

Elena: A Mediation Infrastructure for Educational Services

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ABSTRACT

The paper presents the work of the Elena project. The contribution of this paper is twofold: The first part of the paper elaborates on the notion of educational services. Educational services are differentiated from learning objects and put in context of web services. A model for educational services is introduced and current limitations of metadata standards are addressed. In the second part of the paper a mediation infrastructure for educational services, so called smart learning space, is sketched. The architecture of smart learning spaces is based on P2P and semantic web technologies.

Categories and Subject Descriptors

K.3.1 [C]: computer Uses in Education

General Terms

Smart space for learning

Keywords

educational services, semantic web, P2P

1. INTRODUCTION

In this paper we illustrate a mediation infrastructure for educational services. We envision a scenario where educational services are announced and mediated by electronic means. Although the web enables access to all kinds of educational resources, it is difficult for learners to find appropriate educational services such as courses, seminars, and web-based training applications. Corporate and independent learners aim to choose educational services from heterogeneous sources and heterogeneous quality. However, since an electronic, world wide infrastructure for the mediation of educational service offerings is missing, learners' choices of educational services are limited towards pre-selected catalogues.

This limitation is addressed by a concept called smart learning space. Smart learning spaces are defined as service mediators, which support the personalized consumption of heterogeneous

educational services provided via assessment tools, learning management systems, (meta) repositories of educational material and live delivery systems such as video conferencing systems. Smart learning spaces are built on top of learning management networks. Learning management networks connect systems like the ones mentioned above and provide an infrastructure for the provision, booking and consumption of educational services.

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We envision that the mediation of educational services will become a killer application of the semantic web. While electronic (educational) resources already incorporate a significant amount of information even without explicit metadata (e.g. file names, hyperlink structures, headings and titles, etc.), educational services need a human and - following the vision of the semantic web- also machine-readable description in order to make them available. Service descriptions cannot be derived from file names, html tags. In addition, metadata annotation of services pays off since the consumption of services results in costs and information-rich service descriptions contribute to a more effective service selection. This economic aspect will trigger the wide-spread use of service annotations. Based on this assumption we envision the raise of educational service mediators as presented herein.

The remainder of the paper is structured as follows. In Section 2 we present a usage scenario of the smart learning space. Section 3 describes how we define and model educational services. Additionally, a comparison between educational services and web services is introduced. Section 4 describes our mediation architecture and we report about our efforts defining an ontology for educational services. Section 5 provides related work and Section 6 concludes the paper with our plans for future research.

2. USAGE SCENARIO

In smart learning spaces learners can choose learning services from heterogeneous sources. Users maintain their own learning profile, where learner background data such as job titles, hobbies, previous learning events as well as demographic data such as location are stored. Based on this profile Joseph, a department head of a research institution, for example receives recommendations of courses such as "Team Leading in Not-For-Profit Organization", "Fishing in Hungary" and other learning service offerings, which seem to be relevant for his professional and private life. Learning services are provided by associated institutions and in-house learning service providers, for example a learning management system, which hosts various web-based training applications. Joseph's personal learning assistant (PLA) frequently queries the learning service providers for offerings matching Joseph's profile.

When Joseph becomes interested in a particular learning service, the PLA takes care of registering Joseph for the particular service. In the case the learning service will be consumed as part of his professional engagement, the PLA automatically takes care of requesting authorization from Joseph's authorization authority, in his case the head of the personnel department of his research institute. After booking the PLA directs Joseph to the learning service and updates his learning profile.

3. DEFINING EDUCATIONAL SERVICES

3.1 From Learning Objects to Educational Services

Traditional educational services, e.g. the delivery of a course, rely on human or physical resources, such as instructors or lecture halls. Even in the case of a fully electronic educational service (e.g. skill assessment with an electronic tutoring system) most likely there is also some kind of human support involved, where you can turn to in case a learner encounters problems. Both, traditional and electronic educational services use electronic or physical educational resources such as case studies, exams, exercises, lecture notes, simulations, text books, tutorials etc. In order to support the provision of the service. These educational resources are commonly referred to as learning objects.

Because of the extensive use of resources, educational services do not come for free. Hence, an exchange transaction comprising provision, offer placement, announcement, booking, and settlement of educational services need to be supported by a mediating infrastructure.

Educational services, which make use of physical or human resources, are offered according to a specific schedule since the use of those resources needs to be managed. A talk is held at a specific point of time, a course is offered within a semester period, tutoring sessions require an appointment, etc. When it comes to the delivery of an educational service, providers follow a specific objective. In the case of the delivery of a course, for example, the accompanying objective can be explicitly expressed by the educational objective and the learning goals of the course. Consumers of services are motivated by a particular objective when they consume a service. Mediation of educational services requires to match the goals of the learner with the objective addressed by a learning service.

