ГОДИШНИК НА СОФИЙСКИЯ УНИВЕРСИТЕТ „СВ. КЛИМЕНТ ОХРИДСКИ“

ФАКУЛТЕТ ПО МАТЕМАТИКА И ИНФОРМАТИКА
Том 98

ANNUAIRE DE L'UNIVERSITE DE SOFIA „ST. KLIMENT OHRIDSKI“

FACULTE DE MATHEMATIQUES ET INFORMATIQUE
Tome 98

Modeling and design of Learning Content Management Systems: UML as a tool for learning system design

KORNELIYA TODOROVA

Problems in advanced e-learning like development and delivery of dynamic flexible reusable and adaptive learning content are discussed in the paper. It is proposed an extended learning content model which purpose is to demonstrate how required flexibility can be achieved and it is offered a detailed description of design process of learning system that supports management and delivery of reusable and adaptive learning content. For this purpose advantages of UML as modeling tool for design of learning systems are discussed in the paper and elements of different types of diagrams and their implementation in the process of systems design are described. In the paper UML diagrams are used to show how necessary functionality of leaning system can be represented in clear and accurate manner and it is conducted overview analysis and of existing tools for development of UML diagrams. The model proposed is explained with several types of UML diagrams and a prototype of user interface is proposed that will provide required functionalities related to learning content manipulation and other activities related to leaning process like users profile management and their performance assessment.

Keywords: modeling, UML diagrams, state, class, system design, use case, collaborative, sequence, statechart diagrams, ontology, learning content model, reusable, flexible, adaptive learning content

2000 MSC: 68N30

1. INTRODUCTION

Delivery and development of high quality learning materials are critical for individuals and organization success in the conditions of globalization of information society. Main task of experts and specialists in the field of e-learning is to

develop and support systems that allow effective learning materials to be created, edited, stored and delivered. Basic problems related to development and delivery of dynamic, flexible and adaptive to learners' needs of education learning materials are discussed in the paper and an extended and modified learning content model is proposed. Different types of learning systems are developed for the problem solution. Most complex of them are Learning Content Management Systems (LCMS). They allow learning process to be managed and their most important functions are related to learning materials manipulation. The goal in this paper is to design LCMS following the Unified Process (UP) methodology and according to it the development of high efficient system that supports e-leaning processes will achieve. Development of effective software systems that cover users' requirements and expected functionality depends on following the phases of systematic development process of learning systems. For this purpose users' requirements have to be gathered and documented and phases of analysis, planning, design, development, implementation and evaluation should be implemented. One of the most important phase and often missed or bad conducted one is design phase. Aim of the paper is to analyze and design development of Learning Content Management System that supports creation of reusable and dynamic learning content and learning process management. The definition used in this paper of LCMS is that the functionality of LCMS is an union of Learning Management Systems (LMS) and Content Management Systems (CMS) functionalities ([3]):

$$LCMS = LMS + CMS[RLOs].$$

In this paper UML model of use cases that describe system requirements is presented. Realization of the model should be analyzed and designed with class diagrams, sequence and collaboration diagrams and object and state chart diagrams. Last type of diagrams used in the paper is deployment type diagrams. Their purpose is to demonstrate the design process of LCMS as it is defined on the base of basic and users' requirements and to show how it will interpret the new model of learning content described here. User interface that supports processes in the proposed model is presented at the end of the article.

2. DESCRIPTION OF LEARNING CONTENT MANAGEMENT SYSTEM

2.1. LEARNING CONTENT MANAGEMENT SYSTEMS REQUIREMENTS-BASIC REQUIREMENTS

Basic requirements [11] to the Learning Content Management Systems are extensibility, granularity, usability and scalability . They are used in the process of LCMS deign .

A common definition of Learning Content Management System proposed by Maish Nichani in his paper [3] is following:

$$LCMS = LMS + CMS[RLO].$$

where LCMS is Learning Content Management System, LMS is Learning Management System , CMS is content Management Systems and RLO is Reusable Learning Object. Aim of RLOs is to present leaning content in the form of little independent pieces and this way leaning materials can be combined in appropriate context according to users' requirements and needs of education LMSs have to provide support for the following operations: development and delivery of course catalog, registration and management of users' accounts, assessment of students performance, score reports and support for different tools for synchronous and asynchronous communication. Content Management Systems have to allow creation, editing, approval, publishing and storage of content. On the base of combination of its capabilities, a LCMS has to offer, not only the management of the entire learning process, but the following functionalities also:

