A Framework for Semantic Integration of eLearning Services

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Abstract

The primary characteristic of the Semantic web is shared understanding, a fundamental challenge now facing e-Learning community. The aim of this paper is to highlight the role of ontologies for enabling the semantic interoperability of learning services and to propose a conceptual framework for integrating e-Learning services using ontologies.

1. Introduction

Sharing and reuse of digital information have been an important computing concern since the early 1960s. These concerns have become even more central to the effective use of distributed information resources -electronic learning systems (e-Learning) being a typical example [7, 8, 11]. Current approaches have been based on a syntactical level. Being able to understand meaning of information brings integration of learning objects and services to a new layer of automation, flexibility and usability [1].

Learning Objects (now moving to "Learning Services" as the service oriented programming paradigm matures) have been used as a global concept that served as conceptual axis that pulled together common interests within e-Learning. The fundamental idea behind learning objects is that instructional designers can build small instructional components that can be reused a number of times in different learning contexts [9]. While, most of the metadata tagging approaches provide a means for describing, sharing and reusing resources, the concept of interoperability and heterogeneous access to content chunks is yet to be fully achieved.

The main aim of this paper is to analyze the role of ontologies for enabling the semantic interoperability of learning services within the domain of e-Learning. Next section provides a brief review of e-Learning and the Semantic Web with an analysis of the role of ontologies for integration e-Learning systems and a framework for integrating e-Learning services using ontologies defined in Section 3. Finally future research challenges to educational technologists, computer and information scientists is being highlighted.

2. The Role of Ontology for Integrating eLearning Services

e-Learning systems are made possible by the ubiquity of Internet standards such as TCP/IP, HTTP, HTML and eXtentensible Markup Language (XML) -an evolved representation format for interoperability. Additionally, emerging schema and semantic standards –such as XML-schema, Resource Description Framework (RDF) and its extensions, and the DARPA Agent Markup Language and Ontology Inference layer (DAML + OIL) together provides tools for describing web resources in terms of machine-readable metadata. See [2, 3, 6, 7] for a thorough analysis of these technologies. While, some these technologies are matured and already in use, ontology representation languages promise to play an important role in the development of the semantic web.

The adoption of XML Standard with open Internet protocols has further defined a way of integrating distributed resources at the software service level. There is a rapid evolution and adoption of Service Oriented Computing (SOC) paradigm [12] that utilises services as fundamental elements for developing applications. This provides a foundation in achieving interoperability and heterogeneous access to learning resources. SOC involves service layers, functionality and roles as described by the Services Oriented Architecture within which, services are self-describing, open components that support rapid, low-cost components of distributed applications.

Alongside evolutionary representation formats for interoperability, many metadata standards have also emerged for describing eLearning resources. Amongst others are: Learning Object Metadata (LOM), Sharable Content Object Reference Model (SCORM), Alliance of Remote Instructional Authoring and Distribution Networks for Europe (ARIADNE, Instructional Management System (IMS) (see [3, 7]) for details. While, most of these approaches provide a means for describing, sharing and reusing resources, the concept of interoperability and heterogeneous access to content chunks is yet to be fully achieved.

Using service-oriented architectures with existing metadata standard may provide a unified way for enabling interoperable e-Learning services. This requires a formal way of representing these services.

Ontology has been a co-opted term from philosophy used in computing to describe formal, shared conceptualisations of a particular domain [2, 3, 4). Tom Gruber (1995) defines ontology as "*an explicit representation of a conceptualisation. The term is borrowed from philosophy, where Ontology is a systematic account of existence. For AI systems, what 'exists' is that which can be represented*." An ontology represents information entities such as person, artefact and events in an abstract way. Ontologies are designed so that knowledge can be shared with and among people and possibly intelligent agents [13].

Ontologies are therefore advanced knowledge representation, which consists of several components including: concepts, relations and attributes, instances and axioms. Hierarchical concepts are linked with an "is-a" relation. For example, we can define two concepts Person and Man. This can be hierarchically linked, as "A man is a person". It is clearly due to the unambiguous nature of ontologies that it has probably become the most rapidly evolving with diverse areas of applications. It has been envisaged that ontological engineering could assist in dealing with interoperability challenges in e-Learning systems [13].

Ontologies enable semantic interoperability between information systems thereby serving a central role for the semantic web and in particular a means for integrating eLearning services. They can be used to specify user-oriented or domain-oriented learning services. Intelligent mediators can also use them – a central notion in teaching and learning. Therefore the development of ontology has been be useful for object or service modelling for e-learning domain [7, 13]. While it is clear that ontology engineering enables interoperability, most ontological structures and protocols are fixed and implicitly assumed. Thus, the agent that engages in integrating different ontologies is assumed to know and agree with both structures and protocols in priori. This is suitable in closed environments. But advances in technologies is increasingly pushing e-Learning towards open, flexible and dynamic environment. It should also be noted that ontologies do not overcome any interoperability problems, since it is hardly conceivable that a single ontology could be applied in all kinds of domains and applications. In order to explore an open and flexible way of integrating ontologies, the next section proposes a conceptual framework.

