User Profile Interchange in a Service-oriented Architecture

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Abstract. An adaptive e-learning system needs meaningful information about the learners, the user profile, to achieve a correct content tuning for each of the students. The gathering of this information is a laborious and time-consuming task motivating the interchange and enhancement of user profile. This paper describes an approach designed for sharing learners' profile information among systems. Our main objective is to provide a standard communication protocol and architecture that makes possible to different e-learning systems to cooperate in order to gather a set of learner model information, richer than that found in a standalone e-learning system. This work is part of a long-term project intended to allow content adaptation for e-learning systems.

Keywords: User Profile, Web services, Data interchange, E-learning

1 Introduction

Existing e-learning systems are not flexible enough to adapt the content presented to users according to their dynamic and complex profiles. More than this, the different systems are not able to exchange the acquired knowledge on the users making the user's information acquisition a very limited achievement. News e-learning systems with adaptation ability are required in order to improve the way in which users learn. Usually, the adaptive systems provide the same content for different types of users that have distinct preferences, knowledge, and goals [10]. Brusilovsky defines adaptive systems as those systems that can access information as user's personal data, characteristics, and preferences harvested and aggregated in a user's model, and able to use this information to adapt different aspects of the system, to the user [3]. Some features of users that can be useful for adaptation include: the knowledge level of learners about a specific topic, their goals and targets, experiences as well as preferences. Information about the user, gathered in a user's model, is crucial when we want to offer adaptability to an e-learning system or other Web-based systems.

The description of the learner profile must be as complete as possible in order to provide an adequate adaptation in an e-learning system. One of the main problems in this issue is the difficulty of acquiring the information about the user. There are two main conducts to obtain such information: explicitly or implicitly. Explicitly acquisition collect data directly as by a feedback form that learners should fill, concerning personal data, preferences, learning styles, goals, etc. The implicit technique consists of logging and mining the operations that the learner performs during the interaction with the system as, for example, recording the pages accessed in a certain period. Semantic networks, rules bases, and fuzzy logic can be applied to those data to mine the learner's preferences and behavior.

In a former research "Tapejara Project" [18] we developed an empirical procedure used to generate learner's cognitive profiles (LCP) and associated these profiles with the learning behavior. The training population sample was composed of 231 employees randomly chosen in a stratified sampling in a Telecommunications Company. The learner's CLP assessment was obtained from the statistical analysis of the Ross Test data [17]. The CLP learning behavior was obtained from the statistical analysis of the navigational log data in an experimental training module designed for this purpose. The statistical results have shown five CLP groups and their style dimensions and the correlation between each CLP groups and their navigational behavior in the Web training module. This is the first step to achieve an autonomous adaptive system able to get implicitly data on the users.

In order to find out which data about the learner are frequently used in e-learning systems, we carried out a search on open source and commercial systems [16]. The learner's model AdaptWeb system [1], for example, contains only personal data and the level of learner's knowledge about a topic. In the Claroline environment (http://www.claroline.net), the learner model is composed of personal data, a list of courses accomplished, and the quantitative history of actions (i.e. downloads and forum participation) in each studied course. These systems store learner's personal data in different internal structures. However, this learner information is not shared among different e-learning systems, which forces the learner to re-inform it for each different system. Data among e-learning systems should be shared, avoiding the learner burden to provide personal information every time he uses a different system. Besides, a system can offer information, which another system does not have. For example, in another project that we conducted, AdaptWeb [1] we are able to provide information about the learner's level of knowledge on a specified topic. This learning environment is extended, from the present limited adaptation possibilities, to a more developed level of adaptation based in a detailed learner profile and using inference about this profile to offer a specific learning path for each situation.