- Creation of learning content
- Storage of learning content
- Editing of learning content
- Management and delivery of learning content in different formats

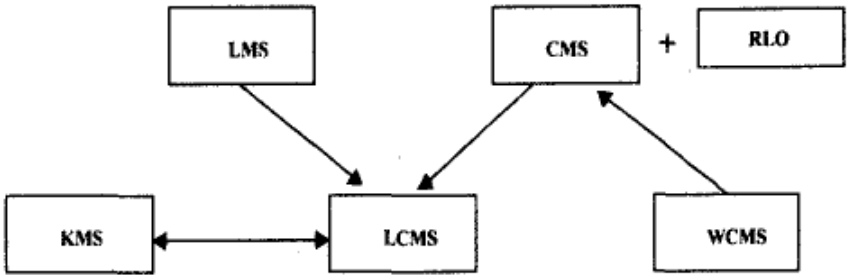

Fig.1 Types of learning systems

3. DEVELOPED MODELS

In the paper a model for delivery of learning content is developed on the base of main components of e-learning and knowledge management proposed by IMS Global Consortium: learning environment, learning components, learning objects structure, information object description and content assets as text, video, audio etc.

First the general model by IMS will be presented.

ID-based Learning Content Model is proposed by IMS Global Learning Consortium[8]. Learning environment is defined by its components, used databases and communications. Courses, curriculum and competencies are learning components of the model and each learning object is defined as a combination of objective, practice and assessments. Each information object describes different concepts, principles and procedure in a separate knowledge domain. Content asset in the terms of multimedia is described as a mix of text, video, audio and so on. All described components have to be managed by a Knowledge Management System and with addition of communications and databases that store them they provide e-learning. Dividing the entire e-learning system in small parts allows high reusability of its components to be achieved. This way flexibility and adaptability of learning materials is gained. Purpose of separation of courses in learning objects as combination of information objects and at the end as content assets is to increase reusability and adaptability of learning content. But in the basic model it is not clear how that reusability can be provided and supported. A proposal how necessary level of flexibility can be achieved is given in the developed modified model. Most important question is how all these small and independent parts to be gathered and managed. For this purpose domain ontologies can be used and this approach is presented in modified learning content model.

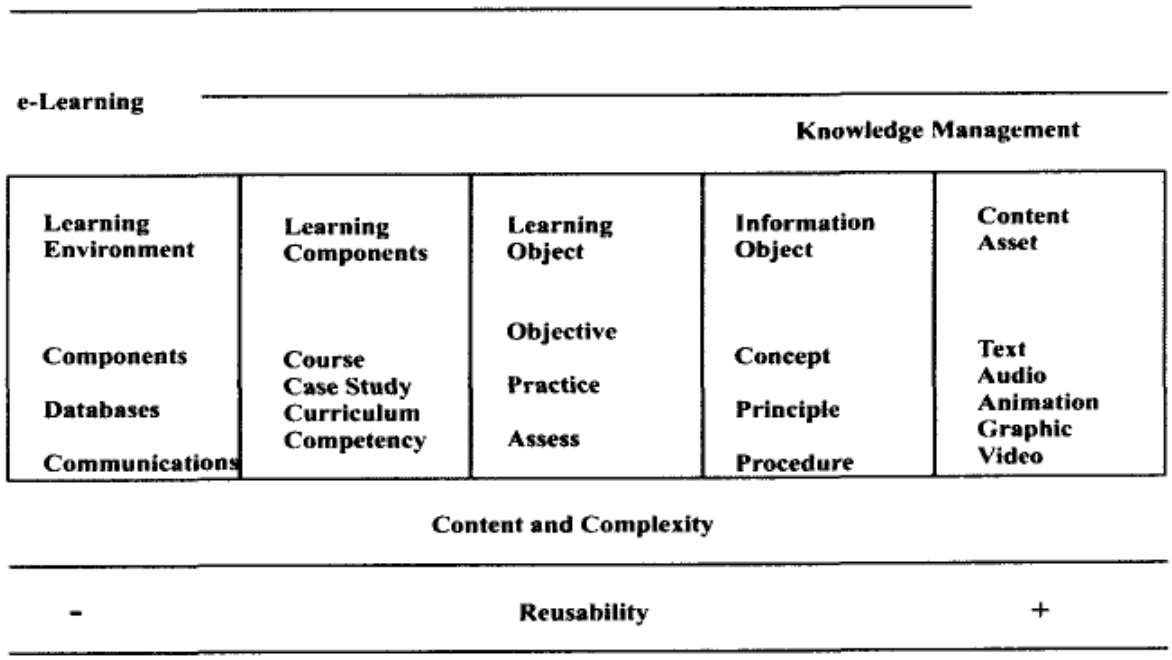

Fig.2 Types of learning systems

We improved the IMS model by replacing learning components with domain ontology concepts, relationships and rules in order to develop dynamic courses that reflect learners' preferences defined in learners profiles. The resulting improved model is presented in the next section.

