aim the independence of platform and interoperation already exist, the main advantage of the Web Services technology is the use of Web protocols to exchange messages instead of the proprietary standards, such as RMI.

The Web Services technology was used at this work as a consequence of the standardized functionalities it offers. Besides, the SOAP protocol may operate over HTTPS, and then the learner's information cannot be observed without advanced hacking techniques providing a good level of data privacy.

2.2 Standards for Learner Model

The two most important standards for learner modeling are IEEE LTSC Personal and Private Information Standard (PAPI) [4], and IMS Learner Information Package (LIP) [5]. Both standards deal with several related categories of information about a learner, some of them are used in this work. The characteristics of the main standards of learner models are presented next.

The IMS LIP standard contains several categories for data about a user. The *identification* category presents demographic and biographic data about a learner. The *goal* category presents learner targets, career expectation and other objectives. The *QCL* category is used for the identification of qualifications, certifications, and licenses from recognized authorities. The *activity* category contains learner-related activity in any state of completion. The *interest* category maintains any information describing learner hobbies and recreational activities. The *relationship* category aims for relationships between core data elements. The *competency* category serves as slot for skills, experience and knowledge acquired. The *accessibility* category aims for general accessibility to learner information by means of language capabilities, disabilities, eligibility, and learning preferences. The *transcript* category presents summary of academic achievements. The *affiliation* category presents information about membership in professional organizations. The *security key* is used for setting learner passwords.

The PAPI standard distinguishes *personal*, *relation*s, *securit*y, *preferenc*e, *performanc*e, and *portfolio* learner information. The *personal* category contains information about names, contacts and addresses of a learner. *Relations* serve as a category for relationships of a specific learner to other persons (e.g. classmate). *Security* aims to provide access rights. *Preference* indicates the types of devices and objects which the learner technological support is able to recognize. *Performance* contains information about measured performance of a learner through learning material. *Portfolio* access the previous experiences of a user.

The learner model used in this work follows the model defined by the SeLeNe project [6], which suggests the mutual use of PAPI and LIP standards. Each one of these standards presents deficiencies in some characteristics and none of them includes the definitions of learning styles and cognitive styles, which are extremely important for this work as these styles are the keystone for content adaptation.

2.3 Related Work

The interest in the creation of a distributed and interoperable learning system over an Internet, a federated e-learning environment, increased in the last years. Several projects were started to investigate the use of standards for the exchanging of educational data between e-learning systems.

The Edutella Project [8] provide a RDF-based metadata infrastructure for P2P (Peer-to-Peer) applications exchange the educational resources (using standards like IEEE LOM, IMS, and ADL SCORM to describe course materials). In the same way, the CANDLE Project (Collaborative and Network Distributed Learning Environment) [9] uses metadata to describe course material to make it more reusable. CANDLE extends the metadata set defined by the LOM (Learner Object Metadata) [4] standard of the IEEE. These additional metadata describe learning objects by their purpose (learning goals, assessment methods), complexity level, type of learners (face-to-face, distance), setting (corporate, university), estimated time for completion, and others. The Open Learning Repository (OLR) [10] aims at metadata-based course portals, which structure and connect modularized course materials over the Web. The modular content can be distributed anywhere on the Internet, and is integrated by explicit metadata information in order to build courses and connected sets of learning materials. Modules can be reused for other courses and in other contexts. IEEE LOM metadata is used by authors to help them choose modules and to connect them into course structures.

Elena [11] is an operational learning services network based on the interoperable communication infrastructure named “smart spaces for learning”. A personal learning assistant is a component of a smart space for learning, which helps learners in searching and selecting learning services. The personal learning assistants are also able to recommend learning services based on the learner profile.

The SeLeNe (Self e-Learning Networks) [6] project offers advanced services for the discovery, sharing and collaborative creation of learning resources, as well as a personalized access to such resources.

The Edutella, CANDLE and ORL projects deal with problems related to the reusability of the educational material and are concerned about making learning objects (LOM) available at repositories on the Web, in a way that they can be accessed and used by other systems.

