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Learning Units Design based in Grid Computing

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Abstract:

The development of cooperative, flexible and reusable learning environments is a need in modern education. The IMS Learning Design specification has played a very important role in modelling and describing complex learning sequences; these tools and applications are used for making this standard design and interpretation easier. On the other hand, grid computing is starting to be used in teaching learning processes to solve complex tasks that require computing power and storage capacity. In this article, some alternatives are given to combine grid computing with teaching learning processes based on IMS Learning Design. Some elements are proposed to be considered in designing a Grid Learning Object (GLOB) to achieve communication with the "IMS Learning Design Engine". We have applied this method in designing a learning unit about the diagnosis of diseases in animals through images.

Keywords: IMS Learning Design, Grid, Elearning Grids, Learning Objects

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1. Introduction

Elearning has increased lately as a result of the development of tools and techniques which make the modelling of the teaching learning process more flexible to students and professors. There are very powerful Learning Management Systems (LMS) that allow institutions to publish teaching materials and to manage courses adaptable to a specific educative community's conditions. Likewise, the utilization of the Theory of Learning Objects has enhanced the creation of standard contents, well classified and easier to find and reuse. Many specifications and initiatives have been developed which allow providers to catalogue teaching materials of different kinds, as well as to package the contents and to design learning units that can be reused in different LMS and courses.

IMS has created many specifications which are used extensively in e-Learning. IMS Learning Design one of the most important specifications (IMSLD, 2003), easing the formal description of the teaching-learning process through a language that defines "Who does what, When and with What contents" a specific objective is achieved.

Many research projects have developed which make possible the use of IMS Learning Design (IMS-LD) by students and professors (IMSLD, 2003). The present tools permit the design of powerful and complex learning structures, where educational activities are developed in parallel with the participation of several users in a cooperative environment. Nevertheless, they are limited for searching big volumes of information that occasionally surpass terabytes, are geographically scattered and undergo frequent change.

Lately, grid computing has developed as a way to join computing resources (CPU, memory, etc) to solve highly complex problems. With the use of these technologies, it is possible to distribute processing and data capacity to different computers transparent to users to achieve super processing capacity (Pankratius 2003).

In education, many complex tasks were ignored that can now be solved by grid computing. Recently, a model that permits the integration of the functions of grids in eLearning systems has been proposed (Pankratius 2003). The new paradigm, called e-learning grid, defines the structure of a grid for learning and establishes how it interacts in general with an LMS. Nevertheless, it does not specify the interaction levels during the design of a learning sequence, where grids are necessary as an alternative to achieve computing efficiency in handling information.

Taking this into account, we propose a model that defines the interaction among the learning units based on IMS-LD and a GRID, in a way that standard learning structures that use the possibilities of these techniques can be created. Some elements are defined as a basis for "IMS Learning Design Engine" and "eLearning Grid" developers to guarantee their relationship.

The most important characteristics of a Grid Learning Object (GLOB) (Pankratius 2003) are described, its use in the teaching process and the relationships that can be established among a learning unit and the different types of GRIDS. At the end, we provide an example that shows how to apply the model proposed.

2. Fundamentals

This section deals with the most relevant elements we consider in this paper: the IMS Learning Design specification, Grid Computing basics and their utilization in the teaching learning process.

2.1 The IMS-LD specification

The IMS-LD specification can model the teaching learning process, unlike others that concentrate only in packaging contents. It is a powerful resource for designing collaborative and reusable complex learning units in different environments. The specification was developed by IMS Global Learning Consortium based on the work of the Open University of the Netherlands (OUNL) in "Educational Modelling Language" (Koper, 2001).

Optimally, a professor would be able to write a learning unit using the languages defined in the specifications, but it requires a lot of preparation due to the conceptual complexity and levels of abstraction that are necessary; for this reason, some tools and projects have emerged to aid the design of learning units using the power of these specifications. Some of them develop adequate interfaces to achieve higher levels of productivity as is the case of RELOAD project (Reload 2002). We have carried out some research work to combine the possibilities that concept maps and specifications offer in such a way that professors can design reusable learning units using a concept map as a basis, which is a well known technique (Iriarte, Marco and Morón, 2004).

There are other projects such as Coppercore (Coppercore 2002) which has created a library of functions and components that allow software developers to create facilities to incorporate and use these specifications in the applications that they develop.