In the present research we are particularly interested in investigating how learners' information can be shared among different e-learning systems on the Web. Achieving this result we will be able to identify, to exchange and to explore the user model in order to create a tailored content to each specific user and situation. To make this possible, we must develop a standard to identify data through the different environments so that they all can "understand" the same data. In this work, the information about learner was designed and implemented as a user model. We defined some techniques for data retrieval of learners' profiles. These techniques were employed in three different e-learning systems. Also these techniques have been applied on a digital library with the goal of recovering the documents metadata in an OAI (Open Archives Initiative) [15] environment as the readers may be modeled in a similar way as students. For an experimental validation of the user model and the retrieval techniques, we defined a service-oriented architecture for sharing data between the systems.

This paper is organized as follows: Section 2 provides a short overview of the related work. Section 3 describes the approach for user profile interchange. Section 4 describes the services-oriented architecture and prototypes of the system developed are presented in Section 5. Section 6 concludes the paper and presents the plans for future research.

2 Related Work

In this section, some solutions that have already been found for the exchange of user data among systems are described. Dolog [8] presents the conceptualization and implementation of a framework, which provides a common base for the exchange of learner profiles between several sources. A Java and Web service API was implemented making use of the framework to allow other systems to plug into the standard based learner modeling component. The learner profiles are described in RDF.

The CPexchange (Customer Profile Exchange) [2] specification is a standard that facilitates the privacy-enabled exchange of customer profile information. The CPExchange specification defines a data model for profile information that relates a customer or other business partner, to an enterprise. The CPExchange specification also defines metadata for associating privacy controls with various subsets of the profile information, as well as operations for query, delivery, and update of this information. The Privacy Information Model extends the P3P 1.0 document [6] to describe the privacy policies covering the profile information being exchanged.

The ebXML [20] allows partners systems to discover each other and to store central definitions and the components that are needed to configure the interchange between them. These can then also be catalogued and shared across a community.

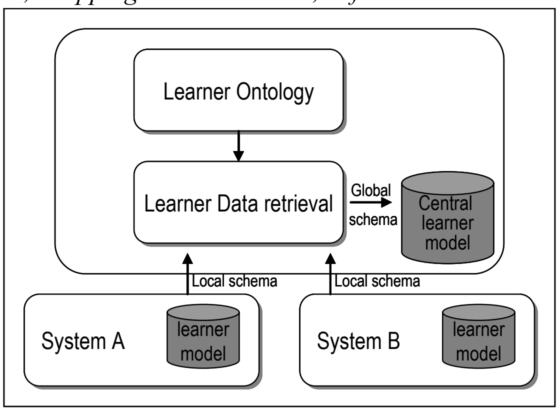
In Dolog's framework, one system that needs data from other system must access a RDF schema of the system to know the description of the structure of the model. Several problems and conflicts could arise because redundant data can occur when both models hold data on the same learner [7]. This heterogeneity problem was analyzed in the 90', in particular the last author has developed research in Multidatabase Interoperability. This problem is assumed to be conceptually solved. A paradigm for integrated access to heterogeneous databases was developed, in which conceptual schema integration is performed via schema mapping [4]. In this approach, available information for a real world entity is captured from different areas where the object is represented. Modeling and behavioral conflict resolution is replaced by conflict report, in order to support the complementary access to different parts of a real life entity and multiple interpretations of stored data. Integrated database access results of conceptual schema mapping, after the conversion of all schemata into a canonical object-oriented data model. This solution makes use of concepts presented in loosely coupled federated databases and the application is straightforward in the present case.

The CPEx and ebXML are specifications to customer profile. These specifications only defined an XML schema allowing a data exchange among the systems. These specifications don't define which communications protocols must be used and how this data must be stored.

3. Learner Profile Interchange

In the introduction, we pointed out the limitations of the learner profiles in adaptative systems and motivated the need of an approach for interchange learner data from different systems. In our approach, these data are collected from various sources and presents different formats. To make the data interchange possible, we also have defined a user model for learners. Our proposed approach for learner profile interchange, depicted in Figure 1, is composed of three main parts:

1. *Learner Ontology: describes the main concepts of the learner model and offers a canonical view of the data exchanged. This ontology will be employed for the inference of the preferred user behavior in AdaptWeb [1].*
2. *Learner Data Retrieval: is composed by four techniques (Search in the Database, Mapping XML instances, Inference and Gathering) for data*



retrieval in the systems. The techniques retrieve data in a local schema format used by each system for optimized local use. All these techniques retrieve data from the local database schema and are necessary to convert data for the global database schema, which is based on the user model.

