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Mixing Educational and UML modelling languages for the design and analysis of E-learning platforms

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Mixing Educational and UML modelling languages for the design and analysis of E-learning platforms

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ABSTRACT. E-learning technologies have greatly improved classic training and learning methods, and have reached a large public including companies' staff, remote and foreign students. Many works have been proposed in the literature in the field of E-learning research so that to allow actors to work with more efficiency and more effectiveness. These recent works based on the use of learning objects and educational modelling languages. Among these languages, EML language (Educational Modelling Language) has been introduced for modelling learning processes, and on the other hand, the LOM (Learning Object Metadata) and IMS (Instructional Management Systems) specifications have been defined for modelling teaching resources (objects).
In this article, we will study LOM and EML languages and use a mixture of these languages for the design an e-learning platform, passing through an UML modelling of learning resources and activities. At the end, an approach for analysing the platform is proposed.
Keywords. E-learning, educational resources, educational processes, LOM, IMS content packaging, EML, modelling and analysis.

1. Introduction

In order to face to a growing need for training, different persons, it was essential to improve training and learning methods. The concerned public is local and foreign students at universities, enterprises' staff, job seekers which want to enlarge their know ledges and strengthen their skills. This was possible thanks to the introduction of computer technologies in the learning field, and later to the use of communication technologies and web services. In this way, have appeared **E-learning** technologies.

E-learning is defined as the training by using new information and communication technologies, such as multimedia resources, Internet and so on intranet enterprises. As the use of such technologies becomes more and more complex and widespread, this requires standardization and organization of learning methods. For that purpose, two aspects have been studied :

- The first aspect concerns educational resources management, which can be of any type: text, bitmap, animations, simulations, forms, and specialized applications. We mean by educational resources or documents, courses, exercises, home works, FAQ,…etc. These documents must be organized so that to make easy access and reuse in large contexts. So, standards have been developed, for defining technical specifications and establishing educational applications and services interoperability. Among these standards, there are the "**IMS-Content Packaging**" specification and **LOM** (Learning Object Metadata) model. The **IMS-Content Packaging** [IMS03] describes the structure and organization of learning objects as a set of files grouped into a package, in order to facilitate exchange of these objects. On the other hand, the LOM model [9], [6] characterizes and indexes educational objects by using metadata.

- The second aspect concerns organization of learning processes or activities done by e-learning actors. The formalization of educational activities has led to another initiative: the EML language (Educational Modelling Language) [5], [7], which describes the characterization elements of educational processes.

This paper investigates modelling possibilities for the design of an e-learning platform, and proposes at the end an approach to analyse learning processes of the platform. For that goal, first, we present each of the languages LOM and EML. Then, we propose an UML modelling for conceiving the platform,

supported by a LOM and EML modelling. Finally, we provide a modelling approach which permits analysis of the platform.

2. LOM SPECIFICATIONS AND IMS-CONTENT PACKAGING

Knowledge and training management needs to represent the knowledge by entities easy to deliver, access and reuse. These entities are said **educational** or **Learning objects**, **documents** or also **resources**. A learning object is defined as any entity, digital or non-digital, that may be used for learning, education or training [3].

Learning objects are the kernel of knowledge in E-learning platforms. Indeed, the different actors, creators of educational contents, courses editors work independently and often without knowing each other. So, they need to rely on common standards to guaranty correct operating with educational resources in a large number of contexts.

Consequently, standards have been defined for characterization of numerical educational documents, so that to allow exchange, sharing and reuse of these documents. These ones are seen as a grouping of elementary elements which can be decomposed and recomposed in different manners in order to be reused in different environments [8]. Among these standards, we find the IMS and LOM specifications.

2.1. IMS-Content Packaging

The Instructional Management Systems (IMS) Consortium is a grouping of 250 educational establishments and companies like IBM and Apple whose goals are to define technical specifications for interoperability of educational applications and services. Among these specifications, we find the **IMS-Content Packaging.** The aim of Content Packaging specification is to provide a standard container structure for holding e-learning resources. This package structure provides a standard vehicle for moving resources across different systems [3].

The conception n this specification views learning objects as minimal, pedagogically meaningful units that are organised around one clear **learning objective** or goal. This is analogious to the Lego brick where learning objects are the basic reusable learning blocks, out of which courseware can be constructed.

