Workflows in Learning Object (LO)-Oriented Web-Based *E-Learning* Delivery Environments

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Abstract

Effective *e-learning* environments should promote high cooperation. Workflow techniques can certainly contribute to such effectiveness because, in these environments, the creation and delivery of learning contents are typically accomplished by individuals through the execution of specific and predefined sequences of activities. Literature in this area has stressed the importance of workflow techniques in *e-learning*. However, it is also important to consider new methods that may reduce development costs such as reusability and standardization. Reusable Learning Objects (RLOs or LOs) play an important role in this context as pre-existing content can be reused to generate other instructional content, adding standardization with lower development cost. Additionally, the technologies present in the WWW compose a well-established paradigm due basically to their flexibility, broad application coverage and low deployment cost. Based on these three sets of technologies, we propose an environment that supports a fully collaborative and interactive application for *e-learning* delivery. In this work we present our preliminary studies regarding the implementation of a web-based workflow management system infrastructure to support a collaborative LO-oriented *e-learning* delivery environment.

1. Introduction

There are many different definitions for workflow. According to the Workflow Management Coalition - WfMC - [1], a workflow "is the computerized facilitation or automation of a business process, in whole or part". The same source defines a workflow management system (WfMS) as "a system that completely defines, manages and executes workflows through the execution of software whose order of execution is driven by a computer representation of the workflow logic". *Web-based* WfMSs use technologies present in the WWW, such as interfaces, communication protocols and tools, in both client and server sides.

WfMSs allow participants of a process to work in a collaborative manner and can be applied to many areas of the human activity other than just business. Following the trail open by many other researchers (e.g. [3], [4] and [5]), we will be applying workflow technologies in *e-learning* as they offer many features that can significantly improve *e-learning* environments such as automatically assigning the right task to the right person in the right point of time and supporting individual planning of the work schedule, allowing students to learn at their own pace. They also support management of information and knowledge sharing, besides encouraging collaboration between students and providing students, as well as teachers, an ability to monitor individual and group activities.

Two other technologies should be considered in order to lower content development and delivery costs and to add standardization to it: Reusable Learning Objects, or simply Learning Objects – RLO or LO – and WWW (or Web) protocols and resources.

In this work we present our preliminary studies regarding the implementation of a web-based workflow management system infrastructure to support a collaborative LO-oriented *e-learning* delivery environment.

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2. Related Technologies

2.1. Workflows

Workflow technologies are capable of supporting control and enforcement of business processes, enabling collaboration between business processes, effective time management and monitoring at various levels, for various categories of users, automatic support for dynamic modification of the existing processes and relatively seamless integration of various tools and applications. Workflows are process oriented business information systems that offer the right tasks at the right point of time to the right person along with resources needed to perform these tasks [2].

The concept of workflows has evolved from the original notion of managing processes in offices and other types of manufacturing to more general contexts where the (organized) cooperation of participants is needed, i.e., where tasks developed by humans and/or systems must be accomplished in such ways or sequences that leads to the achievement of the pre-established objective(s) of the processes.

The main motivation for workflow management is, though, the increase in efficiency, which is carried out by analyzing routines and dependencies within processes and specifying individual steps, resources (tools and data), time constraints and conditions for the completion of these processes [6].

Workflow management systems (WfMS) are used to coordinate and streamline business processes described or modeled in a computable form to be processed by the WfMS. The descriptions comprise the definition the individual steps, the order and/or conditions to be observed when these steps are executed, the data flow between steps, who is responsible for each step and all other resources needed like viewers/browsers, plug-ins, etc [7].

