Application Scenarios for a Learning Grid

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Abstract. This chapter analyses the adoption of the Learning Grid for the development of challenging Application Scenarios in the eLearning domain. The Application Scenarios described in this chapter create a breakthrough in current learning practices. Instead of adopting a traditional information transfer paradigm, the proposed scenarios, in fact, promote and support a learning paradigm centred on the learner and focused on knowledge construction using experiential based and collaborative learning approaches in a contextualised, personalised and ubiquitous way. The purpose of our analysis is to understand and argue about the potential advantages of adopting the Learning Grid for the proposed scenarios. Preliminary findings show that Learning Grid can be considered an enabling technology for the presented scenarios since its features (e.g. dynamicity, adaptiveness, support for Virtual Organisation creation and management, advanced mechanisms for resources and services discovery on the basis of Quality of Services) are key to improve personalisation and knowledge construction in the learning process as well as communication and collaboration inside learning groups.

Keywords. Technology Enhanced Learning, Application Scenarios, Pedagogy, Learning Design.

Introduction

This chapter concludes the first section of this book. In the previous chapters, the authors have provided a detailed description of the Learning Grid and how it combines its three building blocks (Grid, Semantics and Educational Modelling Languages) in order to provide a reference Service Oriented Architecture (SOA) for human learning. In this chapter the reader will see what are the advantages of adopting the Learning Grid as enabling technology for the development of challenging Application Scenarios in different learning contexts.

The chapter is structured as follow. Paragraph 1 provides an overview of several Application Scenarios that can be developed taking advantages of the Learning Grid. The Application Scenarios presented are the ones proposed in the context of the Kaleidoscope Special Interest Group (SIG) for the Learning Grid. Paragraph 2 presents some common features of the proposed application scenarios. Paragraph 3 points out what are the main benefits of adopting the Learning Grid as a reference architecture for the development and deployment of the above scenarios.

Eventually, the main conclusions of our investigations are drawn in the section 4.

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1. Overview of the Application Scenarios

Several scenarios have been proposed inside the SIG for the Learning Grid. A complete description can be found in [1] and [2]. Scenarios presented in [1] are either already under implementation or are possible extensions of existing teaching and learning practices. Scenarios presented in [2], instead, are more futuristic and still to be implemented.

Next sub-paragraphs present a selection of application scenarios defined inside the SIG where paragraph 2 categorises defined scenarios on the basis of common features presented by each of them.

1.1. Distance Programming Course based on Practice

This scenario is based on an existing e-learning programming course running in the Engineering School Léonard de Vinci [3] and, indeed, among the scenarios presented it is the most traditional one.

In this course, students are provided with many programming exercises that are automatically corrected. Moreover, all their attempts are stored so that students can consult their history. Compilation and program execution are implemented as services, students do not need to worry about downloading themselves any programming environment.

As evidenced previously, this is a traditional distance learning scenario presenting functionalities needed for the execution of programming exercises (e.g. compilation) in a service oriented fashion. Anyway, we consider useful to describe the scenario in this paper since it presents some features that can be enhanced adopting Learning Grid. Learning Grid would in fact improve the existing system in the following ways:

- by allowing a distributed code compilation and execution as well as a distributed storage of students' answers, would make the current system scalable in terms of supported users;
- by providing functionalities in a service oriented way, exploiting the WS-* standards, would make the systems open and easy extensible in terms of supported functionalities. Furthermore, some complex functionalities (e.g. a software development environment) can be obtained by orchestrating atomic ones (e.g. a compiler, a debugger, and so);
- semantics would allow for better personalization and flexible course composition and, pragmatically, this would allow for selection of tools and instruments tailored on learner features (e.g. the selection of a C# compiler instead of a Java one).

The main benefits of this scenario are for students that will be able to learn computer programming not primarily by receiving information but by practicing a lot at their own place and at their own pace.

1.2. Enhanced Digital Library

This scenario takes its inspiration from Citeseer [4], a digital library which organizes scientific literature, allowing flexible searching and citation statistics.

The use of Grid technology makes it possible to extend the digital library with new forms of collaborative activities. Apart form papers, more resources can be shared such as formal or informal comments, reviews, summaries, videos, code, etc. in a Virtual Organisation (VO) [5], defined as a coordinated group of individuals and/or institutions that cooperate by sharing resources, according to predefined policies, to achieve a common goal.

