TEAM: Using the Grid to Enhance e-Learning Environments

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Abstract. *Effective e-learning distributed environments should promote high cooperation. Workflow techniques can certainly contribute to such effectiveness. Reusable Learning Objects (RLOs or LOs) also play an important role in this context as learning content is broken into smaller parts to facilitate deployment and execution assignment. Additionally, some LOs may require high levels of computation as in the case of simulations in Hemodynamics in a Fluid Mechanics course. In order to cope with such an application, we envisioned a workflow-based Learning Management System (LMS) using web services as the communication infrastructure allied to the computational power of the Grid.*

1. Introduction

There are different techniques in collaborative learning that are proven to be efficient, not only in the cognitive domain - improving learning capacity and academic performance – but also in social and affective ones – improving group and individual self-confidence. Literature has recently evidenced the importance and effectiveness of collaborative-networked learning environments. Some important research results can be found in [1, 2, 3, 4].

In a full collaborative environment, online group activities are defined and tasks are accomplished by more than one participant and many electronic multimedia artifacts are often exchanged between students and between students and teachers. This case requires task assignments and effective interaction coordination with execution duration control and synchronization. Despite being mostly applied to business processes coordination, workflow management systems (WfMSs) are also being used in e-learning. WfMSs automatically assign the right task to the right participant in the right point in time and provide students, as well as teachers, the ability to monitor individual and group activities [5].

In addition to fostering the collaboration between humans, the WfMS may be responsible for coordinating the execution of tasks involving massive computation and/or data processing. In such a scenario, grid computing offers an adequate infrastructure to be integrated into the WfMS [6]. As an example, consider a fluid mechanics course containing the simulation of a fluid path, which requires the computation of virtual particles trajectories. A workflow task responsible for this computation requires resources available in a grid environment. In this the WfMS could seamlessly integrate resources from both inside and outside a grid infrastructure.

It is also important to break learning content into modules to facilitate deployment and execution assignment. The potential resulting reusability and standardization will contribute to reduce content development costs, as the modules can be re-combined to form other contents. For these reasons Reusable Learning Objects [7], or simply Learning Objects – RLO or LO – are being intensively studied and already applied. Aiming LO reuse and interoperation, LO metadata (descriptions of LOs) are in their way to standardization, as per IEEE initiative [8].

In this paper we present TEAM, which is an architectural model conceived to derive peer-to-peer e-learning supporting environments based on grid computing.

In section 2 we present the characteristics of the e-learning applications that motivated us to develop TEAM having in mind a grid-computing infrastructure. In sections 3 and 4 we present, respectively, the e-learning environment and the architectural model in which it is based. Finally, in section 5, related and future works and the concluding remarks are presented.

2. Motivation

We are studying an e-learning scenario requiring computational-intensive learning objects for simulation purposes; for instance, it must be possible for a student to access a learning module (a LO) capable of doing real-time computation of the path and velocity of particles in the vein system subjected to different blood pressure and viscosity conditions set by the student. It must be also possible for the module to do all the calculations required to render and show interactive 3-D images of vortex formation and other physical phenomena. In this case, computational power must be dynamically and automatically *borrowed* from other computers in the network. These new requirements led us to consider using grid technologies. This project is being conducted at LNCC – *Laboratório Nacional de Computação Científica* (National Laboratory of Scientific Computing) in Rio de Janeiro, Brazil.

The main characteristics of the proposed environment are described in the section to follow.

3. The e-learning Environment

We conceived an environment in which students and teachers would execute instructional steps cooperatively, guided by a workflow management system capable of dealing transparently with distribution, autonomy and technological heterogeneity of the content repositories that are located in the partners' sites. Content is LO-oriented and is described using the LOM standard ([7]).

The processing unit of our environment is called a *peer*. It works as a *gateway* to the environment and provides user's authentication, user-environment interaction control and execution context management (more on this can be found in section 4). Each user needs to be associated to a peer (his/her *home peer*). A site is a logical collection of peers sharing a common learning purpose. Users have transparent access to resources within sites in which his home peer is included.

The environment is logically divided in two scopes, external and internal, according to user roles.

The external scope provides an environment for students accessing courses they are registered to attend. External users "see" the (distributed) environment as just one piece, using services, pulling and pushing artifacts from/to the environment, transparently (independently/regardless) of where they are physically located or have to be sent to. The workflow enactment services provide this transparent vision to external users, routing, retrieving and allocating resources to/from proper peers.

The internal scope refers to the working context of the environment's maintainers (e.g. technical support, application developers, database administrators) and learning content developers – the internal users.