The Selene and Elena projects are also concerned about the reusability of the educational material, besides this, they offer personalized access to the educational material according to the learning model. At these works, each project defines its own learner model based on the IMS-LIP and PAPI standards.

3 The proposed approach

The works described in section 2.3 use the Web Service technology to perform the communication between the repositories of learning objects and the e-learning systems. The Web Services are used for searching and making available the learning objects in the repositories. Metadata are used to describe the objects in the repositories, they follow the IEEE-LOM standard. However, we have found no research projects that present a solution for the sharing of data in the learner model, which would help the systems to have more information about the users. This work presents a solution for sharing these data, which allows the improvement of the learner model. The section 3.1 shows a new learner model for data exchange between e-learning systems. Section 3.2 describes the solution architecture. Section 3.3 show how to integrate e-learning systems and examples scenarios respectively.

3.1 PAPI_LIP learner model

To be developed a solution for data exchange between e-learning systems it is necessary to establish a widely accepted data model. This model follows the learner model defined by the SeLeNe project [6], which suggests the mutual use of PAPI and LIP standards. Table 1 presents the elements used from each standard in our solution, which we have called PAPI_LIP.

Our new learner model was defined to provide the additional definitions of learning styles and cognitive styles, which is not provided by the existing learner model (PAPI and LIP).

Table 1. PAPI_LIP learner model

PAPI elements		IMS-LIP elements	
Personal Information	ID [1]	QCL	Organization
	Name		Level
	Address		Title
	Email		Date
	Telephone		Description
Preference Information	List	Interest	Typename
Performance	Type		Description
	Date	Goal	Description
	Begin		Date
	Finish		Priority
	experience		Typename
New elements			
Style	Cognitive		
	Learning		

The cognitive style of learning is an individual aspect that describes the way that a person habitually approaches or responds to the learning task [12]. According to Gregorc [13], a person's cognitive style is considered one of the most stable user characteristics overtime that influences a person's general attainment or achievement in learning situations. This stability is manifested in the use of hierarchies' processes in the treatment of the information and on the strategies that the learner uses when acquiring new information at a hypermedia system.

Besides these psychological characteristics, matching the cognitive style to the domain content in hypermedia systems is a pedagogical method to make the comprehension easier and lead to a preferred behavioral mode of information processing [3, 12]. This occurs for the reason that the cognitive style interacts with the content structure and processes the information in some differentiated way, which induces the utilization of a specific learning strategy to each cognitive style. The

[1] In this work, ID is the learner best suited identification number, this is an information extremely variable among countries.

cognitive style related to the learning strategy requires the design of the learning resources closely tied with the learner's cognitive profiles.
The cognitive style taxonomy used in this work was defined by Gregorc [13]. The learning style is a collection of individual skills and preferences that affect how a person perceives, gathers, and processes information. In this work, we used the learning style classification by Felder [14]. Table 2 presents the learning and cognitive style taxonomies and theirs respective style descriptors used in this work.

Table 2. Learning and Cognitive Style Taxonomies

Cognitive Style Taxonomy	**Cognitive Style Descriptor**
Gregorc	Concrete Sequential (CS) Abstract Sequential (AS) Concrete Random (CR) Abstract Random (AR)
Learning Style Taxonomy	**Learning Style Descriptor**
Felder- Silverman	Active/Reflective Sensing/Intuitive Visual/Verbal Sequential/Global

3.2 Architecture

The architecture of the proposed solution is composed by e-learning systems that collaborate to enrich the learner data model, these e-learning systems compose a federation. Figure 1 presents the components of this architecture.