For the purpose of this paper ID-based Learning Content Model has been modified. That modification replaces the learning components in the IMS model with domain ontology that is used in LCMS design.

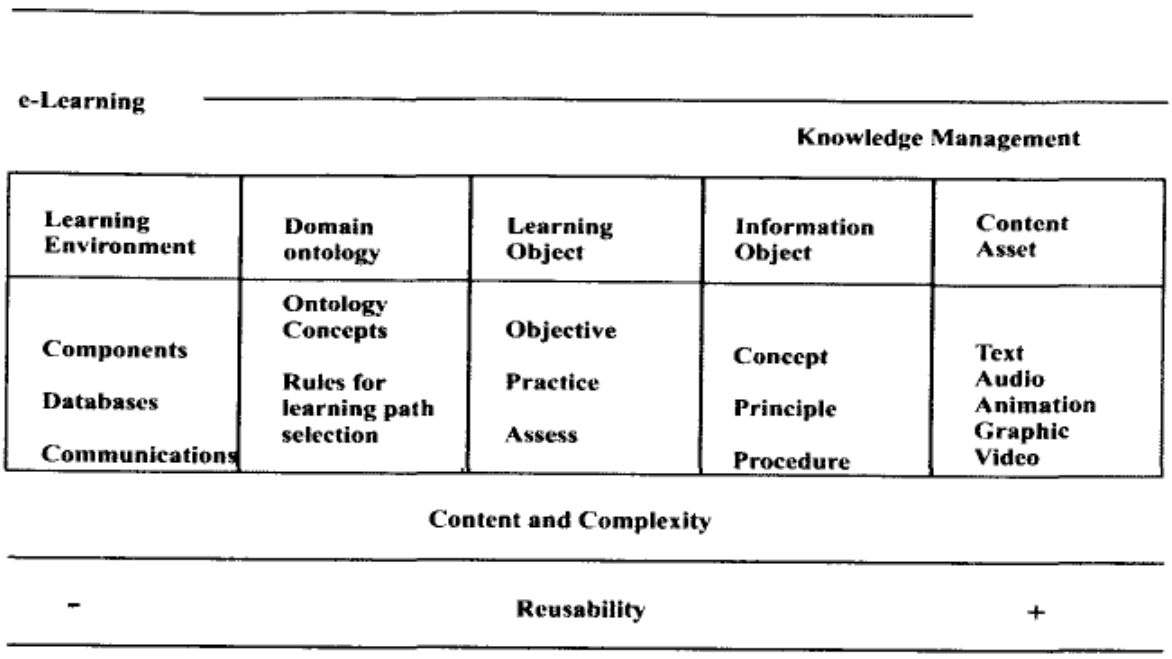

Fig.3 Modified Learning Content Model

Proposed modification allows elements of the learning materials to be organized in a hierarchical way in an subject domain ontology of concepts and learning objects to present information for each concept. Ontology elements allow very detailed level of learning content representation to be achieved. Each concept could be implemented as independent small part of learning content and it could be delivered with other parts of learning content in different contexts according to learners' preferences and needs of education. For this purpose technology of Reusable Learning Objects (RLO) can be used. Generated this way learning content could be searched, used in flexible form and different.

Relationships among concepts and rules are used for combination of different learning objects in different leaning paths produces on the base of learning style preferences and leaner characteristics.

The model proposed demonstrates how advantages of LO could be applied when domain ontology is used to describe basic concepts of subject matter and rules for learning path selection allow small and independent part of leaning content to be combined on the base of defined relationships among them and rules defined by subject domain expert and domain ontology specialist.

The proposed modification is necessary because in the IMS learning content model it is not specified how courses will be created. Often and very important problem in the field of e-learning is development of static content which does not

allow learning materials to be used in flexible and adaptive to learner preferences manner. That is why it is proposed in that section of learning components in IMS learning model to be used domain ontologies that allow basic concepts of subject domain to be defined and described. Thus it is possible to be created metadata for each learning resource and learning resource characteristics to be compared to users' profiles and preferences and learning paths for content processing to be dynamically generated.