How the specification organizes educational resources? It is done according to a model, the ***Content Framework*** [9] which splits resources into:

a. « *The Content packaging* »: groups together physical resources and data necessary to their description into an entity said **package**. A package represents a reusable resource incorporable into an educational platform, and comprises two elements: an XML file (said **Manifest**) which describes content organization and educational **resources** [6], and physical files (physical resources) given into the Manifest.

b. « *The content management* » : organizes system management data. It comprises didactic intelligent resources. As an example, we can say that the content management put courses, users and groups into a database to allow the system to load a course or initialize a group. The organization is done through two elements:

- **The data source:** organizes data on users (learners, schools, enterprises).
- **The run-time environment:** organizes learning and interaction rules, where abilities and objectives are programmed.

2.2. LOM Model

The variety of activities and tasks required in an e-learning platform, and the adaptability needed for systems require to handle extremely fine educational resources. So, the need for characterizing numerical

documents in the learning context emerged. To achieve that goal, it is necessary to define an extensible but simple standard useful in different learning environments. Among the proposed models, was proposed the LOM (Learning Object metadata) [9].

This model was introduced by the Learning Technology Standards Committee (LTSC), for the description of educational objects (resources).

It is considered as a common characterization system in the educational information domain. To describe an educational object, LOM uses a standard for metadata presentation, which can consist of several optional elements: title, author, description, editor, collaborator, date, resource type, source, language, relation, scope and rights management [6]. It defines nine categories, each one giving a certain aspect of the object: the general description, the life cycle, the metametadata, the technical information, the educational part, the rights, the relational aspect, the annotation and classification.

3. EML LANGUAGE

Special attention was attached to the performance of individual and group learning activities, designed to attain learning objectives. So, the learning object centric view of the e-learning world evolved to a learning activity centric view [10]. For that objective, was introduced EML (Educational Modelling Language).

EML is a new model for the standardization of electronic learning system [7]. It was developed by the OUNL (Open University of the Netherlands) at the end of the nineteenth, and was available in December 2000. It integrates metadata not only on educational resources and their contents, but also on roles, links, learners' interactions and activities. It also models learning processes.

The modelling language EML is based on two notions which form the kernel of an educational meta-model:

3.1. Unit of study

It is the smallest unit which gives learning events to the learner, by satisfying one or several related objectives. It consists of series of activities which can be without content (like a conversation between a learner and his teacher), or the result of the unit (like producing a report after a research activity).

3.2. Pedagogies

EML is also based on the notion of pedagogy and "teaching objects" like: Learning tasks, educational objectives, pre-requisites, roles, files and learning environment.

In brief, to model in EML, we create units of study. This creation follows the steps below:
- Definition of the pre-requisites and educational objectives.
- Definition of a scenario which specifies how activities must be done.
- Definition of the activities referenced in the scenario.
- Definition of activities environment.
- Assignment of activities to actors' roles.
- Specification of learning development conditions.
- Definition of meta-data.

In what follows, we will use the two modelling languages presented above, in order to take into account e-learning specificities, while designing an e-learning platform.

4. DESIGN OF THE E-LEARNING PLATFORM

Our objective here is to present the most suitable methodology for designing an E-learning platform, on the basis of standards. We first perform a modelling of the information system, using the UML language. Then, this modelling is refined by considering E-learning particularities.

So, in order to build an e-learning platform, we proceed as follows:

- We first identify object classes of the information system, by modelling it with UML language.
- Then, we model educational documents (objects) by using the IMS and LOM specifications, and deduce classes associated to these objects.
- Finally, we model educational processes (activities) by using EML language, and deduce classes associated to these activities.

4.1. UML Modelling

The E-learning platform is a software environment which provides learners which training courses and manages all embedded entities and activities. Three actors' types are handled: the learner, the teacher and the administrator. In order to identify object classes of the system, we build first an UML use case diagram which illustrates the general functionalities corresponding to each actor of the platform. This diagram is given below :