At present, some grid computing tools have emerged; they gather scattered computers and resources and operate in a dynamic and automated way. For example, for teaching Medicine it is necessary to have complex images as well as to obtain data in real time so as to do some exercises and take decisions. As result, it is necessary that the tools and specifications of the design take all these aspects into account.

2.2 eLearning Grids

Grid computing dates back to the era of distributed computation, particularly in "MetaComputing" where geographically distributed computers are united in a way that they are perceived as a more powerful one.

Modern grids are adaptable because they adopt web technologies and standards as XML or Web Services. During its evolution, computational grids and data grids have developed. The first ones organize and distribute computation resources (CPU, memory), and the data ones are oriented towards manipulating "petabytes" of data.

Elearning grids emerge due to the need to integrate the facilities of grids in eLearning systems, where highly complex applications of high computational cost were ignored as such technologies were not available.

The Grid Learning Object (GLOB) is defined as an alternative to use grid computing in eLearning. This definition combines both the functionalities of a traditional learning object (Wiley 2001) and the GRID computing power. Figure 2 shows a GLOB's structure.

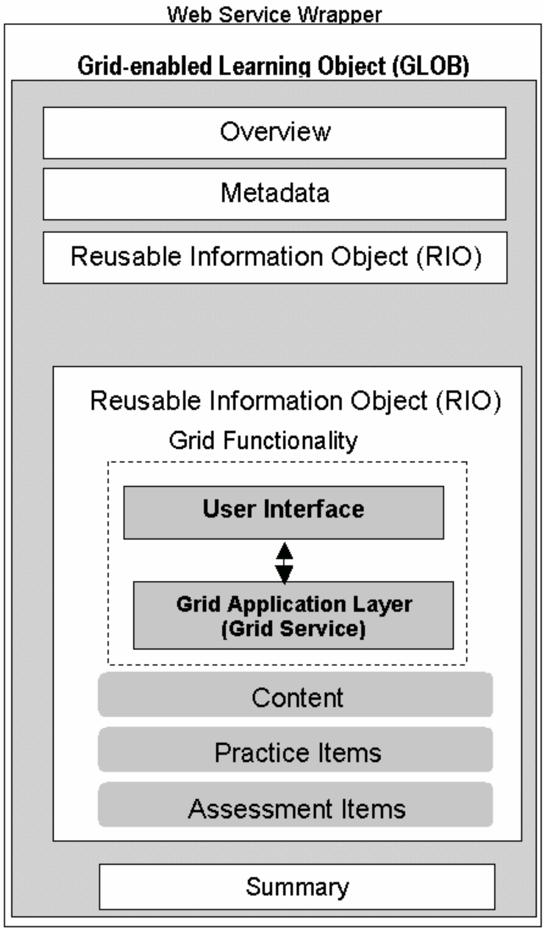

Figure 2 Grid Learning Object's structure (GLOB) (Pankratius 2003)

As observed, the GLOB has different parts: The metadata, which contain the information that characterizes the grid. The Reusable Information Object (RIO) contains the necessary information for the grid to be reused; it also includes contents in different formats, practices and tasks.

The RIO also has the facilities of a grid implemented as Grid Service. Users can get these services through a user interface. The "Grid application Layer" is where grid applications oriented towards elearning are implemented; to achieve this, they use Core Grid Middleware services (Pankratius 2003). GLOB constitutes an interface between a Learning Management System (LMS) and a GRID. To have access, a user interface is used. Nevertheless, due to the complexity of a modern learning environment, a more effective communication is needed to know the details in the execution of a Grid so as to take them into account in the teaching learning process, as can be seen below.

3. Interaction between an IMS-LD based learning environment and an eLearning Grid.

As we have stated above, learning needs distributed computer techniques to attain higher quality and cooperation in solving complex problems.

Units of learning (UoL) based on the IMS-LD specification make cooperation possible in a learning environment. Many important projects have been developed which offer alternatives to connect learning environments with several distributed computational existing models.

Halm, et al (2005) have created a model that connects IMS-LD with Peer to Peer (P2P) architecture and other hybrid systems based on distributed computation. They make use of the possibilities this architecture offers to exchange information and resources among the components of a unit of learning (UoL) through a Peer Server that coordinates all the elements that take part in it.