Described technology allows flexible learning courses to be created and proposed learning content to be most appropriate one for learning background, previous experience, level of expertise and needs of new knowledge and skills of a separate user.

4. IMPLEMENTATION OF UML DIAGRAMS IN LCMS CHARACTERISTICS DEFINITION

4.1. PHASES OF UNIFIED PROCESS

Systematic process of software development, according to UP methodology, has the following phases: analysis of gathered users' requirements, design of software system, planning of process of development, implementation, testing and evaluation of developed system. Four phases of Unified process have been followed to define and analyze users' requirements and to design LCMS according to them: inception, elaboration, construction and transition [1].

In the phase of inception [2] it is conducted identification of components of the system and needed functionality is discussed with subject matter expert. For this paper main users of the Learning Content Management System are defined: student, teacher, administrator and content developer. Necessary functionality is defined on the base of LCMS characteristics- management of learning process like users profile manipulation and features for creation, storage and delivery of learning content. In the phase of the elaboration a detailed design of subsystems and objects related to system is performed. For this purpose UML diagrams are used and they are presented in next section of the paper. In construction phase the program code has to be written. In transition phase delivery of system is conducted and it is not discussed in the paper.

The model proposed allow created learning materials in the form of LOs to be organized by domain ontology and on the base of defined rules and relations among them to be executed processes of dynamic learning content delivery. For this purpose a prototype of user interface that allow LO to be developed, edited and deleted and users characteristics to be defined, is developed. Thus adaptive and flexible leaning courses can be offered and delivered by designed LCSM.

Tools for modeling of learning systems and their advantages and disadvantages are very important for the process of design. When a software tool has to be chosen

following factors influence on the decision- cost, features, scalability, and hardware platform.

Other features that are overviewed in the process of tools selection are support for the whole set of standard UML diagrams, easy navigation, multi-user support, facilities for code generation, integration with other tools. It has been conducted tools analysis according to listed criteria. Three of the most popular and common used UML tools have been analyzed.

MS Visio [4] allows different elements like classes, objects, activities and states to be created and exchanged among diagrams by drag and drop technique and it is well integrated with other application of Microsoft Office. Rational Rose [9] allows reverse engineering to be used and gives capabilities for classes and objects management and produced that way elements to be stored in a repository and change in one diagrams to affect others. Poseidon [10] visualizes systems, communicates effectively about architecture and code and allow documentation of users' requirements to be done. The tool uses reverse engineering to get a visual model of existing code and allows the model to be previewed and code to be edited within Poseidon itself. Other capabilities are to export diagrams and document requirements with UMLdoc and collaborate through standards-compliant export to XMI.

All these features are available in analyzed three most popular UML tools - MS Visio, Rational Rose and Poseidon but most powerful one and most integrated with other external tools is Microsoft Visio because it offers easy for use and intuitive GUI and for this reason it is selected for system design.

4.2. DESCRIPTION OF PROPESED MODEL USING UML DIAGRRAMS

In the process of Learning Content Management System design different types of UML diagrams will be used. UML (Unified Modeling Language) was developed in 1994 [5]. Its purpose is to support Unified Process. UML is very appropriate when a system design have to be developed and system has to be defined in different points of view. [7]

Used UML diagrams are very useful for definition of different parts of the designed LCMS and relationships among them and their place in the entire system. Different types of UML diagrams allow states and processes inside the system and interfaces that students use to exchange information with the system to be decribed.

Use case diagram is used to describe main participants and the entire system architecture and relationships among them - LCMS and processes like registration of users with their characteristics like professional background, level of competence in subject domain, needs of education and preferred learning styles on one hand and content development as RLOs and capabilities for their editing, updating and deletion so proposed information to be accurate and up-to-date on the other. Another functionality is grades recording for assessment of learners performance. Main participants in the learning process are defined in their different roles: teacher, student, administrator and content developer according to their duties and responsibilities..

The most important relation is interaction of learning content developer that creates and edits learning materials as LOs and dynamic generated courses could be used by teachers and students as it is proposed in developed learning content model. Class diagrams are used to define user class (main participants in the system) with their attributes (characteristics) and operations (relationships with other classes and subcalsses). It can be used generalization to summarize common characteristics like it is shown on Diagram 1.

In this paper there is a class "User " with following attributes : username and password and other personal characteristics -name, e-mail address and so on.