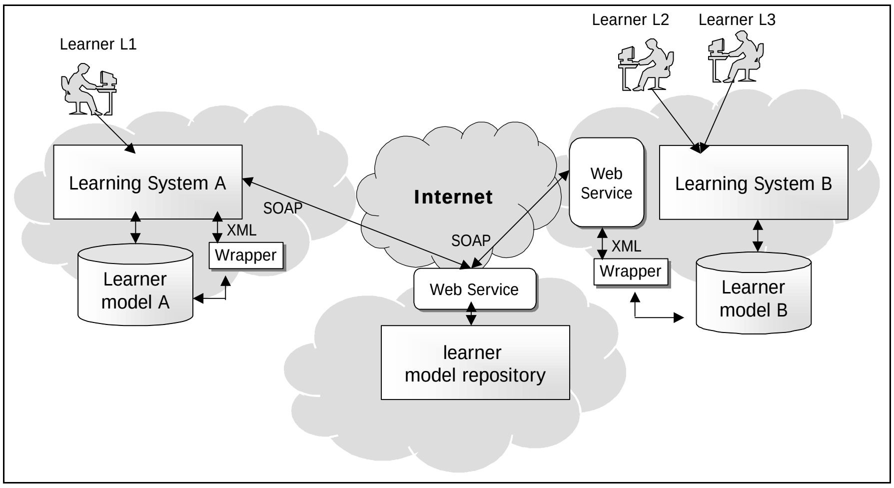

Fig. 1. Architecture of the proposed solution

The main element of the architecture is the repository for the learner model. This repository store the data collected from the various e-learning systems.

Although the figure 1 shows a repository as a unique element, its implementation could be a complex distributed system with data replication and fault tolerance. However, the access to a repository is unique through the Web Service.

The repository requires an authentication mechanism for the e-learning systems access authorization. This authentication permits e-learning systems to fetch data from the repository. Moreover, the central repository needs a specific authorization from each of the e-learning systems in order to be able to fetch data from its local databases.

Communication between the repository and the component systems is carried through Web Service, which exchange the data through the new learner model defined in this work, PAPI_LIP.

3.3 Integrating E-learning systems

Any e-learning system that needs the data stored in the repository should require access to it. The repository administrator will evaluate the access requirement. After the initial access, the definition of the operations available from the web service is sent to the e-learning system in the WSDL format. The component e-learning system needs to implement an interface responsible for calling the functions of the repository web service. The communication will always be made through SOAP.

There are three types of systems that can use the data stored in the central repository. The first type is represented by the e-learning system A in our architecture. This system collects data from the repository to enrich its learner model. The second type of system is represented by the e-learning system B in our architecture. This system can fetch and store data in the repository. In both systems the exchanged data are represented in XML and follow the PAPI_LIP model. The communication is made from e-learning system to Web Service through SOAP. A wrapper is necessary to convert data for the system database. If the database used by the systems stores data in XML following the PAPI_LIP format, then the wrapper is not necessary. The third type of system represented by repository can retrieve data in any e-learning system database. To do that, the e-learning system needs to implement a Web service. The Web Service accesses the e-learning database, the communication is made from Web Service to Web Service through SOAP and the received data are in PAPI_LIP format.

For example two scenarios are described where the presented solution can be used.

Scenario 1: a learner L1, for example, logs into the learning system A, provides the security number and registers in a course. After, the learning system retrieve the learner model from the repository and inserts it into system database.

Scenario 2: the learning system B, for example, is able to discover learner’s cognitive style observing the learner’s navigation pattern while in the course. After that, the learning system inserts the just discovered cognitive style into the central repository.

4 Conclusions and Future Works

This paper presented an architecture for the exchange of learner's information between applications on the Web. The Web Service technology is used as it allows the simple communication between Web applications through the HTTS protocol. Our goal with this work is to make different e-learning systems to cooperate in order to reach a set of learner information richer than that currently found in standard stand-alone e-learning systems. The learner information is stored in a common repository. The data exchanged between applications follow the learner model defined in this work, which was based on the main characteristics of the existing learner model standards, PAPI and LIP.

Some experiments have already been made aiming the validation of the proposed architecture. However, more research still must be carried on in order to improve the offered functionalities. The implementation of an active behavior at the learner models repositories is under investigation. This kind of behavior can be implemented through the ECA rules in order to notify the e-learning systems every time some relevant data is updated or inserted in the common repository. The opposite is also valid, since an e-learning system can also have an active behavior, which would give a warning to the central repository. Moreover, other notifications classes that can also be defined by active rules are on research schedule. This work is part of a larger research project AdaptWeb® [15] that offers an adaptive environment for educational contents. The already developed software, in PHP and MySQL, is available from SourceForge [16].

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