Educational services of different granularity exists. Small educational services such as assessment or short lectures can be combined to high level services such as courses and degree programs. This means that some services will be of more atomic nature and others will be more high-level one. Educational services are educational events that are performed to reach a specific educational objective.

3.2 Modeling Educational Services

A smart learning space needs a common model for describing educational services. Educational services announced need to comply with this model. Other models can be used too, but need to be mapped to the common model.

The following figure is a first snapshot of the Elena Common Data Model:

- Educational service description
- Educators
- Educational resource
- Educational technology
- Physical Places
- Terms and Conditions
- Schedule

In smart learning spaces the artefact subject to exchange is the educational service. An educational service requires resources such as educators, educational resources, and educational technology when delivered. Educational services can be offered according to a specific schedule and are bound to terms and conditions.

Since the focus of the IEEE Learning Object Metadata (LOM) standard lies on modeling educational resources, LOM does not provide a vocabulary, which is rich enough to describe comprehensive educational services [12]. At the time of writing, metadata initiatives have put little emphasize on the pedagogical context in which an educational service is offered. Role-based attributes may open new ways to develop a didactic-related ontology [1]. A language for describing the timing of educational events such as the EDL language [10] is required to provide a rich enough vocabulary for scheduling information.

3.3 Educational Services versus Web Services

When designing a mediation infrastructure for educational services the role of web services needs to be clarified. A web service is a network-accessible interface to an application. Several standards have emerged in this area. SOAP [13], an XML-based information exchange protocol between distributed applications, is the most common way to communicate with web services. WSDL [16] and DAML-S [3] are computer-readable descriptions of web services.

Network accessible educational services can be modeled with web services. Not only fully electronic but also human-assisted educational services like tutoring per email or video-conferencing [10] can be modeled with web services.

Web services can play a crucial role when it comes to the management of educational services. Web services can be used to announce and contract educational services, register learners, and feedback learning results.

In order to combine educational services of different granularity levels a workflow model is needed. For example, you may need to enroll into a specific assessment session before registering a course. The following efforts try to address this problem:

- ebXML BPSS, from ebXML, Business Process Specification Schema [4],
- XLANG, from Microsoft, Web Services for Business Process Design [8],
- WSFL, from IBM, Web Services Flow Language [6],

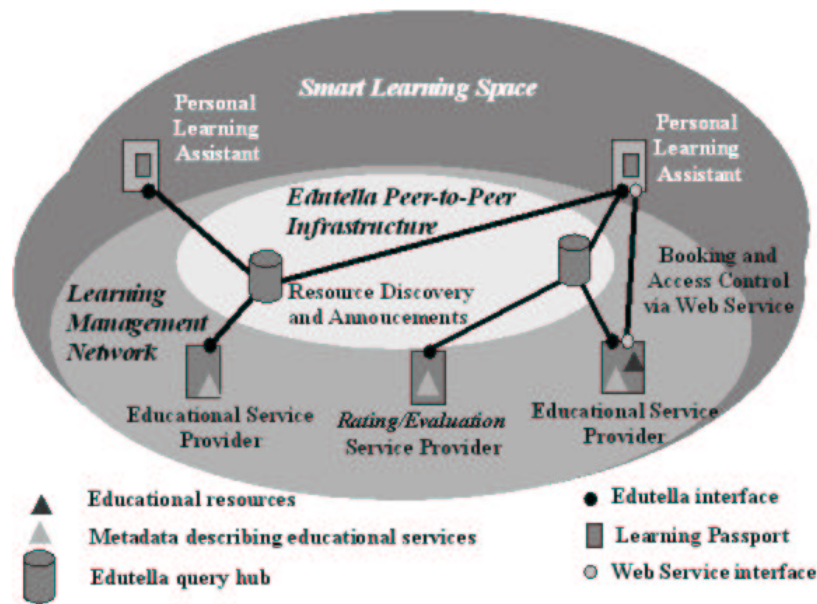


Figure 1: Mediation architecture for educational services

- The Web Service Modeling Framework WSMF [2].

The modelling of educational services with web services also opens the possibility of automated integration of educational services into a smart learning space and the automated combination of them. To perform this task, however, we need also semantic information about the services.

4. SYSTEM ARCHITECTURE OF SMART LEARNING SPACES

4.1 System Components

Figure 1 depicts the various components of a smart learning space. In a smart learning space educational service providers are connected within the learning management network, which is based on Edutella [9]. Edutella is a peer-to-peer (P2P) technology that aims at connecting highly heterogeneous educational peers with different types of repositories, query languages and different kinds of metadata schemas. Each Edutella peer is capable of performing a number of basic services such as querying, replication and mapping. Educational services providers either connect directly to the network as Edutella peers or use other Edutella peers (e.g. the Universal Brokerage Platform for Learning Resources[12]) as a gateway to announce their services in the network.