On the Other hand, grid computing is expanding due to its use in solving complex problems and due to the facilities that many tools offer to create GRID instances (Globus 2001), it has increased the availability of different types of GRIDS. Despite the neutral mechanisms that characterize GRIDS, which make them independent to the low level infrastructure to file data and handle resources, it is necessary to look for alternatives to use these tools in the teaching learning process. Some solutions have been given, as the one stated by Pankratius (Pankratius 2003), referred to in section 2.2, which defines an "eLearning Grid" and its relationship with a LMS through a Grid Application Layer and the user interface.

Researchers at Valladolid University, Spain, are developing a tool called GRIDCOLE. It is oriented towards the development of a collaborative learning environment through the combination of IMS Learning Design and the open grid service architecture (OGSA) (Foster, Kesselman, Nick and Tuecke, 2003) which defines a service-oriented structure for the construction of grid infrastructures. This tool has some desktop applications that allow the interaction with the grids used in the different learning activities defined in an IMS-LD document; it has a learning flow engine that is a collaboration script interpreter, which determines the sequence of activities to be performed by each participant.

Despite the results, a more direct interaction is required among the elements that compose an IMS-LD, the IMS learning design engine and the grid to achieve an active role in the teaching-learning process and hence to use the results to regulate and control the learning flow.

This section proposes a model that defines the relationship between an IMS-LD based learning unit and a grid, so that software developers and teachers can improve the "IMS Learning Design Engine".

This relationship is achieved through some modifications in the GLOB and the "IMS Learning Design Engine" together with the elements that compose the IMS-LD.

We consider that there is an LMS that has its own repository of learning objects that both professors and learners can use in the teaching-learning process. The LMS favours the design of IMS-LD based learning environments and has an IMS Learning Design Engine. It is also assumed that during the design process, a Grid is required by the professor to solve a highly complex computational task, or to present the student a document that is the result of combining the existing data in different computers or instruments that are in places unknown to the users. It is very important that the GRID adopts a Grid-enaBled Learning Object (GLOB) structure (Fig 2).

It could be assumed that the GRID could be activated through the GLOB user interface, but the necessary coordination between the other activities and roles that are part of an IMS-LD based learning object environment would not be achieved, as the "Runtime Engine" would not know the results or the GRID execution state to control the teaching learning process. The following schema shows the elements to consider for interconnecting both structures.

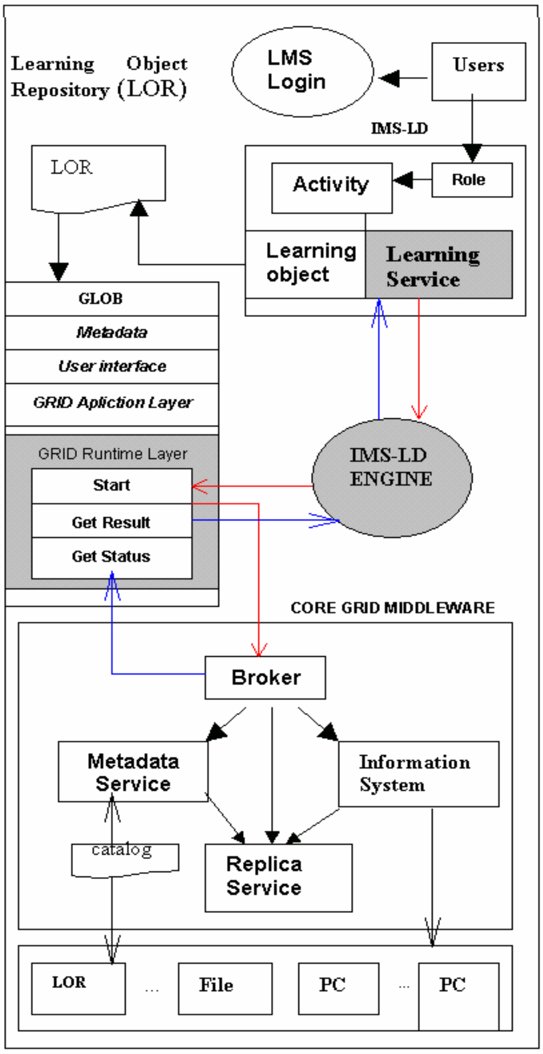

Figure 3. Relationship between an IMS-LD based learning environment and an eGrid

As can be seen, our proposition is based on establishing the relationship between both structures through functions added to GLOB and the "IMS Learning Design Engine", using the elements that make up the IMS-LD. In this manner, it is not necessary to modify the specifications.