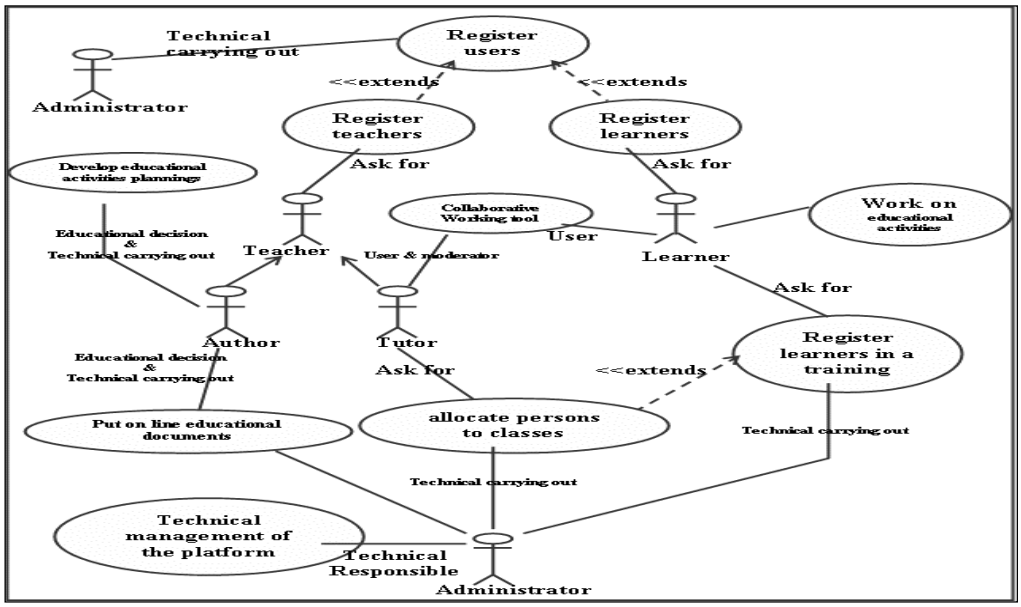

Fig.1. Use case diagram of the platform functionalities

After that, we model the functioning of the system. For that objective, we have structured the study into six aspects::

- User management.
- Training management.
- Educational documents management.
- Educational follow-up.
- Communication.
- Events history.

For each aspect, we have described the actions representing all possible behaviours of the system by UML diagrams. We give some of these diagrams below :