3. *Central learner model: The central repository stores data gathered in the others systems. The data are stores in a global schema according with the user model.*

Fig. 1. Learner profile interchange

Our proposal has the advantage of allowing the consistent interchange of learner profiles between different systems through a user model. In the following subsections we detail our proposal and how the requirements explained here could be satisfied.

3.1 Model for Learner Profile

Interoperability and reuse of the learner model can be achieved by having data describing it in terms of an established standard model to describe the learners' information. The two most important standards for learner profile are IEEE LTSC Personal and Private Information Standard (PAPI) [14] and IMS Learner Information Package (LIP) [12]. Both standards deal with several categories related to information about a learner and present deficiencies in some characteristics. Neither PAPI nor LIP includes the definitions of either cognitive or learning styles, which are extremely important for the adaptation effort. The cognitive style is an individual aspect that describes the way as a person usually approaches or responds to the learning task [11]. The learning style is a collection of individual skills and preferences that affect how a person perceives, gathers, and process information [9]. Based in these standards, we defined a learner model with the addition of the behavioral characteristic.

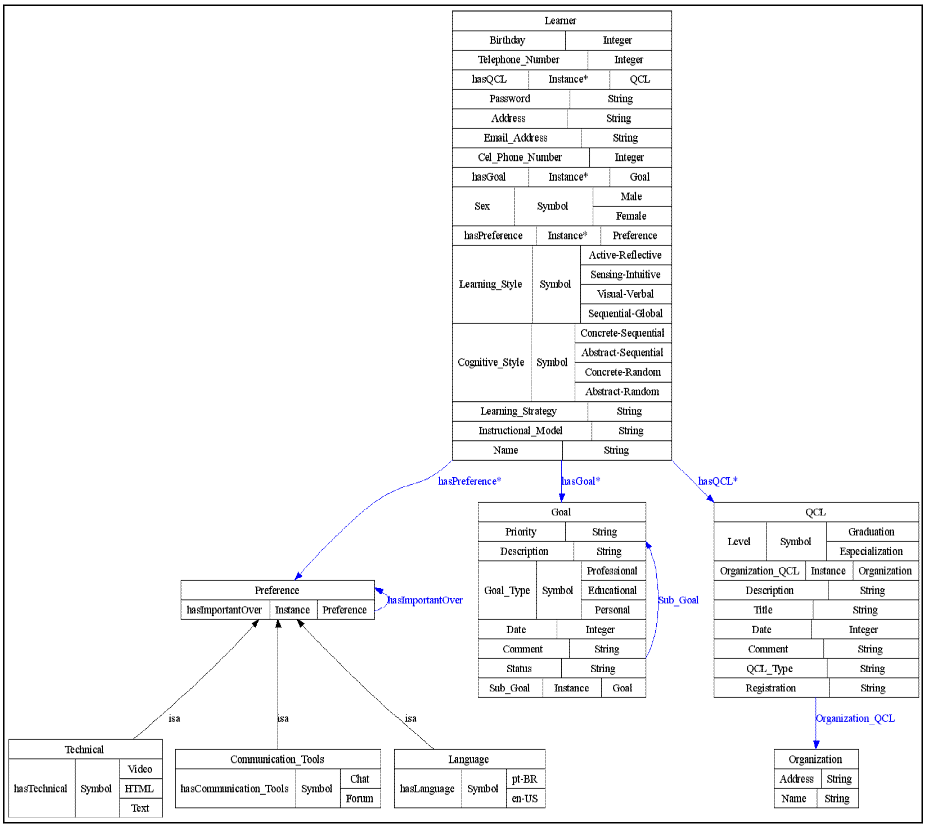


Fig.2. The Learner Model

The learner model, graphically represented in Figure 2, consists of the central class Learner with properties characterizing the learner personal information. This class comprises the following PAPI elements: ID, Name, Address, Email and Telephone.