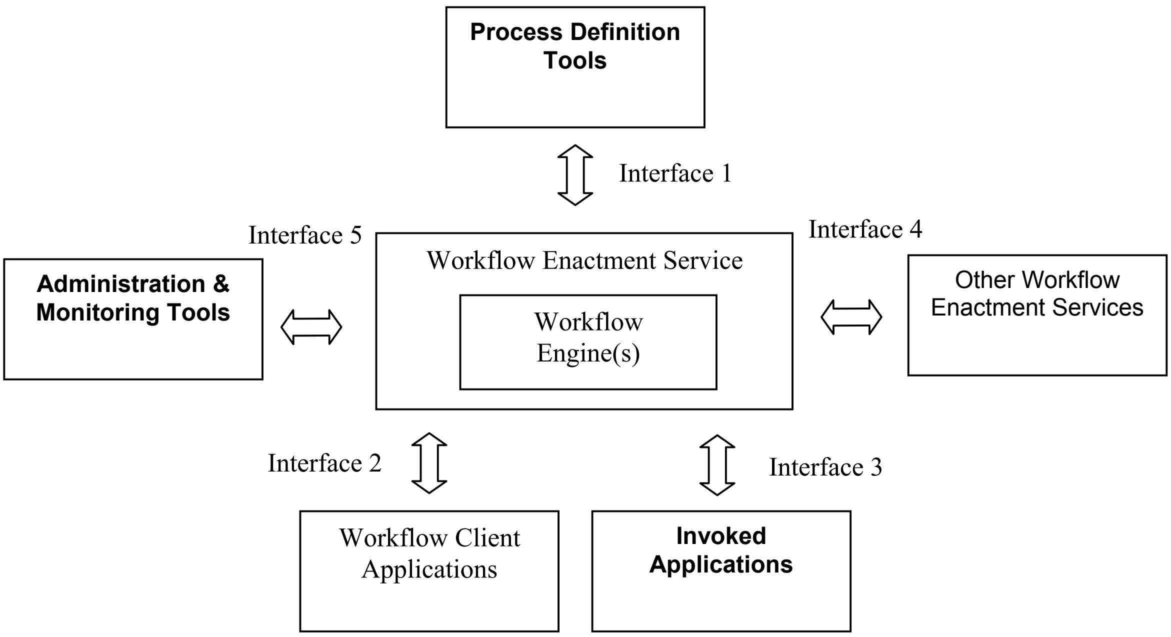

Figure 1 – Workflow Reference Model - Components and Interfaces [1]

The Workflow Management Coalition defines in [1] the workflow model (figure 1) illustrating the major components and interfaces within the workflow architecture. The WfMC proposed a specification in XML for interface 4, leaving the other interfaces open for specification proposals. In this work we are interested in the details of interface 2 and the client applications. Aspects related to processes definition and specification are also important but will be discussed in another work.

As workflows are useful for applications where coordinated participation of individuals, groups or systems is important, our current interest is to use workflow technology in *e-learning*, specifically (in this work, as a first step) in the delivery of learning content. It is believed that integration enabled by workflow technology would provide more flexibility and a more effective learning environment [2].

In the market of tools for *e-learning* there are LMSs (*Learning Management Systems*) capable to manage the instructional content (delivery, access and content security, etc.) and the flow of activities needed during content delivery. If we add to these LMSs the ability to manage cooperative execution of content, we will be providing them with characteristics and objectives of WfMSs [8][9].

The definition of the components, classification of the functionalities and sequence of the steps that are part of a typical *business* workflow have to be specialized (or adapted) to *e-learning* as, in this case, the focus is on the development and delivery of instructional content.

In *e-learning* the activities typically executed are: (1) elaboration of instructional contents, including conception, search, development, assembly, revision, approval, registry and publication; (2) definition of the activities in the LMS; (3) execution of the contents (delivery) by students, with possible cooperation among them and/or teachers and (4) content execution control activities such as statistics, individual or group assessment, etc.

The actors (executors) of these activities are the content development specialists, teachers or assistants (be human or software agents) and the students. The (digital) artifacts manipulated during the execution of content are forms, browsers and viewers, editors and learning objects – LOs – composed of content files (PPT presentations, PDF documents, MS-Word documents, etc.), special tools for their manipulation and possibly a set of manipulation rules or restrictions.

The routes correspond to the sequences of activities required by the learning process that are classified as *required*, *optional*, *alternate* or *parallel*. Routes are declared during content creation.

Rules eventually existent may impose conditions to the execution of an activity, possibly restricting execution time of a certain component or, in a more extreme situation, excluding/blocking a student from the learning program.