The Grid can be designed with or without pedagogical purposes. When it is desired to incorporate it to a learning process, it is necessary to create the GLOB, which is oriented towards this goal. It has the necessary documentation through metadata and contains some services that guarantee to get to the real Grid. In the GLOB definition it is called "Grid Application layer" (Fig 2). To achieve our objectives, we propose to add to this structure a new layer called "Runtime Interface Layer" which permits it to establish communication with the "IMS Learning Design Engine". This layer includes other services which support knowing the status of GRID and other execution results, among others. In this paper we are not going to analyse the details for its adequate functioning; but just to make reference to three services (GET_status , GET _Result , Start) as shown in Figure 3. Its use is explained below.

Though Grid implementation is not the object of this paper, we make some comments about the elements that make up its structure, which helps to understand our proposition.

In a Grid, there is an intermediary system (Broker), which together with the other subsystems that make up its architecture, manages the grid resources, that can be either data or computers. In data grids, the interaction with the "metadata service" is very important; which together with the metadata catalogue manage the data using the "Lightweight Directory Access Protocol (LDAP) " (Chervenak, Foster and Kesselman, 2001), that is very effective in handling distributed data. In both types of Grids, some selection mechanisms and management of replicas are used to increase the efficiency in data management and transfer, which can be either independent files or file systems with a specific organization and structure. That is why in the figure we show a repository of learning objects as part of the grid. This type of organization is advantageous for LMSs that require the management of information from many geographically distributed repositories. The next section shows in detail a data grid used to manage information from a variety of learning objects repositories composed of images.

Once we have introduced the elements that compose this model, we turn to the logical sequence to obtain an IMS-LD based learning unit (Fig. 4).

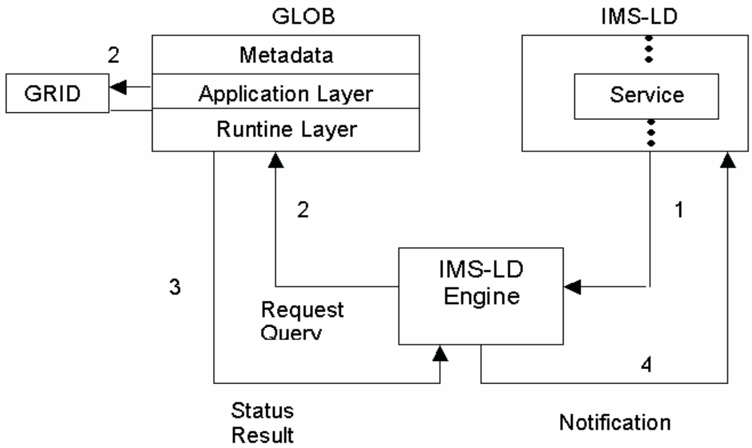

Figure 4. Logical sequence to establish the relationship IMS-LD and eGrid

The available GRIDS are known from the LMS through GLOB's metadata. During the design of the learning structure, the professor should define a "Learning Service", which constitutes an external resource to be used in an activity as part of the teaching learning process. In the IMS-LD specification services such as email are already defined aimed at making easier the "IMS-LD Runtime Engine" configuration. In the case of a GRID, it is necessary to transfer the necessary parameters to the "Runtime" to activate it. To do this, one can use the global-elements, Global Attribute 'class' and the metadata (IMS Global Learning Consortium 2003) that the "Runtime" can have access to the learning service when it is activated. The "Runtime Engine", using the information of these elements, creates a query that is sent to the Grid Service "START" of the "Runtime Application Layer", which activates the Grid.

Once the grid is initiated, the "IMS-LD Runtime Engine" may know its execution state and the results obtained through the GET_Status and GET_ Result services implemented in the GLOB's "Runtime Interface Layer". The grid's execution state can be used by the "IMS-LD Runtime Engine" to manage notifications and parameters that are useful in the learning sequence that is being designed.

