Exploring Semantic Description and Matching Technologies for Enhancing the Automatic Composition of Grid based Learning Services

Gustavo Gutiérrez-Carreón , Thanasis Daradoumis and Josep Jorba

Open University of Catalonia, Av. Tibidabo 39-43 - 08035 Barcelona, Spain
{ggutierrezc, adaradoumis, jjorbae}@uoc.edu

Abstract. In the implementation of e-learning frameworks, a problem still unsolved is how to use and integrate low-level learning services to compose more complex high-level services or tools that make sense to both tutors and learners. In that sense semantic description of Grid learning Services appears like a powerful tool to be used for discovering and matching learning services depending of a set of parameters inside the learning framework. These parameters must represent significant functional characteristics of a learning Grid environment formed by a set of distributed e-learning resources and services. The main objective of this article is to present a review of existing technologies related with semantic description and matching and some techniques used at present to provide Grid Learning Tools and Services automatic composition.

Keywords: Learning Grid, Learning Services, Automatic Composition.

1. Introduction

Distant e-learning emerges as one of promising means for people to learn online. Although there is a substantial increase in computer and network performance in recent years, mainly as a result of faster hardware and more sophisticated software, there are still problems in the fields of integrating various resources towards enabling distant e-learning. Service-based educational systems open new ways in the usability of the Grid as their primary requirements include the provision of adequate services for sharing, syndicating heterogeneous resources and relevant content discovery. The Learning Grid paradigm aims at making use of the collective intelligence and the personalized use of a range of available and potential Grid Learning services. In that sense Grid Learning Services, taking advantage of technological support of Web services in general and Grid services in particular, have fundamentally changed the way that e-learning frameworks were developed. As a learning service example we could consider a Learning Object (LO) [1] from the point of view that a LO is any digital resource that can be used, reused or referenced to support learning, but not in the sense that it is necessarily designed to explain a stand-alone learning objective.

In the field of Grid services, an important issue is how to achieve the correct integration of inter-organizational and heterogeneous services on the Web. If no single Grid service can satisfy the functionality required by the user, there should be a possibility to combine existing services together in order to fulfill the request. In that sense a lot of efforts have been made to develop techniques and methods for search [2,3], discovery [4] , matching [5] and composition [6,7,8,9,10] of grid and web services using semantic description, which showed that important advantages could be achieved if compared with syntactic search.

In general, a framework used for Web service composition [6] (Fig. 1) describes two kinds of participants, service provider and service requester. It contains the following components: a translator, a process generator, an evaluator, an execution engine and a service repository. The service providers propose Web services for use. The service requesters consume information or services offered by the service providers. The translator translates between the external languages used by the participants and the internal languages used by the process generator. For each request, the process generator tries to generate a plan that composes the available services in the service repository to fulfil the request. If more than one plan is found, the evaluator evaluates all plans and proposes the best one for execution. The execution engine executes the plan and returns the result to the service provide.

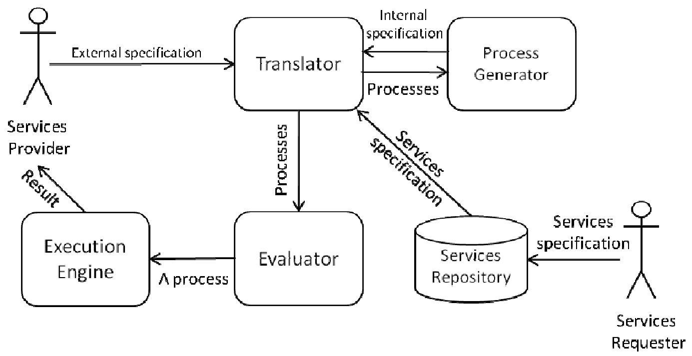

Fig 1. The framework of the service composition system [6]

The paper takes the above research work into account and proceeds to provide an overall review of those models that mostly contribute to the semantic enrichment of Grid based learning services description and discovery (Section 2). Then, Section 3 goes further and describes technologies for web services matching and composition. Consequently, we propose a conceptual model that explores a new way these models and technologies can be used to enhance the automatic composition of Grid Learning Tools and Services. Section 4 concludes the paper and describes future work.

2. Grid Learning Services Description and Discovery

WSDL (Web Service Description Language) [11] describes the functional information of services such as input parameters, output parameters, service providers and service locations. However, it is limited in supporting the discovery, execution, composition and interoperation of Web services. WSDL cannot provide semantic information of Web services that enable the semantic description of services capabilities.

Currently Globus Toolkit [12] is a common way to implement Grid Services. Globus Metacomputing Directory Service (MDS) implements a standard Web Services interface to a variety of local monitoring tools. Thus, within Globus Toolkit, MDS allows one to register Grid services. Besides it, UDDI has been also used in the web community for business service discovery. Both of them only support keyword based search and are limited in semantic description.