Figure 2, adapted from [10] for LMSs with WfMS support, illustrates the relationships among the main functions (and respective functional areas). It is important to mention two other characteristics that are not illustrated in figure 1: (1) besides the users of the content execution services, there are users of the analysis tools, content definition and modeling and (2) the environment, which is typically distributed, depicted as the integrated view that the users have.

The type of workflow that better models learning processes is the *production* one (also called *structured* [11]) as it has an execution structure completely defined during content modeling phase, even considering the alternatives possibly offered to students during content execution.

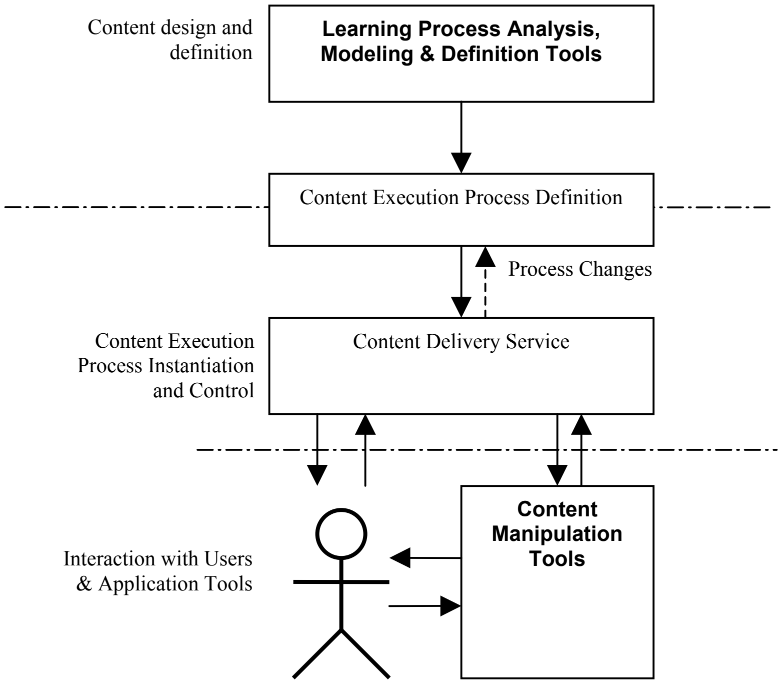

Figure 2 – LMS with workflow management support (adapted from Workflow Management Coalition - The Workflow Reference Model, Document Number TC00-1003)

2.2. Learning Objects

Our proposal for this *e-learning* environment is also based on learning objects, which are the artifacts mostly exchanged during the execution of a learning program. For this reason, we will briefly present the main aspects of this technology.

A reusable learning object (RLO), or simply learning object (LO), is [12] a reusable collection of learning material to present and support a unique learning content or [13] a *small instructional component* that can be used to support learning in *different environments* or, even, [14] any entity, digital or non-digital, that can be used for learning, education or training. In our discussions we deal only with digital entities.

In the definitions above, a *small instructional component* means a module or lesson to teach a specific concept, a fact, procedure, process or principle. *Different environments* mean that the content can be used or executed in different LMSs.

A content developer may create a new content or assemble one by aggregation of appropriate pre-existent LOs. The idea is to diminish the efforts/costs needed to produce these learning components that are, in general, expensive to produce as they may contain multimedia presentations, simulations and animations. LOs provide, among other advantages ([8], [15] and [16]), a great flexibility in the organization of learning material.

LOs and their components are typically described through the use of XML tags that are defined, ideally, by international standards and specification directions. The tags help users and search engines when they search objects repositories.

Many organizations look for the creation of standards in order to establish a discipline when defining the contents of LOs, allowing the standardization, providing an improved LO database quality and reusability, independently of the LMS used. By defining a common conceptual schema and representing these metadata in known languages like

XML [14] we achieve a better semantic interoperability. There are several standards currently available; among all we distinguish the LOM (Learning Object Metadata) of the IEEE Learning Technology Standards Committee (IEEE-LTSC), the IMS of the IMS Global Learning Consortium and the SCORM (*Sharable Content Object Reference Model*) of the ADL Advanced Distributed Learning. The IMS standard is based on the IEEE-LOM, describing it in XML (the *XML Binding*), and the SCORM adopts this description by attaching it in one of their *books* [17]. Due to the affinity and interdependence of these three standards we decided to adopt the IMS standard.