Among the benefits of the Learning Grid and of the exploitation of the VO paradigm to achieve the enhanced digital library we point out:

- the capability to harmonise and interconnect several heterogeneous distributed digital repositories, thus creating a network of digital libraries having a single point of access (e.g. a VO portal);
- advanced mechanism to authenticate and authorise users to access digital libraries as well as other resources of the VO;
- advanced mechanism for annotation and search of contents in the repositories;
- notification mechanism allowing the VO users to be advised when new contents matching her/his interests, needs, preferences is uploaded.

Personalisation options could be specified at individual level or at VO level. The access to the environment could be done through a grid portal, which is a Web-based application that provides personalisation, single sign-on, content aggregation from different sources and hosts the presentation layer of information services.

Furthermore, the enhanced digital library can be considered as a base scenario for more complex collaborative research environment, user centred, allowing the researchers to learn with some hints (classification of documents) provided by his/her supervisor(s), by other people in the research group, and most importantly, by himself-herself. Thus, this scenario fosters the transition from a content-oriented learning solutions to a user-centred collaborative model.

1.3. Enhanced Virtual Laboratory

Virtual Laboratories are exploited by several eScience communities such as astronomy and earth science communities, bioinformatics, researchers and pharmaceutical companies, and so on.

Currently actual implementations of Virtual Laboratories are mainly in terms of problem solving environments providing functionalities to addresses key issues of the above communities, and they are mainly used for sharing and access to data and information, data mining purposes, to support data to information and information to knowledge processes, to execute simulations and experiments.

Rather than enumerate all the possible example of Virtual Laboratories in detail, we shall look at a future learning scenario, the Enhanced Virtual Laboratory, exploiting the learning Grid features to combine conventional data and computing technologies with technologies from the Semantic Web in order to allows the execution of collaboration activities inside the traditional Virtual Laboratory. Adopting a Learning Grid we can obtain the following advantages.

- To enhance the Virtual Laboratories allowing its customisation on the needs of a specific communities or group of communities. In fact, adopting the dynamicity features of the Learning Grid and its advanced mechanisms for location and discovery, we can build the laboratory on the basis of the real problem to solve by selecting and orchestrating the most appropriate tools, services, sensors and scientific instruments.

- To put the researchers at the centre of the experiments. Experiments often involve many processes or services that need to be orchestrated. Previous knowledge, know-how, and experiences can be taken into account by adopting the personalisation services of the Learning Grid.
- To tailor the scientific processes to the profiles of the researchers not just in terms of selection of more suitable tools/services but mainly in terms of a personalised path of activities of the workflow that are more "simple" to execute given the researchers background.
- To allow collaborative activities among the researchers.

1.4. Virtual Learning Community for Professionals

The following scenario relates to continuous education in medicine. A community of medical professional has to learn new medical techniques based on some innovative research results. They can exploit the Learning Grid to create a Virtual Learning community.

The virtual community behind this scenario consists of a high number of medical professional, a reduced number of professors being involved in the finding of the new knowledge to be learnt by the medical professional, an interactive simulation being developed by a specialised research centre available to the medical professional to simulate the new techniques.

The medical professionals are grouped on the basis of their skill and expertise and, also on this basis, they access personalised learning experience on the new techniques. Next, they are required to virtually apply the new techniques using the simulator service (part of the personalised learning experience). They can collaborate with the teacher either during the course or during the simulation.

The adoption of Learning Grid technologies make easy the implementation of this scenario highlighting two key aspects with respect to possible alternative solutions based on more traditional technologies:

- dynamicity versus static provisioning (i.e. the services are available on fixed servers);
- adaptivity versus pre-defined configuration (i.e. everything have to be pre-configured and installed).

Features of membership negotiation offered by a Grid can improve the dynamicity in the process of creation of groups with similar skills (without Grid facility this should be done statically with the support of tools). Furthermore, the same negotiation features allows to negotiate the terms for accessing the resources of the research centre providing the simulation (without a Grid, this should be done statically with the research centre that a-priori sets the access policy on the resources).

During the simulation execution, the research centre can scale the application to the number of medical professional interacting with it and/or to the status of the network and of resources requiring, if necessary, the provision of additional resources that can be taken also from other providers (without a Grid an adequate number of servers/clusters have to be provided in a physical place and properly managed).