The given elements can be used by software developers to improve and use IMS-LD specifications in the teaching learning process. The following section shows the design phase of a project where this model is going to be utilized to use data and computational grids in handling and processing images that are distributed through different Cuban universities.

4. Implementation of a learning unit to diagnose diseases in animals.

As part of a national project to automate the teaching learning process in the Veterinary Medicine career in some Cuban universities, a group of professors is designing learning structures so that learners can diagnose diseases from the analysis of images and other data given by professors. The images are in repositories in different laboratories and clinical units distributed through the universities of the country, which generate hundreds of images of different systems and organs of several animal species. Both researchers and professors select and catalogue them using DSPACE (Dspace 2002) facilities for handling, distributing and searching metadata; it is used as a basis to create a data GRID that manages the images efficiently.

Another computational GRID is being designed that permits to use the capacity of many computers distributed through different universities to process images and obtain indicators used in the process of diagnosis, which require great computing power.

Considering the elements above, we have designed a learning unit in which the professor presents to the students a collection of images together with other elements and data for them to make a diagnosis about a disease in animal species. The student analyzes the data and sends the selected images to be processed. From the results obtained, he will propose to the professor a diagnosis for his evaluation (Fig. 5).

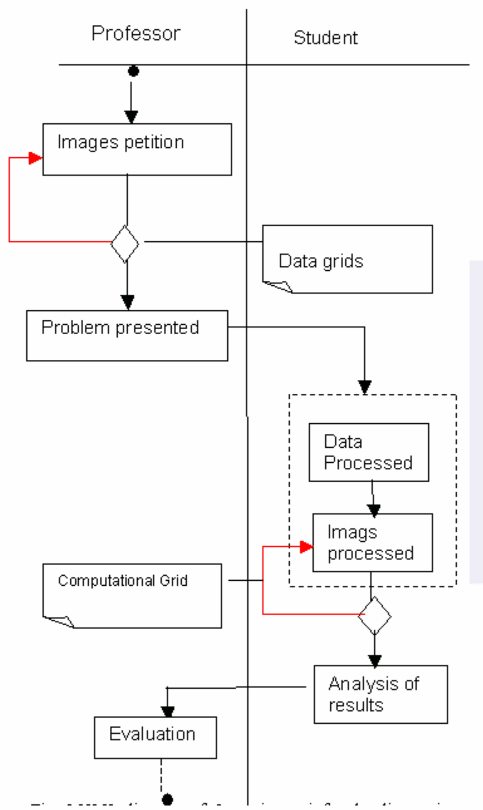

Figure 5 UML diagram of Learning unit for the diagnosis of diseases through images.

As observed, this is a simple learning sequence easy to model through IMS-LD specifications, but if GRIDS that permit the searching of images and their processing were not used, it could be impossible to finish the process, taking into account that the execution of the GRID conditions the sequences of professors and students. It is here where the adequate communication of the "Runtime Engine" with the GRID is required so that this one may know the results of its execution and influence in the learning process flow through the facilities of IMS-LD to handle notifications, variables and conditional structures.

To design this structure, the COMALO tool (Iriarte et al., 2004) is used, which has been developed by the authors. Besides, some modifications will be done to "CopperCore IMS-LD Engine" (Coppercore 2002) to achieve communication with both GRIDS where the functions that compose the "Grid Runtime Layer" will be implemented by a web service. At present, this learning unit is being implemented which will be the basis to study this model's feasibility.

5. Conclusions and Recommendations

In this paper, some alternatives have been presented which permit the interaction between GRID technology and the teaching learning process based on IMS Learning Design specifications, giving the possibility to incorporate big volumes of information as well as to use tools that require great computing power. These elements are used in taking decisions and in the solution of highly complex problems. Sometimes they are ignored in the teaching learning process, due to the lack of technologies for the optimum use and handling of computing resources and geographically distributed data.

Our proposition achieves the connection between both technologies without modifying the IMS-LD specification. Nevertheless, we consider that it is necessary to look for alternatives that permit the incorporation GRIDS as special services within the specifications, as they can be considered as a type of role the professor may define within his design strategy.

It is necessary to study deeply the applications that allow to implement GRIDS, which together with the power of the "IMS-LD Engine" developed by Coppercore and the tools that we have implemented, will let us to validate the effectiveness of the model we propose.

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