The LO conceptual model, the way they are aggregated to form other contents, the detailed data item descriptions of the IEEE-LOM and the definitions and concepts adopted by the members of the PUC's Database Technologies Lab (TecBD/PUC –Rio) are presented in more details in [8] and [15]. Figure 3 illustrates the LO model adopted in our research. Note that, even in the atomic level - ALOs (Atomic Learning Objects), i.e., smallest objects provided with a learning semantics - objects are composed of practice and assessment items in addition to the content.

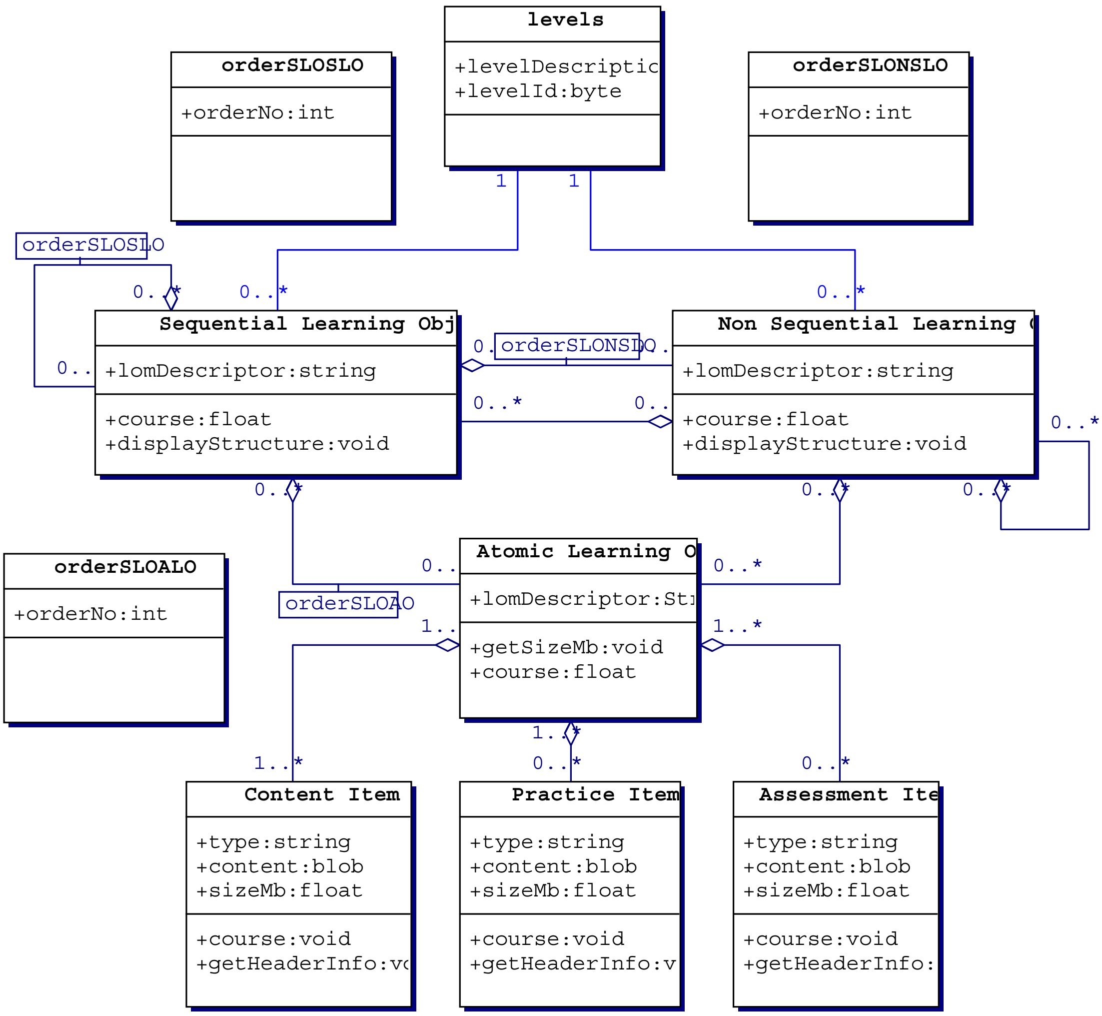

Figure 3 – LO class model adopted.