1.5. Immersive Virtual Reality

In this scenario, a student is learning water and aquifer behaviour by using an e-Learning platform. S/he can access introductory books to gain initial knowledge on the topic. S/he can also use a dynamically generated set of services that, according to her user profile and current PC capabilities create an immersive virtual reality. The service also informs the student about immersion requiring special equipment like gloves and glasses and about the nearest locations where such immersions are possible.

Such immersions allow her to go deeper on the aquifer behaviour and characteristics of water. In these virtual sites, she also meets other students and interact with them. Learning occurs naturally as a result of experiments and interactions with other students.

Learning Grid technology (user profile, semantics, provision of Virtual Environments) is needed to make this scenario work.

1.6. Field Trip

Based on the traditional field trip and on the Immersive Virtual Reality previously presented, the proposed scenario illustrates experiential, contextualised, collaborative and active learning for knowledge creation and experience sharing in the context of a Mobile Dynamic Virtual Organization [6] based on a Learning Grid.

Two departments have a common goal: they are involved in a project related to the Evolution of Classical Greece Architectures. Department A decides to send a group of students in the archaeological site of Athens, while department B sends a group of researchers in the site of Paestum, in order to valuate the contamination of Greece style due to external influences.

Both the departments provides their human resources with mobile and wearable devices and they have their own resources in the departments. Furthermore, they have an agreement to use some resources of the computational centres in the archaeological sites and the two groups can rely upon local network providers and telco operators.

Both groups are equipped with mobile and wearable device enhanced with sensors to be geographically referenced. These sensors send, via the Wireless LAN of the site, information about the location and orientation of the user to a Service Centre that is able to provide notifications about the availability of important structures, facilities and so on. Group A and group B works for the same goal: to create knowledge about the evolution of Greece architectures.

During their activity they store information, experience, emotion, in terms of photos, video clips, text notes, audio comments, etc. Both the groups can collaborate among themselves and with remote experts using the Collaboration Services provided by their departments. The mobile devices indexed these contents using appropriate metadata standards.

The information collected by all students (group A) and researcher (group B) are send via the appropriate network (The device will negotiate with the network service provider (T) operative in that zone which kind of network communication will be used according to the bandwidth necessary, the price, etc.) to a Field Trip (FT) grid service

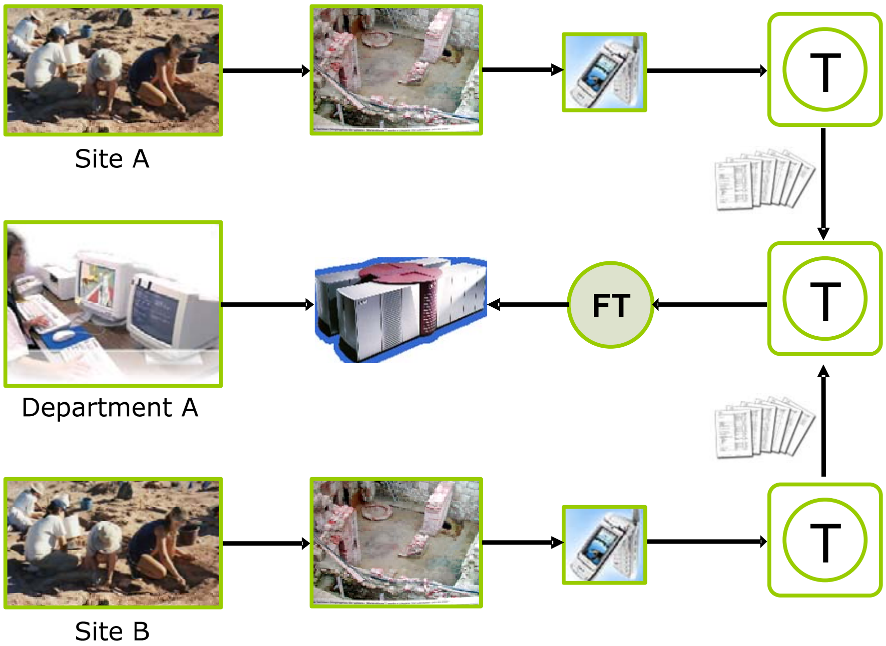

Figure 1. The Field Trip Scenario

created by a teacher of the Department A. The mobile devices will use user biometric data for secure access to Grid.