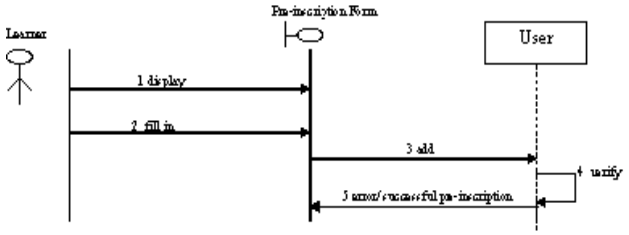

Fig.2. UML Sequence diagram of learner preinscription

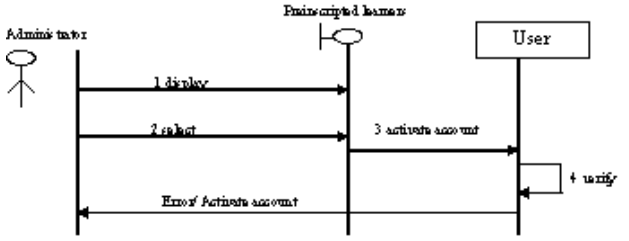

Fig.3. UML Sequence diagram of accounts activation

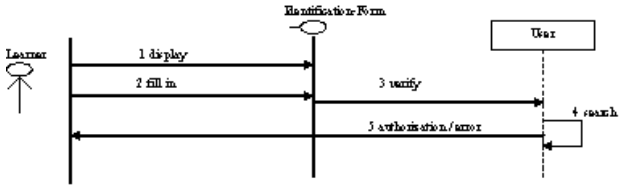

Fig.4. UML Sequence diagram of learner access

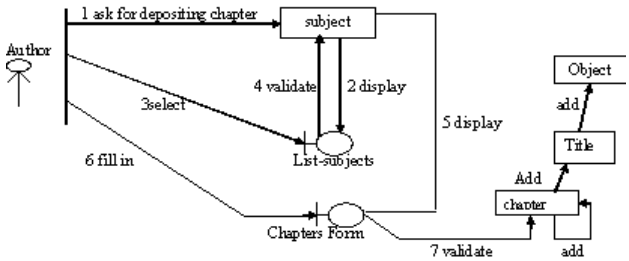

Fig.5. UML Sequence diagram of putting a chapter

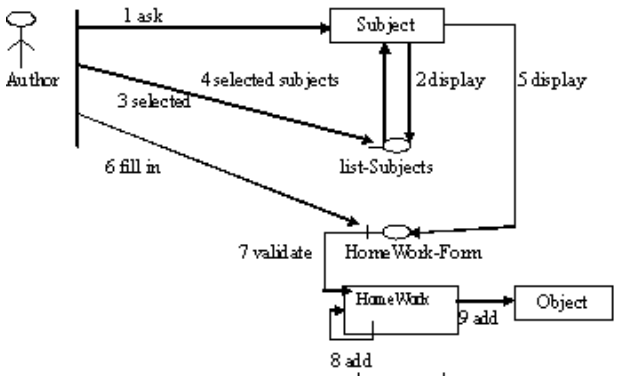

Fig.6. UML Sequence diagram of putting a homework

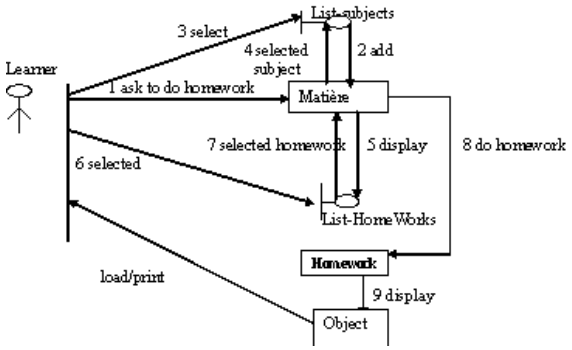

Fig7. UML Sequence diagram of doing a homework

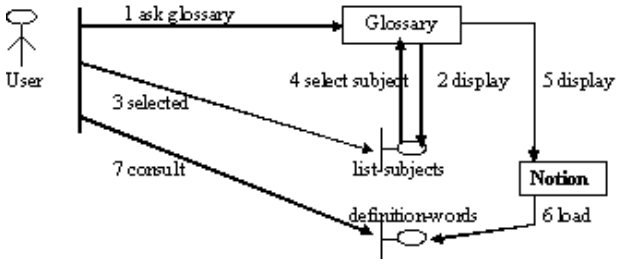

Fig.8. UML Sequence diagram of consulting a glossary

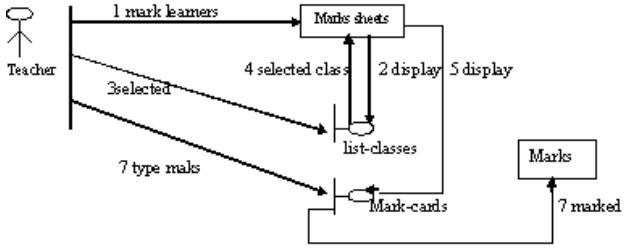

Fig.9. UML Sequence diagram of noting a learner

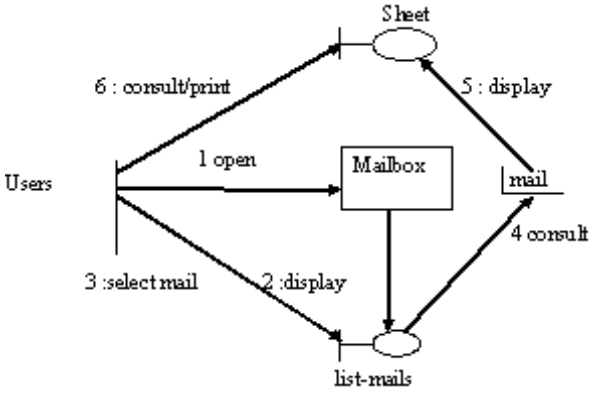

Fig.10. UML Sequence diagram of consulting mailbox

From these diagrams, we have identified classes associated to the platform objects. For each aspect, we have a partial class diagram:

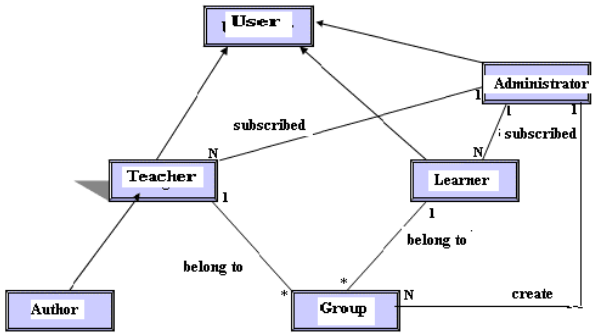

Fig.11. Class diagram for user management

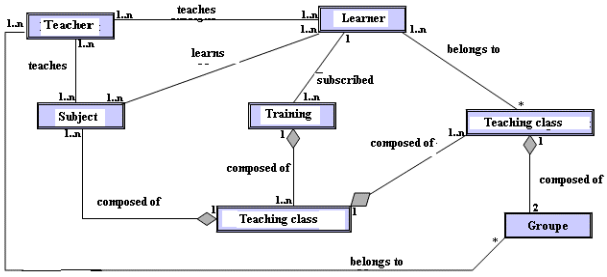

Fig.12. Class diagram for training management

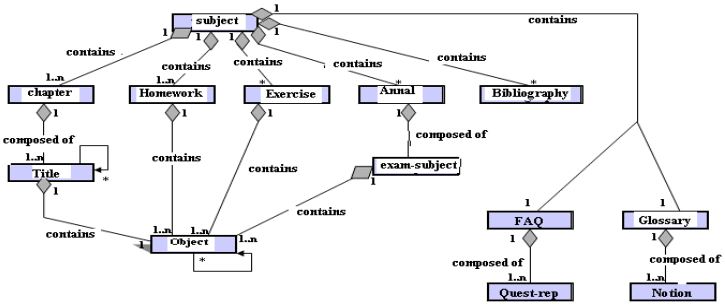

Fig.13. Class diagram for learning objects

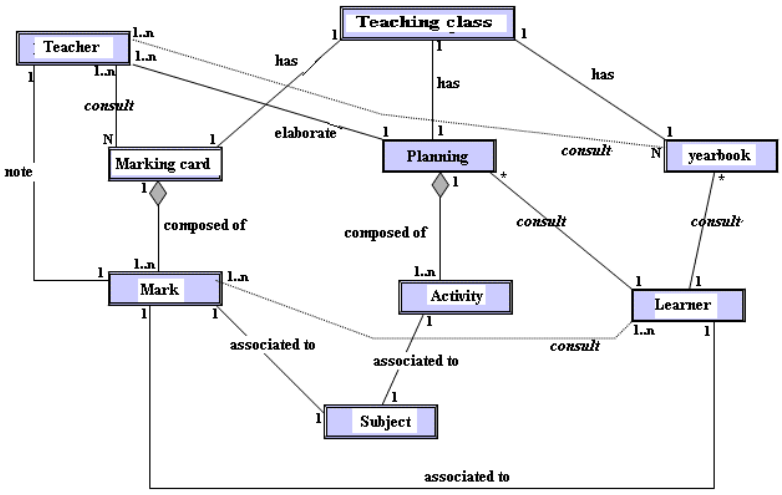

Fig.14. Class diagram for educational follow-up

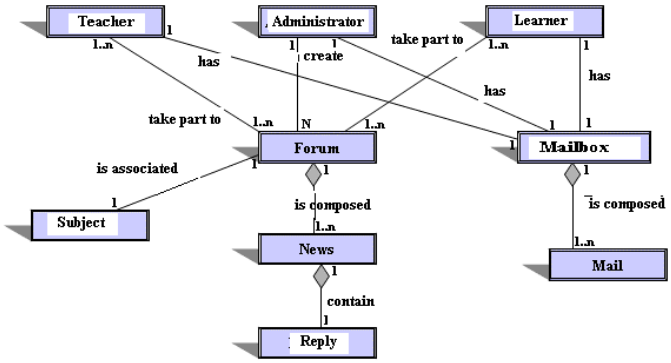

Fig.15. Class diagram for communication management

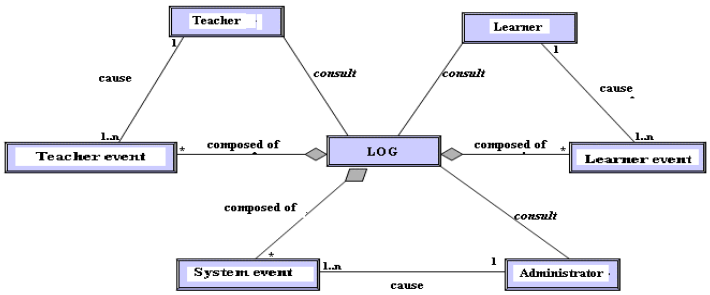

Fig.16. Class diagram for log management

4.2. Modelling Learning Objects

In this step of modelling the E-learning platform, our interest focus on organizing learning objects and characterizing them using metadata.