2.3. Using of Resources Provided by the Web Environment

A well-integrated study environment should include components such as learning and assessments into one fully system supported stream of activities. Workflow technology can then be used to manage these learning activities for different roles [2]. In the previous sections we discussed the importance of the WfMS support and some advantages of adopting reusable modular content in *e-learning*. In this environment, we will also use the following important concepts, characteristics and resources related to web technologies:

- The user ability to remain authenticated as long as he/she remains in the same browser session,
- Files download and upload,
- Web browser extensibility provided running *applets* and a multitude of *plug-ins* required to browse contents in different formats, e.g., .PDF, .DOC, .PPT, etc.
- Web (group) chat,
- Web mail,
- Mail lists,
- Discussion forums/interest groups,
- Bulletin boards.

Other resources can be developed and attached as *plug-ins* and applets to the environment or HTML pages. An example of this is a *real time white board* implemented as a *java applet*.

Some of these resources can be used as complete steps of a learning process, when synchronous interaction is needed (chat, white boards and files download and upload, when an artifact is to be received/sent from/to other participant as a step required), some of them work as asynchronous interaction mechanisms (mail, bulletin boards, which are offered to student and teachers as extra resources), and other can work as the infrastructure to allow execution of LOs (plug-ins to manipulate contents in different formats, e.g., PDF readers, .DOC/PPT viewers, etc.).

3. Description of the Workflow Environment for *E-learning*

In this chapter we present the workflow-related requisites for the *e-learning* delivery environment that we will be developing. In the present work (as in the first phase of the implementation) we do not consider object persistency technology, distribution or heterogeneity of the workflow data/states repositories, which can be abstracted as we can provide a services-based, centralized and homogeneous view to the users and application programs by adopting convenient *middleware*.

3.1. User/User and User/Content Interaction Levels

The range of interaction and collaboration levels among participants and among participants and content and are: (1) the *solitary confinement*, where there is no interaction and collaboration among participants and where the whole content, after downloaded to the students' workstations, can be executed offline, just like in the old CBT way, and (2) the case where there is *full collaboration* and artifacts exchanges among students and among students and teachers. This case requires that a relevant part of the content be executed being the participants online, also requiring task assignments and effective interaction coordination with execution duration control and synchronization. For this case we want to provide an automated content execution management, based on a previously defined computable model. The partial user/user and user/content interaction will occur according to the UML activity diagram illustrated in figure 4.

Orthogonally to the sequences of activities shown in figure 4, the following activities may also be asynchronously executed by selecting, at any time, links ideally displayed on the upper part of each HTML page:

- Access the web mail, with a sign that there are new mails.
- Access to the personal agenda, with markings indicating new agenda items missed or scheduled for the near future. The agenda is maintained by the participant and by the LMS that informs execution of the downloaded contents due dates.
- A list of links to the participants currently online. By clicking a name in the list, the respective participant will be invited to participate of a web chat session.
- A link to the bulletin board.

A link to a page that contains the execution state to show the current position within the learning content execution graph can also be displayed after the choice of a program has been made.

Note that content (LOs) may be executed offline by downloading it ("saving target as …"). Students' activities are automatically tracked by the LMS, which is also responsible for delivering the uploaded artifacts to the proper participant.