The FT grid service, orchestrating speech to text grid services, advanced semantic tool for text and images interpretation and other tools for knowledge management (virtualised as grid services) will analyse the information comparing content produced by group A and group B and formalise, in an ontology based knowledge representation, the knowledge about the evolution of Greece architectures.

The FT service stores all the information in a multimedia repository grid service. For the group A, since they are students, the student's information will be compared by their teachers with their learning objective. Furthermore, teachers of Department A can analyse the knowledge structure created and can require some remedial content. The Figure 1 summaries this workflow.

It is important to emphasize that both the groups are involved in a collaborative process by which they acquire and create knowledge. They are free to move and perform all actions they want during the exploration of sites in an independent way, but they are able to share contents that produce during the visit, to communicate and collaborate among themselves. Students of group A can also rely upon the experience of researchers of group B, that act as tutors for their experiential and active learning process. In this scenario:

- the learner is an active figure placed in a real world context allowing him to be part of a collaborative process aimed to knowledge creation and experience sharing;

- the real context, in which learner is immersed, is enhanced by services and tools to provide real-time collaboration, content management and provisioning, high performance 3d modelling and rendering;
- it relies on a Mobile Dynamic Virtual Organization based on the Learning Grid paradigm: during his learning process, a learner can be considered as a resource that can be accessed (also in terms of experiences) by other persons belonging to the VO.

As we have seen, this scenario uses the typical Grid approach in combination with mobility. Moreover semantics is required for knowledge based services. More details about this scenario are given in chapter 8 of this book.

2. Common features of the proposed application scenarios

The scenarios described in the previous section present some common characteristics. First and foremost, all the scenarios create a breakthrough in current learning practices. Instead of adopting a traditional information transfer paradigm, the proposed scenarios, in fact, promote and support a learning paradigm centred on knowledge construction using experiential based and collaborative learning approaches in a contextualised, personalised and ubiquitous way.

From the above statement, we can argue about the main features of the Application Scenarios that, in the follow, we are going to explain.

- ***Knowledge construction***. For many years, learning approaches and scenarios were based on traditional information transfer paradigm in which there is a central figure, the teacher, whose primary activity is the provisioning of educational contents in order to transmit information to learners. These approaches aim to monitor learner's progresses and to give him a score. In most of the Application Scenarios presented in the previous section, instead, the main goal is the Knowledge construction that occurs through forms of learning based on the understanding of concepts through direct experience of their manifestation in realistic contexts (i.e. providing access to real world data) which are constructed from sophisticated software interfaces and devices, and represented as services.
- ***Experiential based and collaborative approaches***. The Application scenarios presented foresee active collaboration with other students, teachers, tutors, experts or, in general, available human peers, by using different kinds of communication and collaboration technologies, including enhanced presence. The learning resources of the Application Scenarios, moreover, are interactive, engaging, and responsive – active learning and knowledge formation is emphasised above simple information transfer.
- ***Contextualised, personalised and ubiquitous***. In the Application scenarios the learners are themselves at the centre of their online environment, with their individual needs addressed and the quality of the learning experience continually validated and evaluated. Furthermore, a wider and more flexible access to educational resources is provided, including support to multiple different types of devices, interfaces, and network connection types.

Last but not the least, there is another important feature we point out. The Application Scenario proposed are ***learner centred*** meaning that the learner is in the centre of the learning process. The essence of the proposed scenarios is to create dynamic contexts providing suitable conditions for learners (taking into account their features and social context, providing tutoring and enhanced presence), supporting learners during their learning process (also by the use technologies for collaboration, highly realistic virtual scientific experiments, real time simulations, personalized learning path definitions, stateful message exchange sessions to support conversation) and, finally, that let them free to reason about their experience creating, in this way, the knowledge model suitable for them.

In those scenarios, there isn't more an overemphasize of the role of the teacher: she comes into this process as a domain expert whose purpose is to propose educational goals and topic of discussion, to moderate discussions inside a community, to give feedbacks to learners and to prepare educational contents.

