

Smart Space for Learning: A Mediation Infrastructure for Learning 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 learning services. Learning services are differentiated from learning objects and put in the context of web services. A model for learning services is introduced and current limitations of learning object metadata standards are addressed. The second part of the paper sketches a mediation infrastructure for learning services, called Smart Space for Learning. The architecture of Smart Spaces for Learning 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

learning services, semantic web, P2P

1. INTRODUCTION

In this paper we illustrate a mediation infrastructure for learning services as it is currently developed by the Elena project (<http://www.elena-project.org/>). A learning service is in our understanding an event that is provided by a learning service provider in order to support the accomplishment of a specific educational objective. This is achieved by creating a learning environment consisting of educators, educational material, communication infrastructure, meeting places, etc. Examples of a learning service are the delivery of a course, the provision of a web-based training application or the provision of self-study material. We envision a scenario where learning services are announced and mediated by electronic

means. Although the web enables choosing from a variety of educational resources, it is difficult for learners to find appropriate learning services such as courses, seminars, and web-based training applications. Corporate and independent learners seek learning services with heterogeneous properties (traditional courses, online courses, assessment services, mini-learning units, etc.) from heterogeneous sources (in-house training, external training providers, higher education institutions, etc.). The rationality of the selection process of a learning service performed by a human being is limited for the following reasons [15]: limited overview of the learning services available, limited capabilities of processing all the information describing learning services.

These limitations are addressed by a concept called Smart Space for Learning. Smart Spaces for Learning 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 Spaces for Learning 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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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. It also introduces a comparison between educational services and web services. Section 4 describes our mediation architecture and our efforts to define 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 Spaces for Learning, learners can choose learning services from heterogeneous sources. Users maintain their own learning profiles, where learner background data such as job titles, hobbies, previous learning events as well as demographic data such as location are stored. Learning profiles are also dynamically updated with the learning progress. Thus, for example, Joseph, a department head of a research institution, may have a learning profile that leads to recommendations of courses such as "Team Leading in Not-For-Profit Organizations", "Fishing in Hungary" and other learning service offerings which seem 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) periodically obtains learning service offerings from the Smart Space for Learning which might be appropriate for him. When Joseph becomes interested in a particular learning service, the PLA takes care of registering him for the service.

3. DEFINING EDUCATIONAL SERVICES

3.1 From Learning Objects to Learning Services

Traditional learning 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) there is most likely also some kind of human support involved, learners who encounter problems. Both traditional and electronic learning services use electronic or physical educational resources such as case studies, exams, exercises, (components of) lecture notes, simulations, (components of) text books, (components of) tutorials, etc., in order to support the provision of the service. These educational resources are commonly referred to as learning objects.

Learning services are complete entities designed for a specific purpose and targeted at a specific audience. Providers of learning services can state clearly which kind of skills they want to develop and train in the learner. Learning objects are of a more general nature and of a smaller granularity level. Educators and (semi-) automated tutoring systems compose learning services out of learning objects and other educational resources. Because of the extensive use of resources, learning services - especially in the corporate world - do not come for free. Hence, exchange transactions comprising provision, offer placement, announcement, booking, and payment of educational services need to be supported by a mediating infrastructure where users are authenticated.

Learning 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 a learning 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 learning services requires matching the goals of the prospective learner with the educational objective addressed by a learning service.

3.2 Modeling Learning Services

In Smart Spaces for Learning the artefact subject to exchange is the learning service. A learning service requires resources such as educators, educational resources, and educational technology, which have to be modeled. Learning 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 learning objects, LOM does not provide a vocabulary, which is rich enough to describe comprehensive learning services [14]. A particular drawback of LOM, for example, is the lack of unambiguous concepts. Educators need to know when they browse a learning resource catalogue if they are confronted with a full educational service such as an educational activity or material that they can reuse for their own lectures.