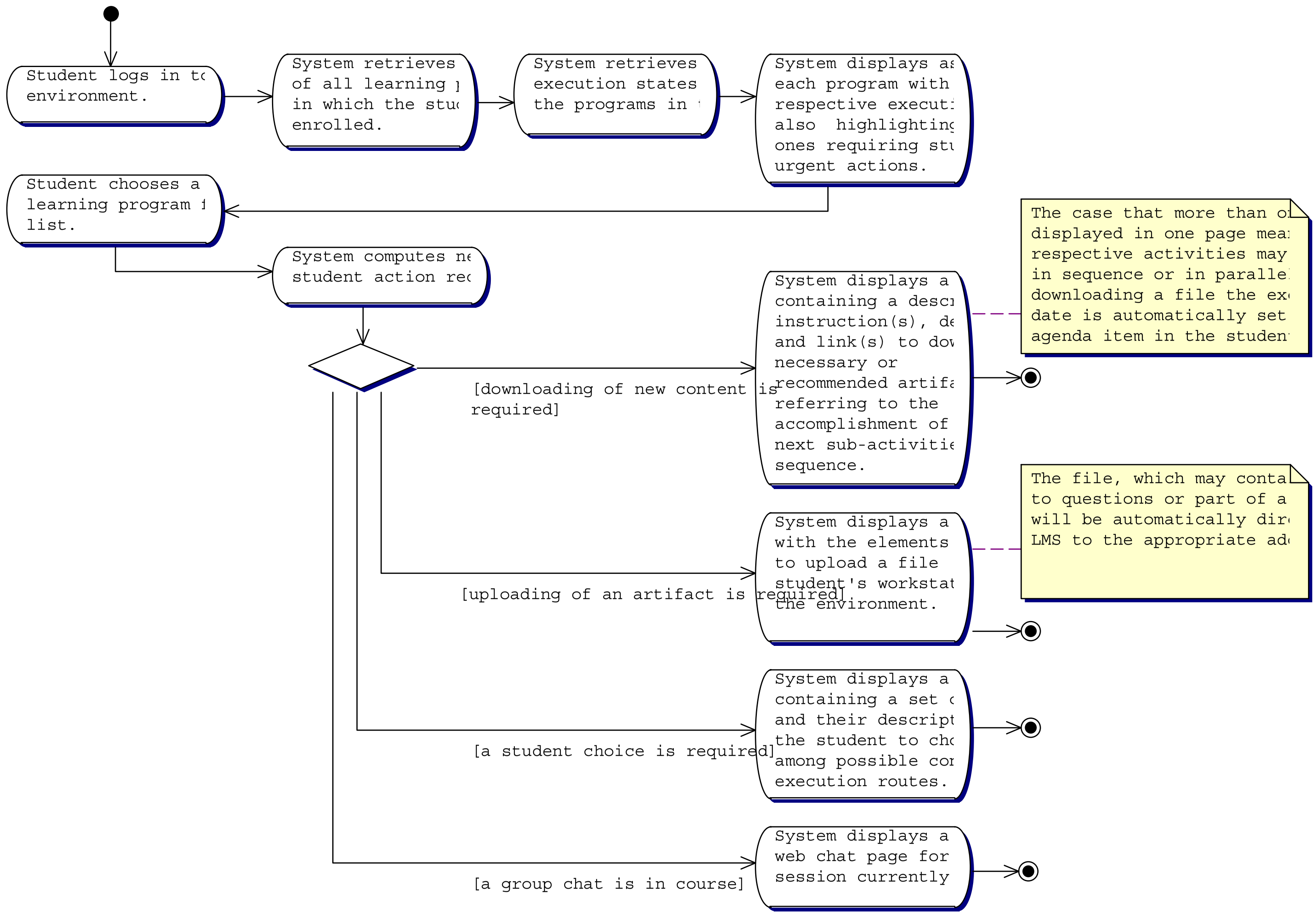

Figure 4 - Activity diagram illustrating user/LMS interaction.

4. The Workflow Conceptual Model

One of the documents that describe the WIDE - Workflow on Intelligent Distributed database Environment - project [18] proposes a complete workflow model structured as three other different models [19]:

- The organization model, which describes the agents that participate in the execution of the activities specified when modeling the workflow,
- The information model, which describes the information items that are managed by the workflow engine, both in the definition environment as well as in the execution environment, and
- The process model, which describes how the different activities to be performed are related, and how the other two models, Organization and Information, are combined with this into a complete workflow model.