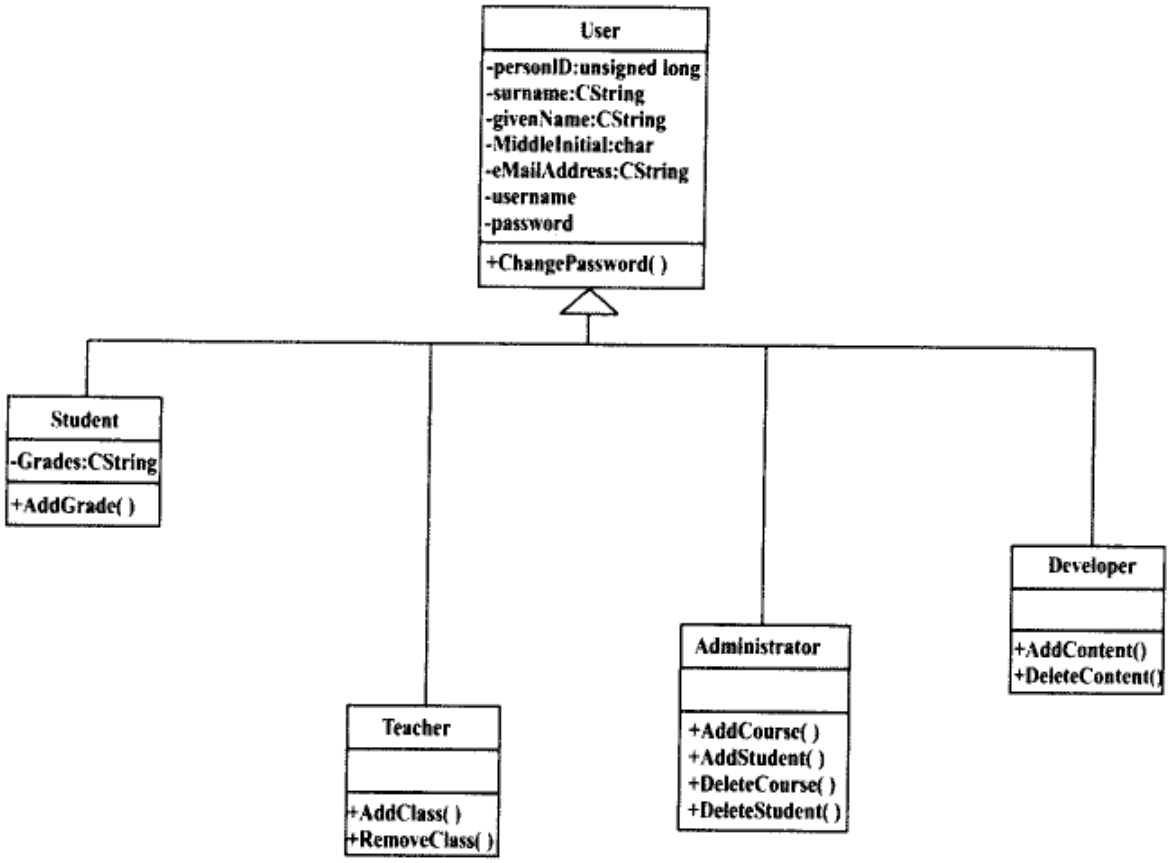

Diagram 1. User class and its generalized subclasses – student, teacher, developer and administrator with their common and specific attributes and operations

Class diagram is used to define attributes and operation for each class- teacher, student, administrator, developers. Each of them has username and password. Entities of teacher subclass has classes that have to be taught as attribute and operations for adding and removing classes. Student subclass has grades. Relationships between teacher, student and classes (courses) are defined by name of the association (user role) and multiplicity (1:1,1:M, N:M).

Databases that will be used are described with composition and generalization and types of learning content are defined as aggregation of text, video, audio and graphic components. That way it is applied recommendation of the proposed model learning resources to be created in different formats so they can be used in different

contexts and that way to allow users with disabilities to have access to the proposed learning materials.

Diagrams of interaction like sequence and collaboration diagrams are used to describe messages that are sent between users and different parts of the system : database, learning objects repository (LOR), web interface and log files. They represent interactivity and communication among different parts presented in the first section of proposed model- learning environment with its databases, different types of communication among participant and LCMS components and subsystems - web interface, LOR and learning materials.