LOM suggests the learning resource type attribute for the purpose of classifying learning resources (the attentive reader might note that although LOM is based on the notion "learning object", the educational type classification attribute is called "learning resource" type while no further explanation on the difference between those two notions is provided in the document). For learning resource type, a vocabulary of 15 values has been defined, which has the following weaknesses when applied it in the context of educational mediators:

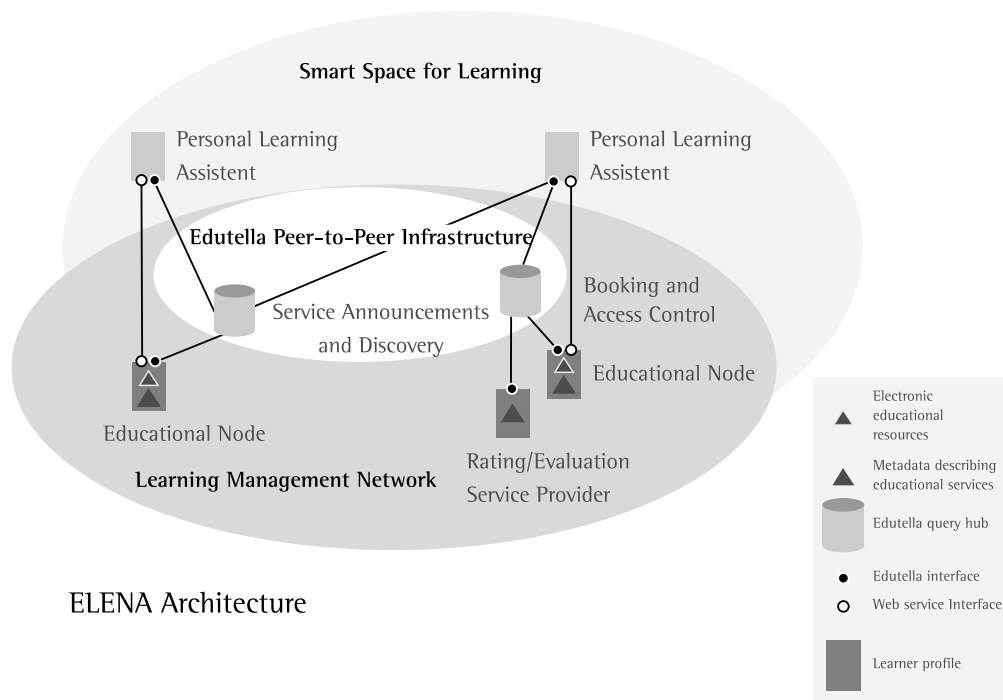
- While some of the meanings of the attribute values overlap [6], e.g. diagram, figure, graph, the value space can be perceived as a subjective selection from a large set of potential values. This impression is reinforced when looking at the variety of learning resource types used by some of the platforms mentioned above. (A survey on learning resource type values is available at <http://nm.wu-wien.ac.at/e-learning/lr-types.htm>.)
- LOM's value space for learning resource type mixes up media type, educational activity type and educational material type [14], but without providing a sufficiently rich set of attribute values for any of those attributes. For example, diagram, graph and figure refer to a media type; exercise, lecture and self assessment to an educational activity type; table, slide, and narrative text to an educational material type.

At the time of writing, metadata initiatives have put little emphasis on the pedagogical context in which a learning 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 [12] is required for modeling scheduling information.

Educational services comprise learning services and services that supplement learning services. An educational service can be used in order to prepare or control learning services. For example, a brokerage service for educational material can be used for preparing the delivery of a course. Learner assessment services can be used to identify knowledge gaps. Evaluation services are used to determine the quality of a learning service. Reputation services can be used to quantify the reputation of a learning service provider. The Smart Space for Learning mediates educational services, but focuses on the mediation of learning services.

3.3 Learning Services versus Web Services

When designing a mediation infrastructure for learning services it is necessary to clarify the role of web services. A web service is a network-accessible interface to an application. Several standards have emerged in this area. SOAP [16], an XML-based information exchange protocol between distributed applications, is



ELENA Architecture

Figure 1: Mediation architecture for educational services

the most common way to communicate with web services. WSDL [19] and DAML-S [4] are computer-readable descriptions of web services.