The table 1 maps the presented Application Scenarios against the most relevant learning features they presents. It is worth to mention that the mapping evidences just the major features of each Application Scenario. This means that, for example, the *Distance Programming Course based on Practice* scenario presents as main features the Experiential and Active Learning and the Personalisation even if it is clear that in the scenario also Accessibility is a need.

The filed trip is, among the application scenarios of the SIG, the most complete one in terms of learning features. Even if, of course, they can not be considered as a statistical sample of the learning scenarios we can retrieve as useful information that the two most common features are the *personalisation* and the *communication & collaboration.* In the next sections we present the benefits of adopting the Learning Grid for the proposed scenario focalising our attention mainly on the above mentioned two features.

3. The Benefits of the Learning Grid for the Proposed Scenarios

This section gives an overview of the benefits of the Learning Grid for education, in general, and for the proposed scenarios. Then we will focalise our attention on two of the most important features of the scenarios, namely the personalisation form one side and the communication and collaboration from the other side.

Generally speaking, the importance of Grid in education has been emphasized by G. Fox in [7]. In [8] the impact that Semantic Web technologies can have in e-Learning is also evidenced. As described in the first chapter of this book, the Learning Grid combines Grid and Semantic Web technologies in defining an open and service oriented architecture to support human learning.

The Learning Grid is based on a Service Oriented Model, the Open Grid Services Architecture (OGSA) [9]. In general, Service Oriented Architectures (SOA) relies upon the service's concept and its technical implication (e.g. message based strategy with respect to method based one) and provide a suitable approach to implement a composition paradigm or building block approach, where a set of capabilities or functions is built or adapted as required, from a minimalist set of initial capabilities, to meet a need.

Table 1 - Mapping the Application Scenarios against common learning features

SIG Scenarios	Main features of Application Learning Scenarios					
	Knowledge Construction	**Experiential Active Learning**	**Communication and Collaboration**	**Personalisation**	**Contextualisation**	**Ubiquity and accessibility**
Distance Programming Course based on Practice		X		X		
Enhanced Digital Library	X	X	X	X		
Enhanced Virtual Laboratory	X		X		X	
Virtual Learning Communities for professionals	X	X	X	X		X
Immersive Virtual Reality	X		X	X	X	
Filed Trip	X	X	X	X	X	X

This is clearly useful in most of the presented Application scenarios that strongly relies upon a composition paradigm allowing the creation of (personalized) learning experiences (re-)using data, units of learning, knowledge, tools virtualized as services and distributed across different organizations.

In particular, the OGSA model is based on a stateful and dynamic service model based on a set of WS-Specification able to manage the state associated to a service/resource. Recognizing the need for state management in learning scenarios (e.g. knowledge acquisition in informal learning happens as results of a conversational process among peers actively involved in experiments), an underlying stateless service model would force the developer to manage the state at higher (e.g. Application) level. From a technical point of view, this is an additional effort that the adoption of Grid technologies can minimize and, in some case, can eliminate.

Another important reason is that the Learning Grid, bringing together Grid, Semantic Web and Web Service technologies, can be considered as glue among these different technologies that, taking them alone, can only provide partial benefits to our Application Scenarios. We do not see, in fact, an advantage to use only Semantic Web technologies (providing a very good support to Knowledge management, sharing and creation, resources annotation) and to spend effort to define advanced algorithm for resources reservation (to support efficient resources management allowing 3d simulations and immersive VR) or to use Semantic Web technologies (providing a good support for contextualization and personalization) if they have to be reinforced with mechanisms to discover, acquire, federate, and manage the capabilities, resources and contents needed to create/deliver the personalized learning experiences.

In the nest sub-paragraphs, we focus our attention on two of the common features of our application scenarios, such as the *personalisation* and the *communication & collaboration*, and present the added value of the Learning Grid.

3.1 Benefits of the Learning Grid for personalisation

Personalisation is one of the major trend in Technology Enhanced Learning and one of the common feature of the scenario presented in this chapter. The purpose of personalisation is to dynamically adapt and delivery educational contents and services matching the learner needs and preferences according to her/his profile.

Currently, personalisation is mainly addressed at the content level on the basis of simple information (traditional preferences such us age, language, school grade, …) stored in a student profile and do not take sufficiently into account the characteristics of the users (especially regarding learning style preferences and her/his knowledge and skills). The Learning Grid provides several benefits for the personalisation coming from each one of its building blocks: Grid, Semantics and Educational Modelling Languages.