For that purpose, we apply the LOM model and IMS Content Packaging specification. So, each subject teached through the platform is represented by a **package**. As a subject handles a set of educational objects, the package groups into a directory:

- The set of physical files or « resources » necessary to the building of a learning document.
- The set of subdirectories of each document type, which contain files associated to each learning object:
  - a **"manifest"** file written in XML, which describes the hierarchical structure of the learning object, and
  - a meta description file, which describes document's content by several elements (general, life cycle, technical, educational, relation, classification, ..).
  - Style sheets which permit to do a personal make up depending on the user profile.

We illustrate packages by giving some examples below :

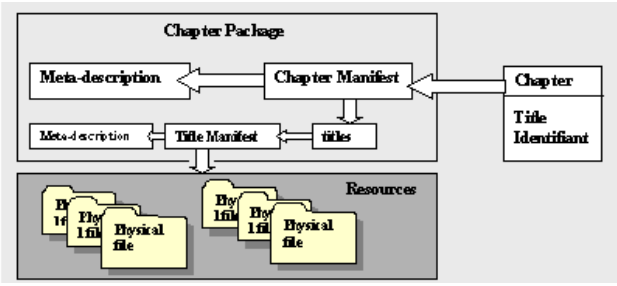

Fig.17. Chapter Package

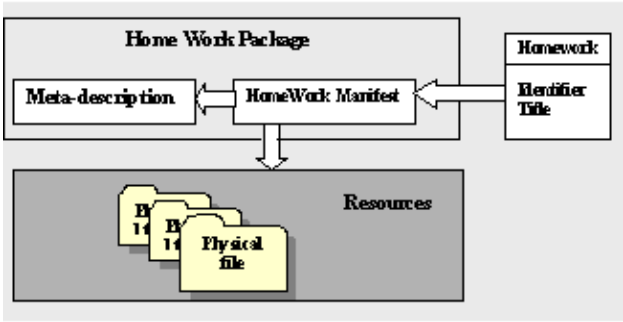

Fig.18. Exercise Package

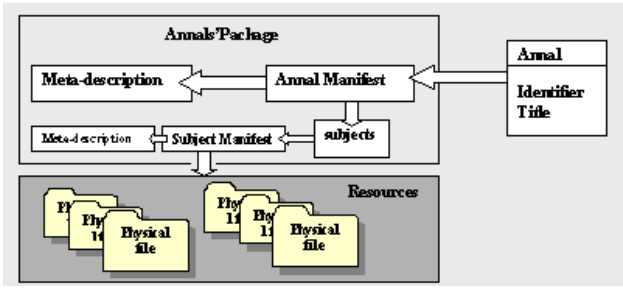

Fig.19. Annals' Package

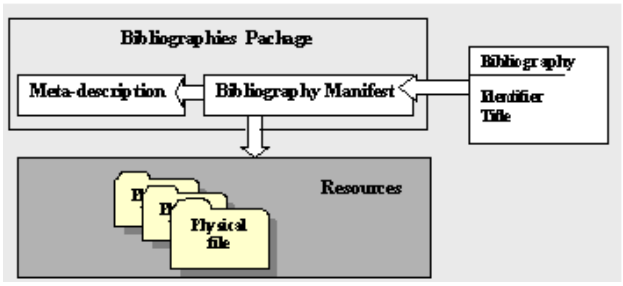

Fig.20. Bibliographies Package

4.3. Modelling Learning processes

Training through the E-learning platform is done by attributing to each actor a set of learning activities. Two types of activities are considered: training activities and follow up activities. Each activity is viewed as consisting of successive logical steps performed in a chronological order. The following scenario illustrates that:

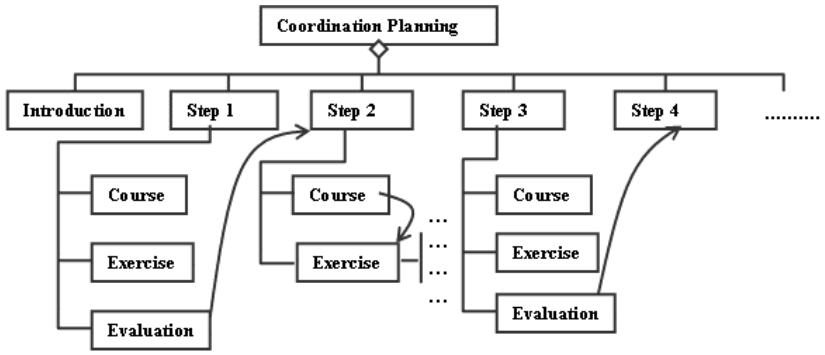

Fig.21. Instantiation of a Learning Scenario

Each activity is characterized, according to EML, by a set of objective, a set of prerequisites and an environment constituted of resources (learning documents) and support tools (glossaries, FAQ, annals,…).