Network-accessible learning services can be managed using web services. Not only fully electronic but also human-assisted learning services like tutoring per email or video-conferencing (based on [12]) can be managed with web services. Web services can be used to provide, announce, contract and deliver learning services, register learners, and feed back learning results [13].

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

- ebXML BPSS, from ebXML, Business Process Specification Schema [5],
- XLANG, from Microsoft, Web Services for Business Process Design [10],
- WSFL, from IBM, Web Services Flow Language [8],
- The Web Service Modeling Framework WSMF [3]
- Business Process Execution Language for Web Services [2].

The modeling of learning 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 educational services.

4. SYSTEM ARCHITECTURE OF SMART LEARNING SPACES

4.1 System Components

Figure 1 depicts the various components of a Smart Space for Learning. In a Smart Space for Learning, providers of educational service are connected within the learning management network, which is based on Edutella [11]. Edutella is a peer-to-peer (P2P) infrastructure that aims at connecting highly heterogeneous educational peers with different types of repositories, query languages and different kinds of metadata schemata. Each Edutella peer is capable of performing a number of basic services such as querying, replication and mapping. Learning service providers either connect directly to the network as Edutella peers or use other Edutella peers (e.g. the Universal Brokerage Platform for Learning Resources [14]) as a gateway to announce their services in the network.

In Smart Spaces for Learning, learning service providers need not provide their services in a fully electronic manner. For example, some learning service providers just list a number of courses, whose availability is spread through the P2P network like a static web page, but using XML and RDF instead of plain HTML for describing them. Others provide a fully web-based training application and a web-service enabled interface, which allows automatic learner registration and reporting of learning achievements. Reputation service providers facilitate rating-like annotations of learning service providers, which are aggregated from evaluations of learning service deliveries.

On top of the learning management network, personal learning assistants interact with the connected peers in order to query for suitable learning services. A personal learning assistant is a component of a Smart Space for Learning which supports learners in searching for, selecting and contracting learning services. Personal learning assistants take advantage of the learner profile in order to augment queries and personalize query results. They recommend learning services on the basis of the profile and have rules implemented which allow them to automatically perform processes such as course registration. The learning profiles can be

(semi-)automatically maintained by the importation of achievement records from learning service providers.

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 [7], they enable the various actors in these applications to communicate with each other on a high level of abstraction. In ELENA, these actors are learning 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.:

```
request17(documenttype tutorial, topic Semantic_Web,
level_of_knowledge novice)
```

Here, the document type comes from an ontology of educational services that contains the various types of educational resources (e.g. Case Study, Course, Online 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. 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 learning services are created or added, they 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 learning services for a request requires more than just simply matching it with their annotations: When the user requests a learning service on the topic Semantic Web, the system should also list services on, e.g., RDF and other mainstream 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-QEL-i [11] or TRIPLE [17].

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 create 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. [18] applies semantic web technologies to implement an e-learning scenario. Attaching metadata to learning modules allows the context-specific integration of learning models. Their work focuses on dynamically creating course structures and not on the mediating of learning services. Their ontology describes the context, structure and content of the learning materials. They use F-Logic as the representation for their ontology.

Integrating semantic information into peer-to-peer networks has recently become an active research area. 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 [9] also aims at combining semantic web and

P2P technologies.

The project SWWS [9] is about creating semantic web-enabled web services to develop new classes of e-business applications. Their infrastructure allows 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 a learning services mediation infrastructure called Smart Spaces for Learning. Metadata and ontologies play a crucial role in the context of educational services. For organizations the consumption of educational resources is a costly process. Hence, choosing the most suitable learning services for each employee is a critical task. A careful selection of attributes and attribute value spaces constitutes an important influence on the quality of a mediation infrastructure.

Currently, IT-mediated learning is restricted to closed information environments. Our mediation infrastructure intends to interconnect heterogeneous learning services provided by heterogeneous information systems and mediate them using learner profiles.

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