Another requirement to advanced LCMS is to deliver high quality learning content. For this purpose a view of systematic process of creation and publishing of learning content is presented to assure the necessary quality. Activity diagram on Diagram 2 defines the process of learning content submitting. For this purpose developed content should be created and after the process of approval it has to be published or edited. The processes described should be supported by each LCMS and diagram represents the flow of processes that should be implemented for development of high quality learning content.

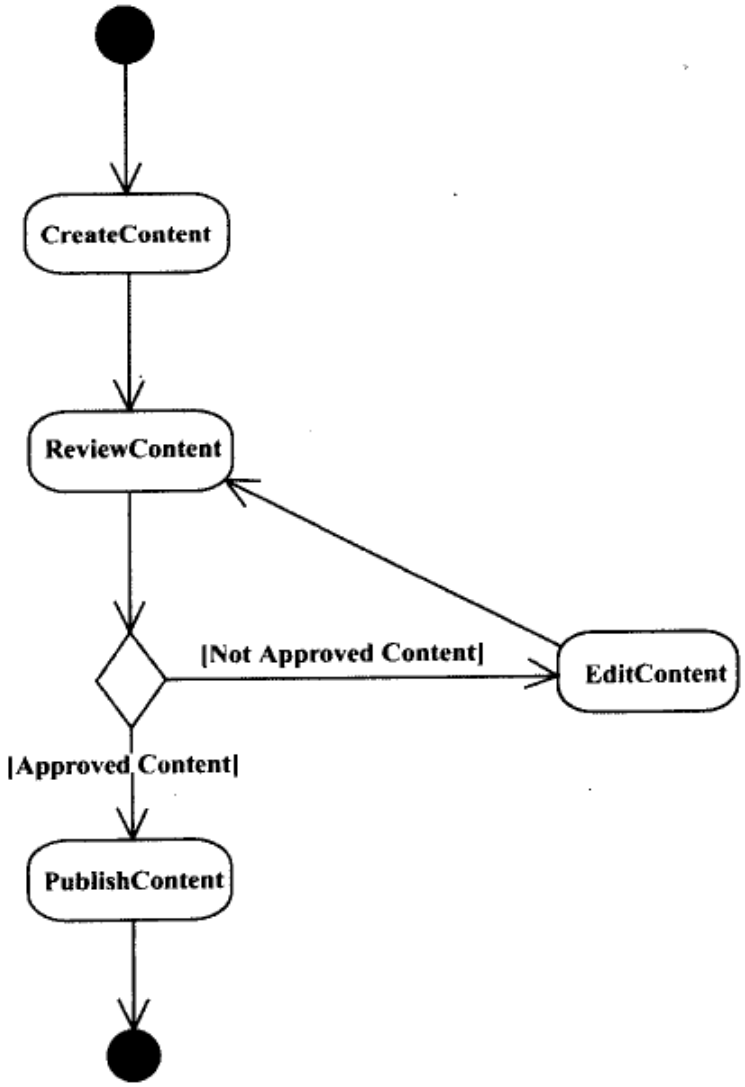

Diagram 2. Activity diagram describes processes related to content management.

Proper navigation is critical for effective education. It allows users to interact with different components of LCMS and with learning content. This way needed flexibility and adaptability are achieved. State chart diagram shown on Diagram 3 represents system menu and possibilities for navigation. It allows different users to manipulate with system components so they can execute their duties and fully used systems features and supported capabilities.