By studying each type of learning activities, we obtain the class diagram given below:

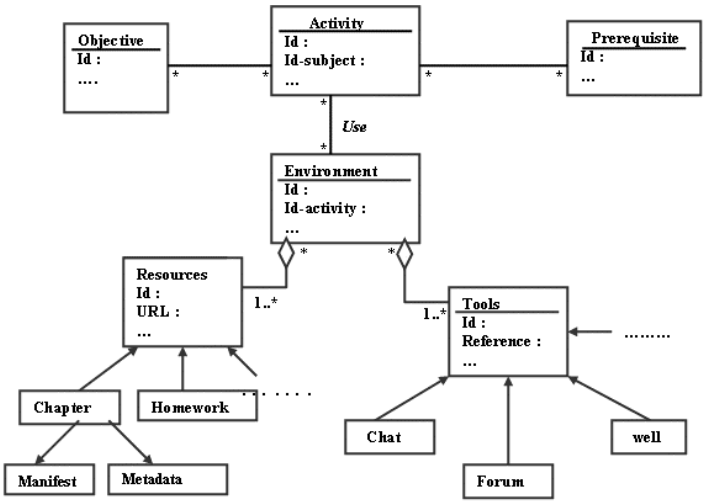

Fig.22. Learning activities Class diagram

Finally, by grouping all class diagrams obtained from the application of the three modelling languages, we have the diagram of Fig.22.

With this class diagram, the designer can carry out an E-learning platform, by adopting the appropriate physical resources such as the suitable database management system, web services, …etc.

5. ANALYSIS OF THE E-LEARNING PLATFORM

Once the design achieved, the conceptor may need to perform an analysis of the platform, in order to evaluate it. The purpose of analysis is to find out qualitative properties on one hand, such as the possibility of blocking, and on the other hand, to compute performance measures such as the number of learners connected at a moment, mean time required to do a homework, mean time response for a question in a forum, the average time response for correcting and marking home works,…etc.

The most suitable technique for studying the performance of a system is modelling and analysis using a formal model. Among the models frequently used and widespread, we have Petri nets, and in particular Stochastic Petri nets. These nets [4], [1] are considered as a powerful model which expresses the most important characteristics and permits, thanks to its probabilistic nature, to perform a numerical performance evaluation. They have proved their efficiency with analytical results, inspired from stochastic processes, especially Markov chains.

So, actually, a study is being done on performance analysis of an e-learning platform, based on the stochastic Petri net (SPN) model. In order to model E-learning processes with the SPN model, we follow the same methodology as for UML modelling, that is, we model all activities related to each management aspect of the platform. So, relying on UML sequence diagrams, we can easily model learning processes. Once the SPN models constructed, we do the analysis step using an SPN analyzer tool.