Learning content developers create new contents from scratch or by reusing existing LOs from various other peers of the *site*. LOs are found by replicating queries to each workflow engine, which takes control of the search process in their respective repositories, and sending results back to the originator of the query. Local search is done in the metadata base.

Figure 1 illustrates the environment, showing the two possible scopes (internal and external) and views (local and global). A continuous double-lined border separates internal and external scopes. A dashed double-lined border illustrates the global view of the environment as seen by internal users.

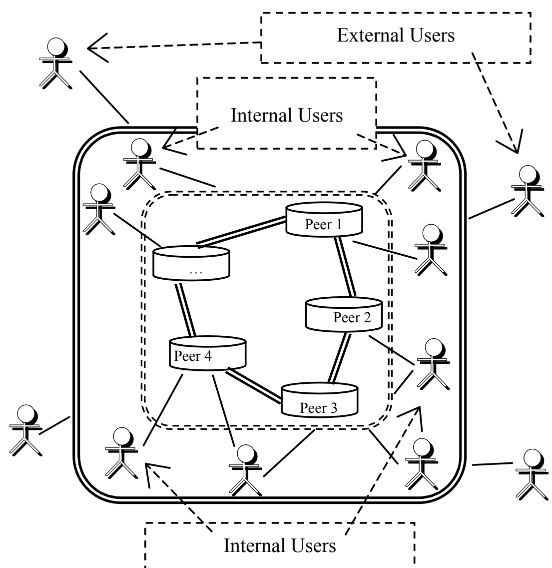

Figure 1. The distributed e-learning environment scopes

In most of the cases, the learning content is an aggregation of *lightweight* LOs in terms of computational power required to run them, i.e., despite of being eventually composed of big sets of bits (e.g., a high resolution image, an MS Power Point presentation with images inside, a movie file, etc.), they require to be shown or played a processing power normally available in clients' workstations. In some other cases, although, the amount of data or the complexity of the model is huge and/or the services that process them consume huge amount of CPU. This occurs typically in modeling, simulation and visualization in scientific applications. In these cases, Grid computing gives us a fundamental infrastructure to manage distributed computational resources.

We named the environment as TEAM, which derives from Teamwork Applications Manager. TEAM is based on the architecture also called TEAM (Teamwork-support Environment Architectural Model). To avoid confusion on references to the architecture and to the environment, we added a superscript A or E to TEAM to designate the architecture and the environment, respectively (i.e. $TEAM^A$ and $TEAM^E$).

4. The TEAM Architecture

We designed an architecture based on the classic architectural pattern for heterogeneous database integration consisting of mediator(s) and wrappers. In an overall conceptual view, the architecture is composed of peers that communicate to each other using regular communication links. Peers are functionally identical but some of them run on top of a grid operating system to access resources provided by grid environment(s). Figure 2 illustrates one simple $TEAM^A$ instance formed by peers P1 thru P7. In this illustration, the system is composed of three sites (Site 1 thru Site 3) and two grids (G1, G2). P4, P6 and P7 act as interfaces of the environment to their respective grids that may include many computers. G1 and G2 may be considered as sites themselves. Each site consists of one or more peers (as illustrated by P2 and P3 of Site 1 in figure 2).

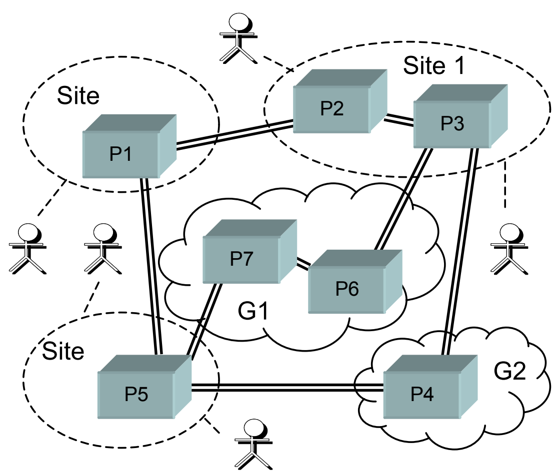

Figure 2. $TEAM^A$ conceptual view

Each peer in $TEAM^A$ is a stack of three layers characterizing a classic *3-tier* architectural model composed of interface, business processes/rules and persistence.

In the first layer, a web browser or a .NET application, for example, may realize the user interface with the environment, which is a set of web services. Standalone applications, working as "experts", "electronic tutors" or software agents with any other purpose, may also interface with the environment. If the access to the environment is done via browser, an intermediate JavaServer Pages – JSP – layer is used.