The learner has both a cognitive and a learning style. The taxonomy of the cognitive style used in this ontology defined by Gregorc [11]. In this work, we used the learning style classification by Felder [9].

The learner has Preferences technical (video, html and text), communication tools and languages. This class follow PAPI standard.

The classes QCL (Qualifications, Certificates and Licenses) is IMS-LIP standard and follow its parameters. Each entry in the QCL has the following elements: Organization, which defines the institution that has given the certificate, level of certificate, title, certificate's date and description.

The class Goal, contains the learner's objectives and follow IMS-LIP standard. The elements of this class are: typename (type of learner's goals) which can be professional, educational or personal, description of the goal, data to reach a goal and priority level.

3.2 Learner Data Retrieval

Learner data is extracted from different sources. We distinguish three categories of data sources: e-learning system database, curriculum and Web. The e-learning system can provide rich information about the learner, like the personal data, preferences, which courses attended, etc. The personal Curriculum Vitae and the Web can provide personal data, educational degree, current topics of interest, conferences and journals publications, honors and awards, impact index of publications, citations and others.

The user model offers a conceptual and formal base that allows consistent metadata integration. To support the metadata retrieval, four techniques were defined to retrieve data automatically or semi-automatically [21]:

Search in the Database, Mapping XML instances to the learner repository, Inference and Gathering.

Search in the Database: retrieves information about learners from the system database.

Mapping XML instances: analyses XML documents and retrieves tags values. This technique can be used to retrieval data from the learner curriculum.

Inference: uses the information about the context as where the learner navigated to infer data values such cognitive style, learning style and others.

Gathering: gathers data from web pages into a combined data store. This technique can be used to retrieve data form the learner homepage, Scholar Google, etc.

All these techniques retrieve data from the local database schema and are necessary to convert data for the global database schema.

4 The Service-Oriented Architecture

In order to validate the approach for user profile interchange, a service-oriented architecture was defined and developed which is presented in the following sections.

4.1 Overview

In a typical service-oriented architecture, a service is made available so that other systems can use it. The services provider creates a WSDL (Web Service Description Language) service description that defines the service interface, that is, the operations of the service and the input and output messages for each operation. The provider publishes the WSDL service description to a discovery agency. Service requesters find services via discovery agencies using UDDI (Universal Description, Discovery and Integration) and use the WSDL description to interact with the service description that corresponds to a service previously selected.

The federated architecture is composed of systems that collaborate to enrich the learners' data profile; these e-learning systems compose a loosely coupled federation and act as service providers or service requesters. The central repository contains the WSDL specification mapped to UDDI for publishing and discovering existing services. The central repository acts as a broker system and can store data gathered in the e-learning systems. Figure 2 presents the components of this architecture.

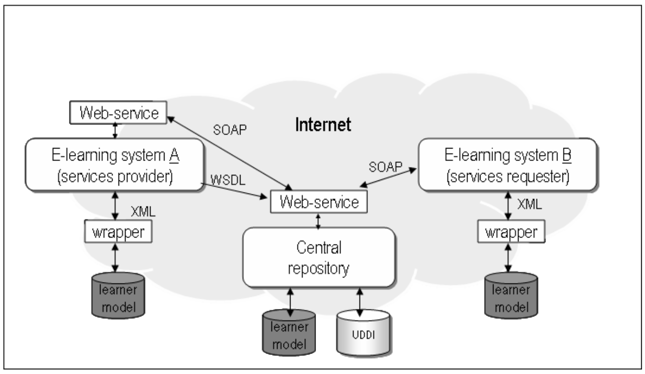


Fig. 3. Service-oriented Architecture

As the repository is dealing with private data, an authentication mechanism is needed so that e-learning systems can access it, and retrieve data from the repository. The central repository needs a specific authorization from each of the e-learning systems in order to be able to retrieve data from its local databases. The repository can implement a privacy policy that describes the access policies for the information it will receive. When the e-learning system provides information to the repository, it determines how the repository will handle this information. The solution we applied is the P3P standard (Platform for Privacy Preferences Project), which provides the formats by which two parts (client and server) describe and enforce their privacy policy [13].