With this in mind, also considering the requisites and characteristics of our *e-learning* delivery environment already described, we derive:

- The agents or executors of the workflow are the students and the teachers. Tutors/assistants/advisors/assistants eventually present, be human or electronic, can be considered as specializations to teachers. This model is described in section 4.1. A more complete scenario, also comprising the modeling phase (or build time phase – see figure 2) is described in [8].
- The information model describes LOs, the other digital artifacts that are exchanged and down/uploaded during interaction and the required execution context. Figure 3 and the class model of the execution context presented in section 4.2 compose this model.
- The process model is composed of the general interaction activity diagram illustrated in figure 4, the activity diagram that models the execution sequence and all the interaction diagrams that define the collaboration sequences among objects, which will become available as we progress towards implementation.

4.1. The Use Case View

Figure 5 illustrates the use case view (at the conceptual level) of the “content delivery” section of the environment, thus being a subset of the use cases presented in [8]. Tables 1 and 2 show some relevant aspects.

▪ *Actor Summary*	
Environment User	Generalization of all users of the environment, which must be logged in.
Student	-
Teacher	-
Teacher/Monitor	Generalizes teachers. Included as a suggestion for responsibilities division or workload balancing.

Table 1 – List of all actors of the environment that participate in the delivery of content.

▪ *Use Case Summary*	
Evaluate Student Performance	-
Authenticate User	User logs in with username/password. System retrieves profile and execution states.
Block/Unblock Student	Teacher/monitor may block any student.
Browse Agenda	Some student agenda items are set by the system automatically when, for instance, the student starts another content module and a deadline is needed or when a synchronization point is defined.
Define Sync Point During Content Execution	Teachers may define a synchronization point during content execution. This sets a new item in the student's agenda. A sync point may me the accomplishment of a specific task by all the students.
Get/Set Bulletin Board Message	-
Get Next Content	System may display a page containing a description, instruction(s), deadline(s) and link(s) to download/view in browser necessary or recommended artifacts referring to the accomplishment of the next sub-activities in sequence. May set a new item in the student's agenda.
Insert Student in Program	Associates students to a new learning program. Creates student-program context space.
List Student Activities	-
Participate in Group Session	Opens a group chat session. A suggestion of such a resource can be found in [20]
Send/Receive Mail	Uses a proprietary and integrated web-based e-mail system.
Set Group Session	Schedules a new group session, setting a new agenda item in the student's agenda.
Set New Student Agenda Item	-
Set Student Data	Maintains student personal information.
Submit Assessment	Student uploads an answered questionnaire or fills and submits a form with his/her answers.
Upload Artifact	Uploads a digital artifact to the system, which will route it automatically to the proper addressee.
View Student Data	Browses students' data.

Table 2 – List of use cases at the conceptual level.

4.2. The Static View

Figure 6 shows the class diagram of the learning content delivery subsystem. Note that *Execution State* is an association class of the association Student-Learning Program. Also note that roles and groups may be assigned to students when they enroll learning programs. Attributes and operations will be *discovered* later, when we develop the sequences diagrams regarding implementation.