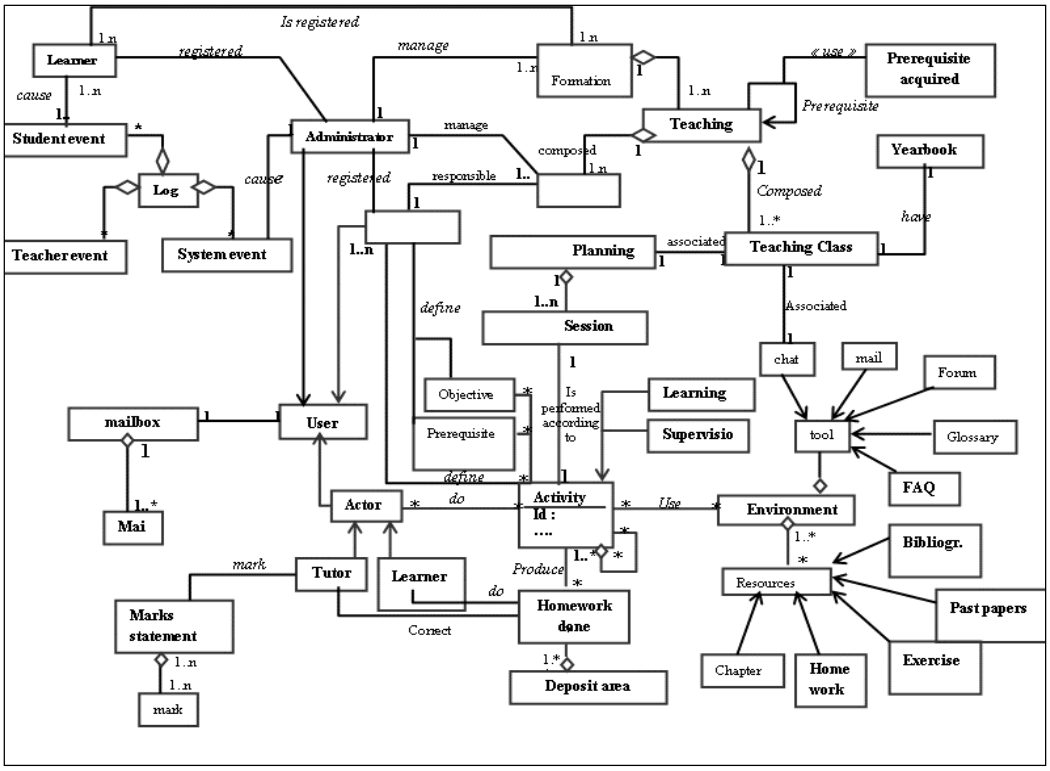

Fig.23. Class diagram of the E-learning platform

6. Conclusion

In this work, our interest was focused on formalizing the design of an E-learning platform, by performing an UML modelling completed by a LOM and EML modelling of educational objects and activities.

We can say that LOM and IMS specifications, and so on EML language, give powerful tools to include the most e-learning specificities, but also we need a formal methodology such as UML to cope with static and dynamic description of the information system. This conceptual study has been implemented into a prototype of an E-learning platform at the University, using HTML, XML, PHP and an SQL database. This prototype has shown the flexibility of the platform, interoperability and possibility of reusing educational objects.

This work must be completed by verification and a numerical evaluation phase, during which we can compute several performance indices. A continuation to this work is currently under study. The use of the Stochastic Petri net will permit us to perform a numerical analysis, as efficient tools exist. We can mention the GreatSPN package which has proved its efficiency in many studies.

REFERENCES

[1] M.Ajmone Marsan . **An introduction to stochastic Petri nets**. 11th PN Conference, pp.2-58. PARIS. June 26, 1990.

[2] T.Boyle. **Design principles for authoring dynamic, reusable learning objects.** Proceedings of ASCILITE 2002. http://www.unitec.ac.nz/ascilite/proceedings/papers/028.pdf

[3] T.Boyle. **Developing and Delivering Learning Objects from a Practitioner's Point of View**. Learning Technology Research Institute. London Metropolitan University. LTSN. April 2003. http://www.londonmet.ac.ul/ltri.

[4] G.Florin, C.Fraize and S.Natkin. **Les RDP temporisés et stochastiques : Définition formelle, méthodes de traitement**. 1983.

[5] H.J.H.Hermans, E.J.R. Koper, A.Loeffen, J.M.Manderveld and E.M.Rusman. **Edubox-EML Reference Manual. Open Univeristy of the Netherlands**. 15 December 2000.

[6] IEEE 1484.12.3/D1. **Draft Standard for eXtensible Markup Language (XML) Binding for Learning Object Metadata Data Model**. Institute of Electrical and Electronics Engineers, Inc. 2003.

[7] E.J.Rob Koper. **Modelling units of study from a pedagogical perspective, the pedagogical meta-data behind EML**. Educational technology expertise center. Open University of the Netherlands. First draft, version 2. June 2001.

[8] Elaine McMurray. **Des normes pour les technologies d'information**. 2003.

[9] Christine Michel, Soufiane Rouissi. **E-learning : normes et spécifications. Etude des spécifications LOM et IMS-QTI caractérisant des documents numériques inter-échangeables et réutilisables pour l'acquisition et l'évaluation des connaissances**. CEM-GRESIC, Université Michel de Montaigne Bordeaux 3. 2003.

[10] Colin Tattersall and Rob Koper. **EML and IMS Learning Design: from LO to LA.** Educational Technology Expertise Center. The Open University of the Netherlands. LTSN. March 2003.