OWL-S [13] is a representative semantic Web service language that arises from the standardization of DAML-S, by integrating OWL-based ontology technology with existing Web service description.

WSMO (Web Service Modeling Framework) [14] provides ontological specifications for the core elements of Semantic Web Services. In fact, Semantic Web Services aim at an integrated technology for the next generation of the Web by combining Semantic Web technologies and Web Services, thereby turning the Internet from an information repository for human consumption into a world-wide system for distributed web computing.

BPEL4WS (Business Process Execution Language for Web Services) [15] provides a language for specifying business processes and business interaction protocols. It can create a composite process by integrating different operations such as Web service call, data manipulation, error report, and process termination.

Nevertheless, these technologies are still immature and incomplete. Moreover, they compete each other; in fact, they still do not provide viable and integrated solutions to the web Services discovery problem.

2.1 Semantic Description of Grid Learning Services

There are some works related to the semantic description of Grid Learning Services. OntoEdu [16] is a flexible platform for online learning which is based on diverse technologies like ubiquous computing, ontology engineering, Web semantics and computational Grid. It is compound of five parts: user adaptation, automatic composition, educative ontologies, a module of services and a module of contents; among these parts the educative ontology is the main one. The main objectives of OntoEdu are to obtain reusability of concepts, adaptability for users and devices, automatic composition, as well as scalability in functionality and performance. In the near future, this platform aims to be adapted to a Grid environment so that it can carry out its activities based on distributed computing.

The work developed in [17] presents a workflow framework for pervasive learning objects composition by employing a Grid services flow language. The learning objects are distributed in heterogeneous environments which have been used to allow effective collaboration and the reuse of learning objects; this fact can help users learn with no limitations of time and space. This work shows the great opportunities that exist in those research groups which make use of Grid technology to develop innovative, pervasive and ubiquous learning scenarios. Though this research work is still encountered at an initial phase, it can be further enhanced by the application of semantic description of learning services.

Finally in [2], the authors have constructed an ontological description for collaborative work tools that allow one to make a manual search of the diverse resources that these tools provide within a Grid environment with the minimum of technical knowledge. This work proposes a Grid-based tool, called Gridcole, which can serve as a basis to implement different conceptual approaches of Grid-based semantic description of learning services, thus extending and endowing it with an innovative, pervasive and ubiquous projection.

In sum, the works presented above try to provide a solution to the complex problem of grid learning services semantic description, but they are either limited in semantic expressiveness for matching services or they do not face at all the difficult task of using and integrating low-level learning services to compose more complex ones. Both these features could greatly enhance and facilitate the tutor's and learners' labor in a complex web-based learning scenario.

2.2 Discovery of Grid Learning Services

Discovery is the process of finding Web services with a given capability [17] . In general, discovery requires that Web services advertise their capabilities with a registry, and that requesting services query the registry for Web services with particular capabilities. The role of the registry is both to store the advertisements of capabilities and to perform a match between the request and the advertisements.

In general, a semantic discovery process relies on semantic annotations, containing high-level abstract descriptions of service requirements and behaviour. Metadata is an essential element in semantic discovery with the capability to expand service descriptions with additional information. The achievement of dynamic composition and automation of services involves discovering new services at run time by software components without human interaction. SOAP provides a description of message transport mechanisms, whereas WSDL describes the interface used by each learning service. However, neither SOAP nor WSDL are of any help for the automatic location of learning services on the basis of their capabilities. Paolucci [18] comments that in order to enable the automation of this process we need a meaningful description of the service and its parameters that can be processed automatically by tools. This implies the possibility to process the context of description by discovery engines.

In this sense, there are some works that aim to improve the semantic services capability of matching. On the one hand, in [19] Paolucci focuses primarily on comparing inputs and outputs of a service as semantic concepts represented in OWL to improve UDDI. This work proposes a way of ranking semantic matching results. This ranking can be used in conjunction with other user-defined constraints to inform of an exact, or potentially useful web-service capability match. On the other hand, there are important lines of research that propose extensions to Web service description WSDL in two ways, annotated WSDL and WSDL-S files [4]. These approaches try to adhere to the current standards while trying to maximize semantic representations required for automation.

3. Grid Learning Services Matching and Composition

There are three principal motivations for Learning Grid Services Composition: build a more powerful service using basic existing services, fulfil service requester's requirement better, and enhance resource reuse while reducing the cost and time of a new service development. IMS Global Learning Consortium[1] proposes an abstract framework [20] representing a set of services used to construct an e-learning system in its broadest sense. Fig 2. shows the dependencies between the different "layers" of the framework.

The Learning Application composition process consists of identifying sub-tasks of the learning process, locating suitable Learning application Services to construct each process, locating suitable Common Services to construct each learning service, formatting the Learning and Common services into a service flow and executing the service flow to achieve a task which is the goal of the learning process.