First of all, the adoption of a Service Oriented Grid, such as the OGSA one, allows for a seamless and ubiquitous access to heterogeneous and distributed repositories. This aspect, together with the availability of services for semantic annotation and advanced mechanisms for resources and services discovery, clearly helps in addressing one of the current issues of personalisation: the enormous number of items of the required quality. Quoting from [10]:

"Depending of the number of parameters taken up in the learners' profiles, an enormous amount of orchestrating decisions would have to be taken. In order to fulfil the individual needs properly, the availability of large amounts of learning related object would be needed in the reach of the orchestrating engine. If we go for a combinatorial simulation and assume, that our learner profile mirrors just five parameters, with the respective number of variables, e.g. (1) five languages, (2) three learning styles, (3) three degrees of difficulty,(4) three age ranges and (5) two genders, omitting so far elements like learner support services, or billing services, we would need a repository of nearly 300 items for just one learning object of one subject domain."

Furthermore, the adoption of Semantic technologies provides support for the various phases of the personalisation of learning experiences. First, authoring tools for the production of learning scenarios can make use of knowledge-based decision making systems to suggest the best pedagogical models and/or activities for a learning scenario, and also use knowledge (e.g. starting skills, personal pro-files, etc…) about the actors in the scenario. Next, in the delivery phase of a learning experience, semantic services can be used to bind at run-time a (learning) activity with an environment (that is a set of resources and services able to execute the activity).

In this binding phase, the semantics can provide some benefits. In fact, in order to find inside a Grid the resources and services that best match the requirements of an environment, the Learning Grid relies upon ontologies to index the core elements of the infrastructure, the educational resources and services.

In particular, to index services and resources of a Grid environment, it is a feature that can be used:

- by the Grid itself, in order to “know” its infrastructure and to provide machine understandable information about its resources and services,
- by knowledge tools, services or agents inside the Grid, in order to perform an automatic discovery of services and contents matching demand’s requirements vs. supply’s offers.

Eventually, it is worth to mention that Personalisation is also difficult to achieve exploiting the current learning standards/specifications (e.g. IMS Simple Sequencing and IMS-Learning Design).

Currently, in fact, exploiting these standards it is possible to sequence discrete learning activities in a consistent way. The created path, of course, can be personalized for a single learner (in the case of IMS Simple Sequencing) but this step is really difficult and it is performed manually by the teacher/instructional designer that has to rely upon her/his expertise and knowledge about the characteristics of the user. In many cases, anyway, the creation of a learning path on the basis of a specific pedagogical model is a joint effort of the designer (expert of the specifications) and of a teacher (expert of pedagogies).

Learning Grid services, by leveraging on semantic descriptions of didactical resources and services, allows to automatic personalise a learning experience first at the level of the knowledge to be created/transferred by/to a learner (e.g. the creation of a Specific Personalized Ontology), next at the level of the pedagogy (e.g. the selection of a suitable Didactic Method and preferred learning styles) and, finally, at the content level (e.g. the selection of suitable contents on the basis also of the Learner Profile that includes existing knowledge and learning style preferences).

The main advantages of the Learning Grid approach is that it is possible to personalise the educational objectives to reach, the suitable way to achieve them and, finally, the instruments by which it is possible to achieve the objectives shifting the complexity of personalisation from instructional designers to the process of creation and delivery of a learning experience.

3.2 Benefits of the Learning Grid for Communication and Collaboration

In the case of the collaborative scenarios (such as the Virtual Learning community for professionals, the Field Trip, etc.) the Learning Grid allows to reach the desired level of dynamicity and scalability for a group/community, to manage its heterogeneity and for transparent ubiquitous resource sharing.

In fact through the virtualisation paradigm, traditional collaborative tools can be virtualised as services (both Grid or Web). This allows to add dynamicity since they can be provided on demand and it is possible to search and retrieve the most suitable tool on the basis of some parameters like, for instance, preferences of the group of learners and/or QoS.

Moreover, exploiting the distinctive features of the Grid services (mainly lifecycle management and statefulness, but also manageability) it is possible to increase scalability and support management of interactions respectively. In fact, it is possible to create more instances of services to support collaboration. Furthermore, the state management capabilities of Grid services allow defining and associating a state to each service (following the WSRF specification, the related stateful resource concept and implied resource pattern). This is an useful feature if we want to maintain trace of some data/information during the cooperation/conversation among the learners.