Communication between the repository and the component systems is carried through a Web Service. To exchange the data between different systems it is necessary to have a single data profile, known by all the systems. To do that, we defined a Learner Profile Exchange Model (LPEM), which was represented in a Web Ontology. The Ontology will be employed for developing inference to support content adaptation to specific user's needs. LPEM is based on the IEEE LTSC Personal and Private Information Standard (PAPI) [14], and IMS Learner Information Package (LIP) [12]. In this work the information about learner model has a minimum group of information, which is enough to this work. Any e-learning system that needs the data stored in the repository implement an interface for calling the functions in the web service repository. The communication is made through SOAP (Simple Object Access Protocol).

There are two types of systems that can use the data stored in the central repository. The first type is represented by the e-learning system B in our architecture (Figure 3). This system only collects data from the repository to enrich its learner profile. The exchanged data are represented in XML and follow the LPEM 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. The second type of system represented by repository can retrieve data in any system database. To do that, the system needs to implement a Web service. This type is represented by the system A in our architecture (Figure 3).

4.2 The Services Definition

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 LPEM format.

The central repository services are related with users' records and e-learning systems that will provide data. The e-learning systems that are associated with the learner's model federation should provide, at least, the following services P3P, Access and Get, described below.

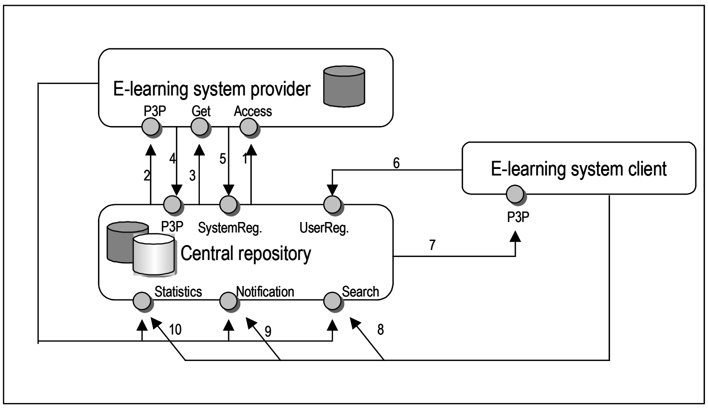


Fig. 4. Services to data exchange

The main set of services that the e-learning systems services should provide are: Access, P3P and at one Get service. Access(1) allows the repository to access its database. P3P(2) returns privacy policies of the e-learning system, which will be compared against the repository's privacy policies. The Get(3) services are directly linked to the categories and elements of the LPEM standards. The GetPersonal returns all elements to the repository (id, name, address, e-mail, telephone) in the LPEM format, it can be of one or more learners. The GetName, GetAddress, GetEmail, Get-Telephone services return only the element requested, that is, there can be a service for each element existent in the standard Personal Information category of the LPEM standard. The GetAllQCL, GetAllGoal and GetPreferenceList services returns all elements of the respective category. GetQCL may return only one register that can be searched by Organization, Level, Title or Date. GetGoal returns only the goals that are related with the date sent as parameter. GetCognitiveStyle and GetCognitiveLearning return the learner's cognitive and learning style, respectively.

The e-learning system should be registered in the repository using the SystemRegistration(5) service to supply data to the central repository. The register of an e-learning system involves the description of its services in WSDL and its privacy policy in P3P. An e-learning system should require the repository's privacy police before its registering. The P3P(4) service provides the repository's privacy policies to the e-learning system.