3. Semantic Integration Framework

Based on the background provided in section 2, it can be seen that the main challenge of e-Learning systems developers is towards moving beyond simple extension of learning resource access to providing mutual understanding that may exist between the diverse learning contents. To meet this challenge, this section presents "Semantic Integration Framework" shown in Figure 3.1. It defines three main layers- interface, service integration and management with service composition running across all the three main layers. The aim of the framework is to provide an integration service platform that offers learner-centric support for web –based learning. Thus, defining semantic relations between source learning resources. This has been developed using web services, an ontology and agent components. The heart of the framework is the service Integration layer – a semantic bridge that defines semantic relations between source and target ontology instances. Here, source ontology instances are different standards used in describing learning objects (LOM, SCORM, XML, etc)

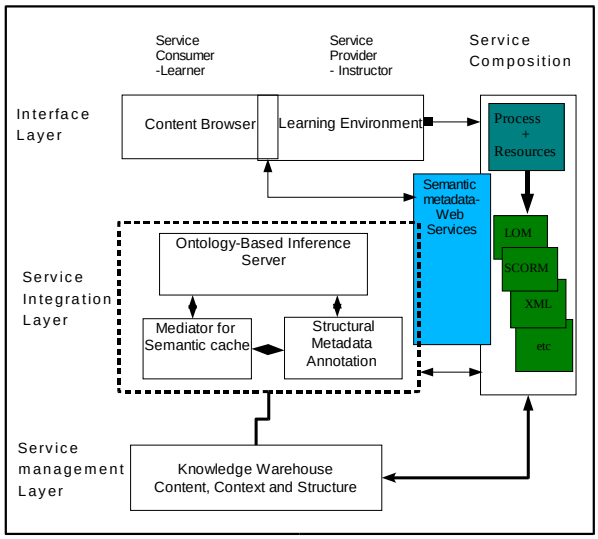

Figure 3.1 Semantic Integration Framework

Based on the framework above, knowledge warehouse use wrappers as a means of allowing different media sources to be combined. Within the framework several learning objects providers can submit their learning objects based on existing metadata standards and be verified for a service based on a well-defined ontology.

The service composition layer provides tools that help with the composition of re-usable learning services. This is done through a defined task/process flow engine – describing the whole process of learning design is beyond the scope of this paper. See ([5, 9, 10]) for a comprehensive discussion on learning design. The framework supports a contextual representation for flexible operation and integration of learning services. This will enable description of low level basic features of a learning object (e.g. content), an intermediate (metadata level) describing the characteristics, functions and associated objects (e.g. title, author) and the high-level description of contexts and meaning associated to each learning object and then services.

At the service integration layer, an ontology-based inference server will define target ontology instances. It specifies the domain knowledge ontology that would better understand the domain information coming from different instances. This is achieved by providing a binding code between the domain ontology inference and source ontology instances using web services. This combination of semantic technology with UDDI inference will make web

services more interpretable so that agent technologies can be used to automatically discover, compose and even execute services. The agents will then interact with the content parser to provide the user with relevant and customised learning needs. Within the service integration layer is also the mediator for semantic cache, this has been introduced to increase semantic comprehension among difference services and models.

Knowledge relating to the relationships between learning objects, which will be gained from the description logic, will be useful in comparing the objects within a learning object repository. When mappings are identified between objects and ontologies, the appropriate mark-up will then be generated for the appropriate learning service.

The interface layer is to provide an integrated user Interface for both the content provider and the consumer. This provides a content parser that would deal with different functions and presentation formats. Thus a learner using Blackboard for example would have their semantic and related information transformed into Blackboard style presentation, which those using standard web browsers would see theirs transformed in XML format. XML standard is used in order to facilitate content parsing for different presentation styles.

4. Conclusion and Further Work

This paper put forward an approach for integrating e-Learning services by exploring the power of ontologies and existing semantic and web services technologies. It defines a framework that is being used towards enabling the semantic interoperability of learning services within the domain of e-Learning. The approach for this research is to define ontologies based on description logic [6] in order to provide a clear semantics to the description of learning services. This will also provide a complete means for semantic querying and extractions.

Further work is being done towards formalising the model for providing a clear understanding of the process of constructing a domain ontology for a very simple learning object with a demonstrable implementation of the presented framework.

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