As enabling technologies for VO, the Grid provides support for geographically distributed community creation and management addressing issues like heterogeneity, Single Sign On, group/community lifecycle management, localisation and instantiation of tools/services, transparent resource sharing.

In particular dynamicity and adaptiveness of Grid technologies are key features in order to provide advanced mechanism for service discovery and instantiation on the basis of Service Level Agreements (SLA) documents allowing, for instance, to deploy and execute a service on the most suitable host of a VO and to monitor at-run-time its SLA; by exploiting flexible and standard based mechanisms for transparent resources reservation, sharing and accessibility, Grid technologies aldo improve ubiquity and accessibility.

Last but not least, semantic capabilities allow semantic annotation of educational resources and services for automatic discovery, the late binding of educational resources and services in the learning environment, improving the capability to support learning community creation and management.

4. Conclusions

This chapter has provided an overview of the Application Scenarios that can be built adopting the Learning Grid as enabling technology. The scenarios presented demonstrate the suitability of an open services environment, such as the one supported by the Learning Grid, to foster a learning paradigm centered on the learner and focused on knowledge construction using experiential based and collaborative learning approaches in a contextualised, personalised and ubiquitous way.

It is worth to mention that the scenarios described in this chapter, coming from the research activities of the Kaleidoscope Learning Grid SIG, present characteristics such as personalisation, communication and collaboration, accessibility, that can be considered as common features of future learning scenarios and can be suitably addressed by the key capabilities of the Learning Grid.

Of course, a real validation and evaluation can happen only if one of the Application Scenario will be deployed and instantiated on top of an instance of the Learning Grid architecture. Some examples going in this direction are presented in the second section of this book. Anyway, starting from the scenarios here described we can affirm the following things.

- Future learning scenarios will be more and more based on a compositional approach in which a learning experience consists of several building blocks (e.g. learning activities, contents, educational services) to be discovered on the basis of learning needs and preferences. The service orientation of the Learning Grid is a key to support this approach and the adoption of semantic technologies simplifies the processes of selection and matchmaking of contents, services and other building blocks of a learning experiences.
- Communication and collaboration will be central in future learning scenarios that will be more and more based on the concepts of *community* or *network*. This trend is evident also in other researches such as the eLearning 2.0 [11] or the Learning Networks [12]. The Learning Grid is so a key technology in supporting the lifecycle management of learning communities. The Learning Grid, in fact, strongly relies on the capability of Grid technologies to manage

VOs and it is enhanced with specific features, standards and Educational Modelling Languages to support learning.

- Personalisation is going to happen at several level. In addition to the personalisation at the content level, future learning scenarios foresee the personalisation at the level of the knowledge to be created/transferred by/to a learner as well as at the level of the pedagogy. To support this multi-level of personalisation, knowledge and semantics technologies are key in order to create and manage ontologies, annotate educational contents and services, perform matchmaking. Educational Modelling Languages, instead, are key to create learning experiences based on several pedagogical models.

Eventually, it is worth to evidence that the Learning Grid is not, of course, the only one technology enabling the creation of those future learning scenarios. Web Services, Agent, Semantic Web or Web 2.0 are all available technologies that can address one or more of the needs and requirements of the future learning scenarios.

The added value of the Learning Grid lies in the "glue" role that this technology has among Web Services, Semantics and Grid. Furthermore, we take advantages also from similar experiences in other scientific fields. The Learning Grid can be so considered as a particular instance of the Semantic Grid improved with tools, services, standards and technologies for the education.

The Semantic Grid aims at reaching the e-Research vision [13]. The e-Education is a specific domain of the e-Research and both have to deal with some common scientific and technological issues (e.g. collaboration between researcher/learners, knowledge management and sharing between researchers/learners, discovery, description and reuse of Scientific Object/Learning Object).

So, it seems a natural choice to leverage on the Semantic Grid technologies and it appear an useful choice also to rely upon a well defined set of services, specification, best-practices and standards developed by the scientific community involved in the Semantic Grid: we do not aim at reinventing the wheel, but contributing to make it smooth and easy to use.

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