The central repository offers the UserRegistration(6) service for users registered in the repository. On subscription, the user should provide his privacy police in P3P(7). Only registered users can search or research data through the repository. If a registered user wants to search the services registered in the repository, he will use the Search(8) service, which returns the services the user requested. The search for a service is carried out through categories of the LPEM model categories. For example, a user may want to search that supplies service that offers the styles of a given learner (Category Style of the LPEM model). An advanced search can also be made, that is, the user can discover the systems that provide the cognitive style to the learners through the Search service.

The Notification(9) service included in the repository sends notifications to registered users warning that new information that interests him have arrived. The information can be: 1) input or output of a new base in the repository; 2) inclusion or alteration of a value. This service is implemented through the active ECA rules (event-condition-action).

The Statistics(10) service is a especial type of search that returns a summary of the access to the repository. Examples of statistical search are: who searched such information, who received the notification before searching data, who received the notification and has not searched data.

5 Prototype Implementation

The prototype retrieves personal learners' data from a XML repository and the two different relational databases (MySQL). This data are store in a central repository. The retrieval technique "Search in the Database" was implemented as Web service (Get_Data) and gets data in a system database. The technique "Mapping XML instances" was implemented as Web service and retrieves data stored in a XML document. We have chosen these target systems because they contain distinct data models and enough data to allow us to carry out our experiment. In this section we will explain a small parcel of the information exchange; the full implementation is being integrated to the AdaptWeb [1] system.

In the XML repository has data about the curriculum learner. In Brazil, the whole research community, from undergraduate learners to senior researchers, must make their curricula available in the Lattes platform [5] to be able to receive any research agency funding. This platform offers a XML interface describing all the research and academic profile. The unique user identification is provided by this repository. In other countries a unique identifier as a national social security number or the national identity number may be employed for identification. The other alternative is to deploy a pattern matching strategy to identify candidates. As an e-learning system needs an administrative component whit unique student identification the first alternative was chosen. Figure 5 shows the upper level Lattes' categories for user data.

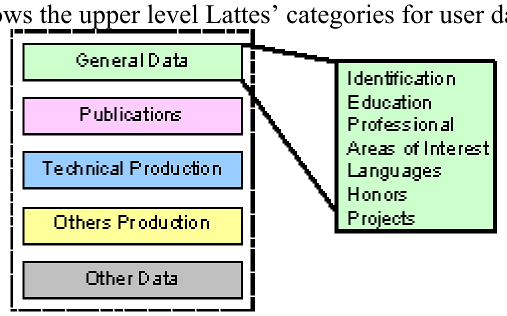


Fig. 5. Lattes categories

Data such as those of the Personal Information, Qualifications and Certifications can be retrieved from Lattes in the XML format. The first Web service was developed to access the data of Lattes XML repository. In Lattes, personal data are in tag "General Data". This data must be mapping to LPEM model. Table 1 shows the mapping from Personal Data of the Lattes to Personal Information of the LPEM model.

Table 1. Mapping Lattes to LPEM

Lattes	LPEM
General_Data.CPF	Personal_Information ID
General_Data.FullName	Personal_Information Name
General_Data Home_Address	Personal_Information Address

The first database accessed comes from the AdaptWeb environment [1]. It offers educational content according to the learner's profile. ID, name, address, email and telephone are data from the AdaptWeb learner's profile, which is stored in a MySQL base. CPF is Brazilian person identification code. Table 2 presents the mapping from AdaptWeb to LPEM.

Table 2. Mapping AdaptWeb to LPEM

AdaptWeb	LPEM
CPF	Personal_Information.ID
Name	Personal_Information.Name
Address	Personal_Information.Address
Email	Personal_Information.Email
Telephone	Personal_Information.telephone

The second database is from the Claroline environment [4]. Claroline is a free-software platform, developed by the Université Catholique de Louvain (Belgium) and released under Open Source license (GPL). Table 3 shows Claroline to LPEM mapping.