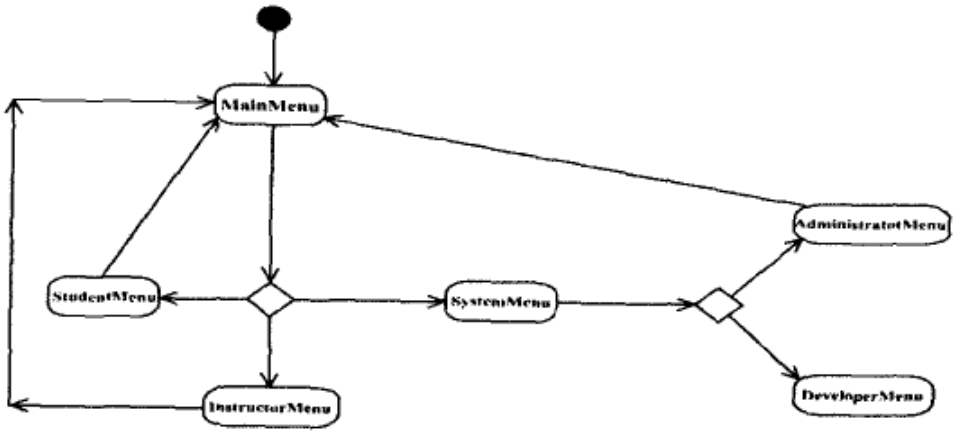

Diagram 3. Statechart diagram defines system menu

Following the proposed model a prototype of user interface has been developed that will provide support for LOs manipulation. The main functionalities related to learning content creation, arrangement and publishing are included in proposed menu of user interface. A menu that will be used by content developer is presented in Fig. 4 and in Fig. 5 – a menu that facilitates activities related to learning process management: creation, editing and deletion of courses and students.

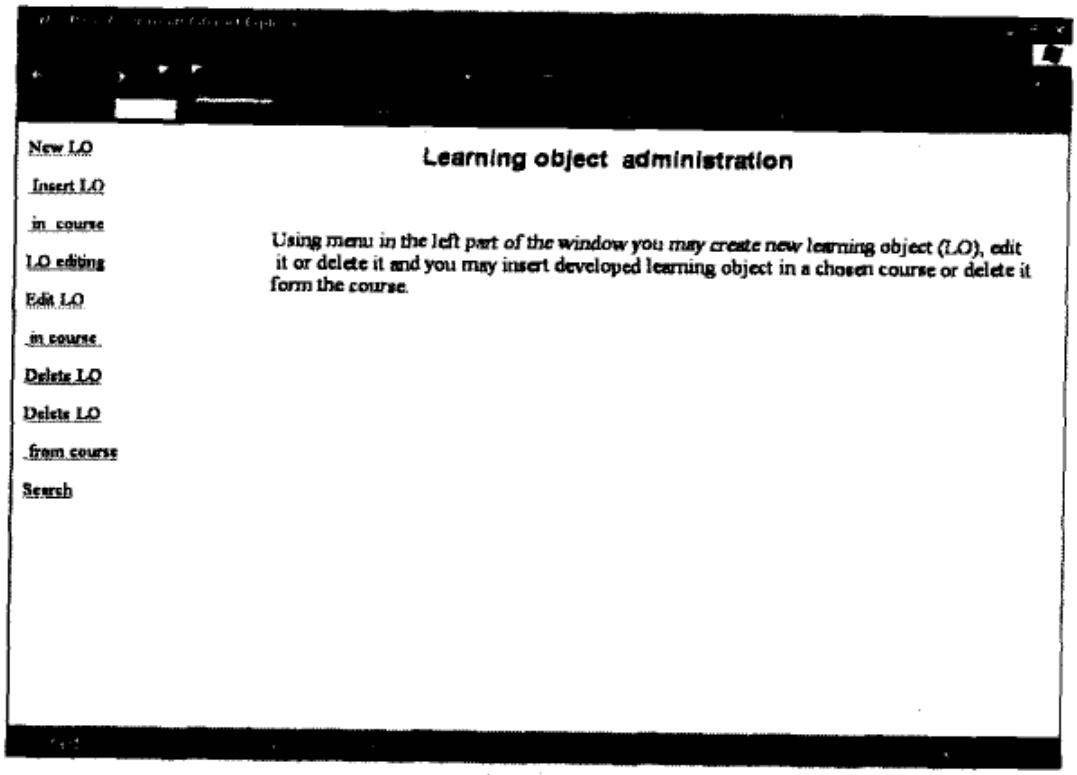

Fig. 4. Developer menu.