The core stage is the composition of learning web services and their adaptation to the needs of a learner or group of learners [21]. Such a composition is carried out by retrieving previously registered objects. Once composed and packaged as learning objects, these composite processes can be executed and then instantiated and adapted to the learner's particular needs.

These adaptations can be realized, either by predefined rules implemented into the process description and driven by the learner behavior, or in a supervised manner. In the later case, the instructional designer can return to the composition tools to adapt the process.

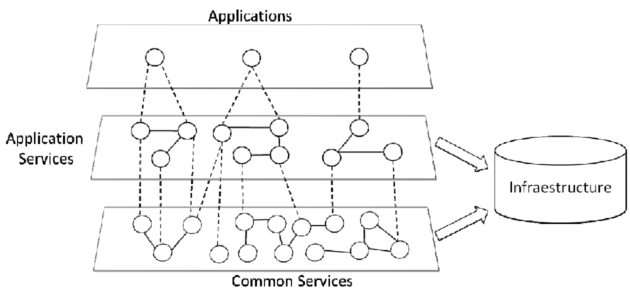

Fig 2. IMS Abstract Framework

Dealing with the specific problem of constructing a suitable workflow for a learning scenario, in [22] the authors propose a framework to facilitate automated composition of scientific workflows in Semantic Grids made up of a Manager Service and other supporting services, including an abstract and a concrete workflow generator. They described these components in detail and outlined their interactions. Finally, they described their implementation and its use within the physics domain. The important features of this approach are: an adaptive workflow generation algorithm and the distinction between different levels of abstraction of the workflow in order to allow reuse and sharing.

[1] IMS develops and promotes the adoption of open technical specifications for interoperable learning technology.

Furthermore, there is a detailed development of learning services matching procedures [5] for locating the most suitable Learning Services, combining and integrating a number of matching algorithms, and adopting two principal approaches: the structural matching approach and the linguistic or syntactic approach. This work focuses on the issue of searching a Web Service with required functionalities and addressing a specific application domain, by means of an ontology-based semantic description.

3.1 A Conceptual Model for Grid Learning Services automatic composition

The model we propose for the automatic composition of learning services (Fig. 3) is based on the use of the defined syntactic and semantic characteristics for the different levels of services involved in the Learning Abstract Framework.

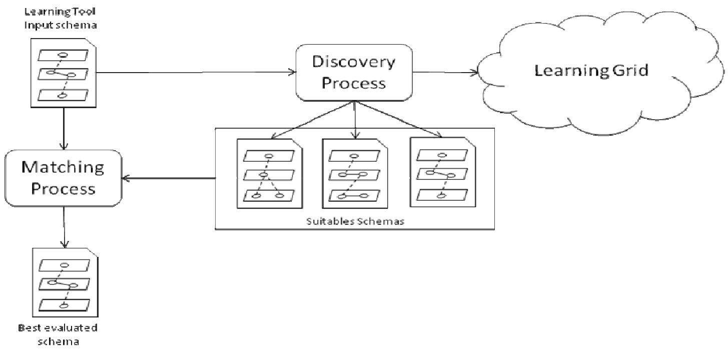

Fig 3. Grid Learning services automatic composition

The first step to carry out the automatic composition is to generate a Semantic schema of the learning tool or learning services that will be composed. This schema will be able to be constructed using the different tools of descriptions at the "syntactic level" through WSDL, or at the semantic level, through service ontologies included in OWL-S, WSMO, SWSF and WSDL-S[5] .

Once the semantic schema of the tool or learning service that we want to build is designed, we have to pass it to our discovery process that will locate a set of different level services in the Learning Grid. The operation of these services as a whole allows to carry out the processes defined in the schema. The result of the search will be a group of suitable schemas that conforms to the functional process described in our initial schema.

These resulting schemas will be compared to the initial schema through a Matching process that is based on a structural matching approach and on a linguistic or syntactic approach and whose result will be the best evaluated schema for our learning tool or services.

Comparing our conceptual model with the works presented in [2, 7, 16 and 21], our approach represents a complete alternative since, on the one hand, we provide a multi-level learning services composition method that enables the construction of complex learning services by means of other low level services, depending on the nature of the learning abstract framework. On the other hand, our approach takes advantage of the semantic and syntactic characteristics of learning services, which facilitates a totally automatic construction of new learning tools based on others previously created.

4. Conclusions and future work

In this work we review some methods and techniques for automatic composition of Grid based Learning Services. In that sense we highlight the importance of defining a contextual based semantic model of the Learning scenario, which is particularly significant in semantic based automatic service searching, discovery, and composition. Future work aims at the implementation of the conceptual model presented in this work in a real, learning collaborative scenario based on Grid.

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