Educational service provider need not to provide educational services in a fully electronic manner. For example, some educational service providers just list a number of courses, whose availability is spread through the learning management network like a static web page but using XML and RDF instead of plain HTML for describing their courses. Others might provide a fully web-based training application and a web-service enabled interface, which allows automatic learner register and reporting of learning achievements. Special rating service providers facilitate rating-like annotations of educational service descriptions.

On top of the learning management network PLAs interact with the connected peers in order to query for suitable learning services. PLAs take advantage of the learner profile in order to augment queries and personalize query results. They recommend learning

services based on the profile via push technology and have rules implemented, which allow them to automatically perform process such as course registration.

Since search takes place in a P2P setting, ELENA also tackles the problem of concept-/ontology-based routing in P2P networks and their construction and maintenance, continuing work on HyperCup in the Edutella project [11].

4.2 Ontologies for educational services

Ontologies have been identified as one of the most important ingredients in distributed, heterogeneous (and, especially, semantic web) applications. Being defined as explicit, shared specifications of conceptualizations [5], they enable the various actors in these applications to communicate with each other on a high level of abstraction. In ELENA, these actors are educational service providers which are realized as peers in a P2P network.

A typical request sent to these service providers looks like "find a tutorial that explains the semantic web to a novice." Unlike in common search engines (like Google), such a request is not sent in its textual representation, but formalized with the help of various ontologies, e.g.:

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request17(documenttype tutorial, topic Semantic_Web,
level_of_knowledge novice)
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Here, the document type comes from an ontology of educational resource types that contains the various types of educational resources (e.g. Case Study, Course, Course Unit, Exam, Exercise, Experiment, Group Work, Lecture, Presentation, Tutorial, etc.). The topic comes from a domain ontology, in this example, an ontology containing all the concepts of computer science. Novice comes from an ontology that models the learners' previous knowledge or, in general, learner profiles. A further ontology that comes into play is a web services ontology that is used by the web services to describe their capabilities. These ontologies are represented with the help of semantic web ontology languages like RDFS, DAML+OIL, and OWL and are based on existing or upcoming standards like Dublin Core, IEEE LOM, WSDL, DAML-S etc.

When creating or adding educational resources, these have to be annotated with the concepts from the above mentioned ontologies. This can either be done manually or semi-automatically, i.e., with the help of linguistic or statistical content analysis.

Finding the desired educational resources for a request requires more than just simply matching it with their annotations: When the user requests an educational service on the topic Semantic Web, the system should also list services on e.g., RDF and other main stream Semantic Web technologies. This is accomplished by explicitly representing relationships in the (domain) ontologies like *is_technology_for* plus exploiting them with the help of inference engines, e.g., with RDF-QL [9] or TRIPLE [14].

Especially in the case of domain ontologies, it is very likely that the various institutions develop their own ontologies for the same or similar domains independently (or use their existing library indexes to bootstrap them), resulting in largely incompatible ontologies. This requires the development of mappings between concepts from these ontologies. Such mappings can, for example be expressed as rules which are enacted by rule engines like TRIPLE.

5. RELATED WORK

Stojanovic et al. [15] applies semantic web technologies to implement an e-learning scenario. Attaching metadata to learning modules enables the context-specific integration of learning modules. Their work focuses on the dynamically creating course structures and not on the mediating of educational services. Their ontology describes the context, structure and content of the learning materials. They use F-Logic as representation for their ontology.

Integrating semantic information into peer-to-peer networks has become an active research area recently. For many applications a text-based search is not satisfactory, especially because the information is no longer organized in hypertext-like link structures. The EU project SWAP [7] also aims at combining semantic web and P2P technologies.

The project SWWS [7] is about creating semantic web enabled web services to develop new classes of e-business applications. Their infrastructure enables semantic-driven mediation of services which is similar to our approach. A central element of the project is a business process description. In Elena we do not have a formal description for the learning process.

The combination of ontologies and p2p opens new promising directions for future research.

6. CONCLUSION AND FUTURE WORK

We presented the design of an educational services mediation infrastructure. Metadata and ontologies play a crucial role in the context of educational services. For organizations the consumption of learning resources is a costly process. Hence, choosing the most suitable educational services for each employee is a critical task. A careful selection of attributes and attribute value spaces constitutes an important influence factor on the quality of a mediation infrastructure.

Currently IT-mediated learning is restricted to closed information environment. Our mediation infrastructure intends to interconnect heterogeneous learning services provided by heterogeneous information systems. In this way new educational value chains can be created.

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