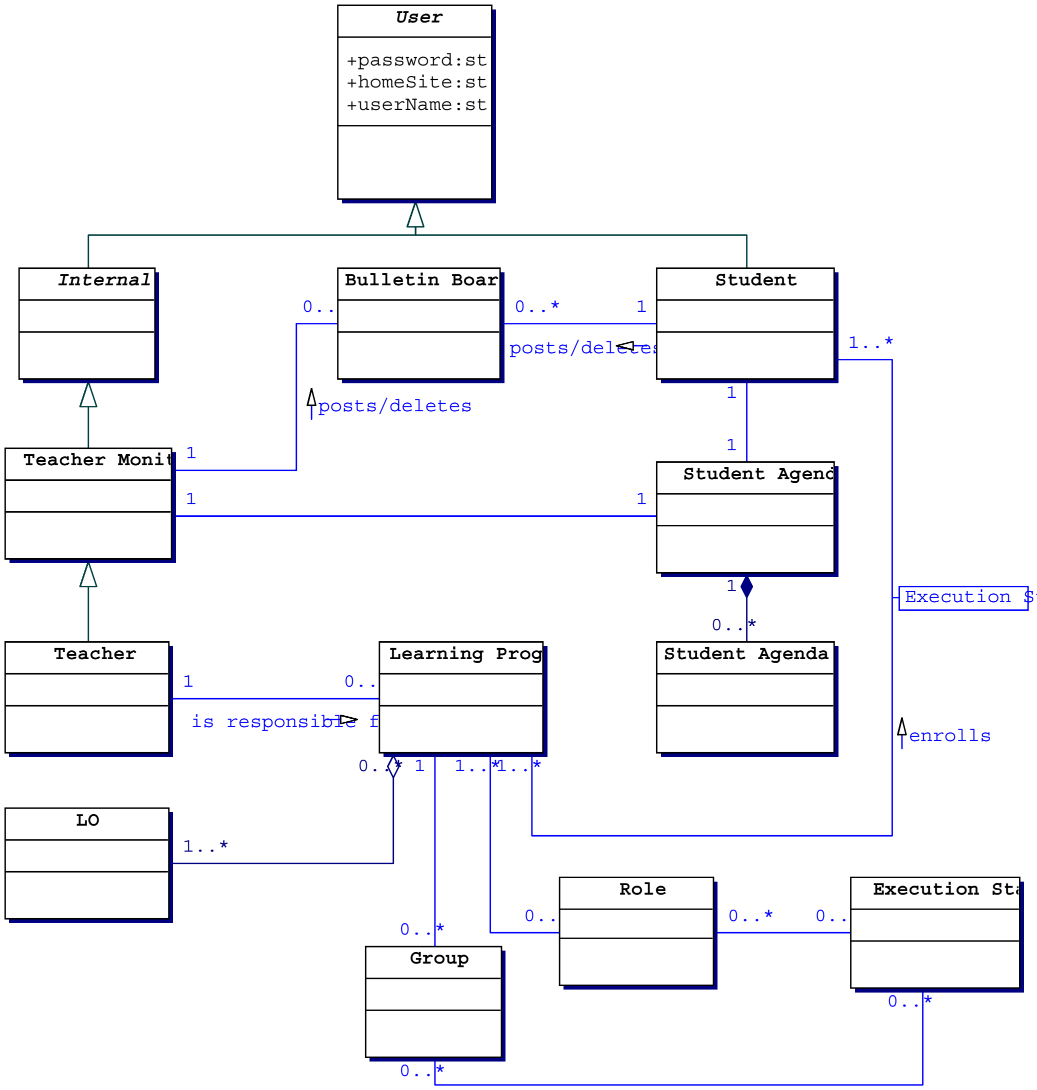

Figure 6 – Class diagram of the delivery subsystem

4.3. The Dynamic View

Dynamic view starts with the activities diagram of figure 4 and will be completed later, when will detail collaboration among objects of the model as we develop the sequences diagrams. By the same time, operations and attributes, as also their visibilities, will become available.

5. Related and Future Works and Concluding Remarks

There are many references on workflow systems and on *e-learning* in the literature. Few of them combine these two technologies. Three of these references were already mentioned in this work ([2], [3] and [4]) and helped us a lot. Another work, *The Instructional Architect*, conducted at the University of Utah ([21], [22]) helped us to understand how a web-based LO-based environment would work fine for *e-learning*.

Our next step is to start working on the development of a prototype for the conceived environment, combining these three technologies and typical resources. We know in advance that we will need a language, definitely XML-based, to model workflows and to allow them to be processed by the workflow engine. In some point along the development process we will also have to start considering distribution and heterogeneity of the storage technology. In this way, the experience acquired with the WIDE project that took place at the University of Milan [18] and the work on workflow specification languages [19] conducted by Professor Casanova and Tatiana (both from PUC-Rio) will also be very helpful. Finally, we expect that Marc Stauch's Master's Thesis submitted to the Technical University of Berlin in March/1999 [23], will help us with some details as it provides the source code of their experiments and a very good text covering the fundamentals. We are sure that this implementation will provide a robust groundwork for our future works here in PUC-Rio.

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