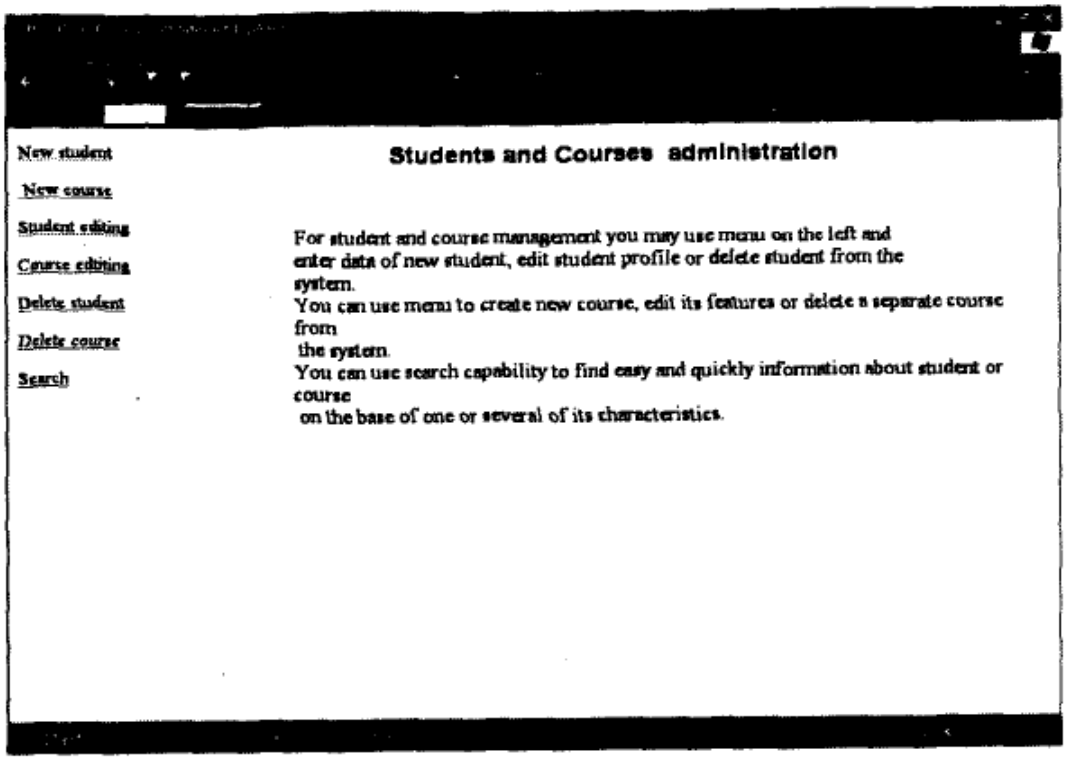

Fig.5 Administrator menu.

5. CONCLUSION

In this paper new learning content model is presented and discussed. Unified Process is applied to design a system that supports the model proposed. Modifications and advantages of developed model and their implementation in designed system are described by UML diagrams because UML is defined as the most appropriate and useful tool that has to be used in all phases of the UP. The conducted analysis of existing software tools for systems design and development of UML diagrams is presented.

A prototype system is designed following the UP methodology. Well designed systems that cover users' requirements and offer expected and necessary functionalities are critical components for effective education.

Different types of static and dynamic diagrams help system design to be executed so precisely and accurate defining of processes, states and relationships of system components and user interfaces to be gained. UML diagrams are used to describe proposed modified model and to document basic and users requirement to advanced LCMS. Learning Content Management System has to offer many functionalities and its parts, participant and communications among them can be well described and presented to users of the system and developers. Thus high quality of developed system and proper documentation for future improvements is achieved. Developed learning content model presents the idea of domain ontology use in

learning objects management and description and how they can facilitate delivery of flexible and adaptive learning materials which is one of the most important tasks of advanced e-leaning. For providing described functionalities it is developed appropriate user interface.

Future work will be related to design and development of learning systems that support high interactivity with delivered learning materials, easy and useful collaboration among participants in the learning process and development and management of dynamic, reusable , flexible and adaptive learning content which can be used in different contexts according to learners needs of education. Another filed for future research is development of new models for learning content manipulation and implementation of learning systems that support proposed models.

REFERENCES

1. Arlow J., Neustadt Il., UML and the unified process: Practical Object-Oriented analysis and design, Pearson Education, 2002 ISBN 0201 770601
2. Ambler Sc. W., Constantino L., L The Unified Process Inception Phase, CMP book, 2000, 0103648841
3. Learning Content Management System http://www.elearningpost.com/features/archives/002084.asp
4. Microsoft Visio http://www.microsoft.com/office/visio
5. OMG http://www.omg.org
6. Jacobson Iv., Booch G., Rumbaugh J., The Unified Software Development Process, 1999,Addison Wesley Longman, Inc.
7. Roff, J. T. UML: A beginner's guide, McGraw-Hill/ Osborn, 2003
8. IMS specification http://www.imsglobal.org
9. Rational Rose http://www.rational.com
10. Poseidon software http://www.gentleware.com/
11. Pressman, R., Software Engineering - A Practitioner's Approach, McGraw-Hill, 1982

Received on January 22, 2006

Faculty of Mathematics and Informatics
"St. Kl. Ohridski" University of Sofia
5, J. Bourchier blvd., 1164 Sofia
BULGARIA
E-mail: cornelia@fmi.uni-sofia.bg