Table 3. Mapping Claroline to LPEM

Claroline	**LPEM Personal Information**
Officialcode	Personal_Information.ID
Nom + prenome	Personal_Information.Name
Address	Personal_Information.Address
Email	Personal_Information.Email
Username	-
Password	-
Status	-
userID	-
-	Personal_Information .telephone

The process of a user search data in e-learning system provider is illustrated in Figure 6.

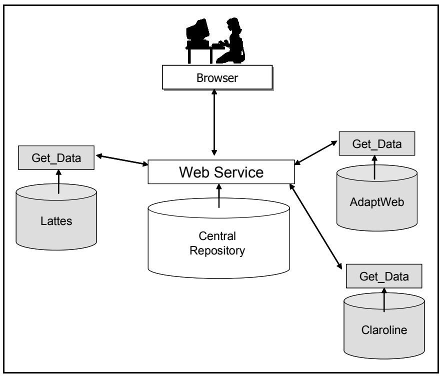


Fig. 6. The interchange data process

The client makes a query that can retrieve data from one of the repositories (Claroline, AdaptWeb or Lattes) or from all of them (All). At this moment, the client also chooses the type of data from the LPEM model it wants, by clicking on the required option (Personal Information, Preference, QCL, Goal, Style). The fields corresponding to the type chosen are displayed. The client should fill one or more fields to request the query. Figure 7 shows the query interface.

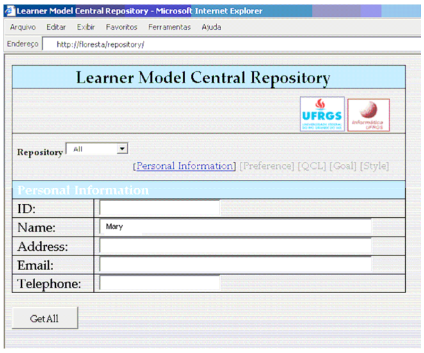


Fig. 7. Query Interface

The Get_Data service receives the user's request in the global schema format (LPEM) based on the user model and maps to local database schema. After conversion between schemas, the Web service makes the query in the database. The same mapping should be performed when the query result is sent to the client. At this moment, each system is responsible for mapping the global schema in the local schema database.

All data are sent through the HTTPS, which confers safety to data sending procedures. Some data may be available to the public, some data may be private, and other combinations are possible. The LPEM model information may be administered and secured separated, e.g., personal learner information is private and secure, while the learner QCL information is public. The learners and administrators and the requirements choose the public nature of the learner information.

6 Conclusion and Future Work

This paper presented an approach for the gathering and exchange of learner's information between systems on the Web. Our goal with this work was to allow different systems to cooperate with each other in order to reach a set of learner profile richer than the set currently found in common stand-alone e-learning systems. We have also defined a learner model that is employed to offer a canonical view of the metadata exchange performed by the cooperative systems.

With the purpose of validating the approach for user profile interchange; we defined a set of services and a service-oriented architecture. Those services, defined and implemented as Web Services, allow not only data exchange but also provide security, privacy, and event notification facilities. A system prototype was developed in PHP language and retrieves learner data from three different systems. Some experiments have been done intended to support the technical validation of the proposed architecture.

Ongoing work is oriented for the extension of the ontology representation of the user model in two directions. First, we are extending the ontology for representing the learner evaluation process thought the addition of the temporal characteristics. Second, we are investigating the requirements related to the inference techniques to be applied for extracting more information concerning the learner evolution along the time and the consequences for the content sequence presentation. Besides the logical organization, the architecture includes the definition of a query language to be used for recovering temporal information concerning the learner evaluation process. All this process are being implemented and validated in the AdaptWeb environment [1]. The experimental validation process of an adaptive e-learning system, under a controlled situation, needs a detailed experimental protocol and a large sample of students. Our efforts will be now directed in the gathering and analysis of this experimental data.

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