The second layer is the functional core of the architecture and is composed of the workflow enactment service provided by its workflow engine. Each engine manages a convenient portion of the whole workflow instance, processing rules and defining messages contents and interaction steps with the users. An enactment service is *wrapped* by a set of web services that form the interface with the first layer, and another set of web services to accept requests from enactment services of other peers in the network (interface 4 of the workflow reference model, as defined by the Workflow Management Coalition). Besides dispatching requests to other engines, an engine may also retrieve, and possibly store, LOs directly from other repositories in the network. The workflow engines are also responsible for synchronizing and/or migrating workflow execution states. Conceptually, the workflow engine layer, besides being the WfMS, also acts as a mediator, providing to the layer above an integrated view of the distributed execution environment.

The bottom layer of TEAM^A provides persistency to the workflow enactment service layer. It is also wrapped by a set of web services that interfaces, via JDBC, with the possibly technologically diverse data sources. The LOs repository in each peer composes a federation of weakly coupled semi-autonomous databases.

For sites running within grid infrastructures, grid services are provided by Globus (see http://www.globus.org/), a *de facto* standard in operating infrastructure for grid computing. Globus provides important features such as reliable user authentication, resource access management (shared computational power dynamic allocation and de-allocation) as also support for service and statistical information.

Peers add to the grid environment the functionality provided by TEAM. From a user perspective, this means that resources provided by TEAM and by the grid can be accessed transparently.

5. Related and Future Works and Concluding Remarks

At LNCC we are developing a grid infrastructure capable of supporting various different types of applications that can benefit from transparent access to grid resources and services. Our intention is to develop a configurable middleware system capable of integrating data and processes in conjunction with grid basic services, such as authentication, file transfer and resource allocation. Middleware functionality is encapsulated by a single web service, which is the grid interface perceived by user applications.

One of these types of applications is e-Learning Management Systems (LMS). These systems support sharing e-learning content between partner institutions and remote collaboration between students and tutors.

In this paper we present TEAM, which is a LMS being developed at PUC-Rio and LNCC. The system architecture is based on workflow technology and on LO LOM standard. The proposed architecture comprehends peer components, corresponding to workflow engines and users' home environment, which communicate in a peer-to-peer model during the execution of collaborative tasks. A set of peers forms a site, giving users a transparent view of their resources.

Some sites may be part of a grid environment. In these sites, peers act as TEAM interfaces to grid resources, providing computing power to LOs requiring intensive calculations and massive storage for huge data volumes. As an example, we are developing a fluid mechanics course to be presented at LNCC, which includes LOs covering fluid path visualization. The trajectory of fluid virtual particles in a path is computed by integrating particles positions in a period of time. A simple visualization experiment involves hundreds of megabytes of data, including particles and model data, and takes minutes of computation elapsed time.

TEAM extension towards its integration with grid infrastructure is at its initial phase. We need to integrate user authentication between both environments, and develop a more refined authorization policy that will include information on user rights to access a LO. We need also to extend our current LO storage and query services. As the potential number of partners in a grid environment is considerable higher than in more conservative environments, we need to rethink how our search for LOs will be implemented. Replication is one service we are considering to include within TEAM.

References

[1] Lin, J., Ho, C., Sadiq, W., Orlowska, M. E., "On Workflow Enabled e-Learning Services, IEEE International Conference on Advanced Learning Technologies (ICALT'01), 2001.

[2] Davis, J. et al, "Workflow Based Just-in-time Training", 7th Australasian Document Computing Symposium, 2002.

[3] Davis, J. et al, "Using Workflow, User Modeling and Tutoring Strategies for Just-in-time Document Delivery", Workshop on Technologies for Electronic Documents (AIEd), 2003.

[4] Santoro, F. M., Borges, M. R. S. Santos, N., "Learning through collaborative projects: The architecture of an environment". International Journal of Computer Applications in Technology (IJCAT), 2003.

[5] Pereira, L. A. M., Melo, R. N., "Um Ambiente de Banco de Dados Para Ensino a Distância Baseado em Workflows e Objetos de Aprendizado", ISSN 0103-9741, PUC-Rio, 2003.

[6] Foster, I., Kesselman, C., Nick, J. M., Tuecke, S., "The Physiology of the Grid", http://www.globus.org/research/papers/ogsa.pdf, 2002.

[7] Pereira, L. A. M., Porto, F. A. M., Melo, R. N., "Objetos de Aprendizado Reutilizáveis: Conceitos, Padronização, Uso e Armazenamento", ISSN 0103-9741, PUC-Rio, 2003.

[8] IEEE P1484.14.1/D6.4 Draft Standard for Learning Object Metadata, IEEE, March/2002.