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COMPONENT-BASED APPROACH IN LEARNING MANAGEMENT SYSTEM DEVELOPMENT

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ABSTRACT

The paper describes component-based approach (CBA) for learning management system development. Learning object as components of e-learning courses and their metadata is considered. The architecture of learning management system based on CBA being developed in Riga Technical University, namely its architecture, elements and possibilities are described. Modern technologies used for implementation of the systems are outlined.

KEYWORDS

Component-based approach, learning management system, technologies

1. INTRODUCTION

The problem of providing a high quality learning and teaching process is becoming more actual since distance education, open education and life-long learning are very popular and useful forms of enhancing education. The availability of the new software technologies possibilities opens the doors to everyone who wants to be involved in the process of developing e-courses. Many scientists work on the technologies and methods of adaptive learning [Oppermann R. et al, 1997; Wey Chen J., 2010; Zaitseva L., Bule C., 2011], models [Bule J., Zaitseva L., 2007; Tsinakos A., 2010; Heineman G.T., Councill W.T., 2001; Scorm, 2013] and standards [LOM, 2002.; LTSA, 2003]. Different learning management systems and portals [eCollege, 2013; Edmodo, 2013; Moodle, 2013; WeBWork, 2013], specialized and universal learning systems [Coursera, 2013; eFront, 2013; Edutools, 2013] are being created and broadly used. Considering such a variety of developed and a huge open-sourcing it is convenient and appropriate to utilize a reusability feature, i.e., apply component-based approach of software engineering to an e-course development.

The aim of the paper is to describe a learning management system development process taking into account component-based approach principles. The following section shows learning objects as the main components of an e-course. The third chapter reviews learning management system architecture. The last chapter outlines the technologies used to implement the described system.

2. COMPONENT-BASED APPROACH TO SOFTWARE DEVELOPMENT

Component-based engineering [Heineman G.T., Councill W.T., 2001] is one of the trends of the software engineering. This approach supposes that software systems are assembled from reusable components (RC). These components are developed earlier and saved in a repository of RC. Then they are used for new system's development. Component-based approach (CBA) also can be successfully applied for learning management system (LMS) and e-learning courses as basic elements of LMS development.

E-learning course is a set of learning objects (LO) implemented using modern computer technologies and consolidated into a scenario that is created to organize a learning process of a definite topic of a subject by student or students' group (Collaborative learning).

Thus, LOs are reusable components of an e-learning course. Learning objects can be of two types: learning object information (LOI) and learning object task (LOT). LOI describes theoretical information of a course – different concepts, examples, etc. LOT is used for knowledge control and/or training during

acquisition of a course. LO has a complex structure and can be not just of various types (LOI and LOT), but also of different kinds and parts within a type. Both for LOI and LOT the kinds are the same since a LOT is supposed to be used to evaluate knowledge and/or skill level on a definite LOI. So, the kinds are as follows: structure, definition, example and rule [Zaitseva L.V. et al, 1989], – depending on what exactly is being described in a LOI. As well there can be various parts for each LO:

- LOI – main, example, explanation. Example and explanation are optional LOIs of different detailing level;
- LOT – two parts: general task and individual task. The general task is the same for all students and individual task is generated for each student separately to specify a general task. Every LOT according to a type has one or several answers, which are also referred as separate LO – LOA. As well there can be included comments for LOTs in general and every LOA particularly – LOC as well of different detailing level.

In addition to LO's complexity there is a list of metadata that should be considered while developing an e-course. The full list of LOs metadata is available in IEEE standard [LOM, 2002]. It is evident that all the data is required to implement an e-course of high quality, but there is always more critical data that should be taken into account for different purposes (Table 1).

Table 1. LOs metadata

LO metadata	Purpose	Description
LO title, description, language, platform, keyword, coverage/topic, type (LOI – main, example, explanation), specialty, program (study level – bachelor, master, college, etc.), purpose, copyright, restrictions	The initial list of reusable LOs to be included into an e-course	The main criteria to choose from the list of LOs available in repository
LO significance, mode of using (control, training), number of tries (LOT), time (acquisition – LOI or performing – LOT), type (LOI – main, example, explanation), difficulty	Possible minor modifications to adapt for an e-course	Means just adaptation of the parameters, not exactly modifications of LO itself
LO representation (media), LOT's type (multiple choice, word, number, etc. [Zaitseva L. et al, 2005]), language	Possible major modifications to adapt for an e-course	It is consider as a major modifications, if changing of media or translation is involved
LOI kind (definition, example, rule, structure), purpose, topic, LOT's type	Decision on developing new LOs	In the case when there are no LOs of specific kind or on definite topic of a course, or there are just one-type LOTs

As it was mentioned earlier, LOs are components of an e-course side by side with different processing programs/modules. Thus, to apply component-based approach for LMS and e-learning course (ELC) development repositories of learning objects and program components are necessary.

3. LEARNING MANAGEMENT SYSTEM ARCHTECTURE

Different classes of users can use LMS. They are: student, tutor, e-learning courses author (ELCA), administrator, operator, but basic classes of users are first three. That's why to present the architecture of LMS (Fig. 1) we selected only three agents. LMS also has a main program module (kernel of a system) that provides users identification and connection to specified agent, a unified interface for all agents, organization and maintaining of connection session, repository and databases maintaining, etc.

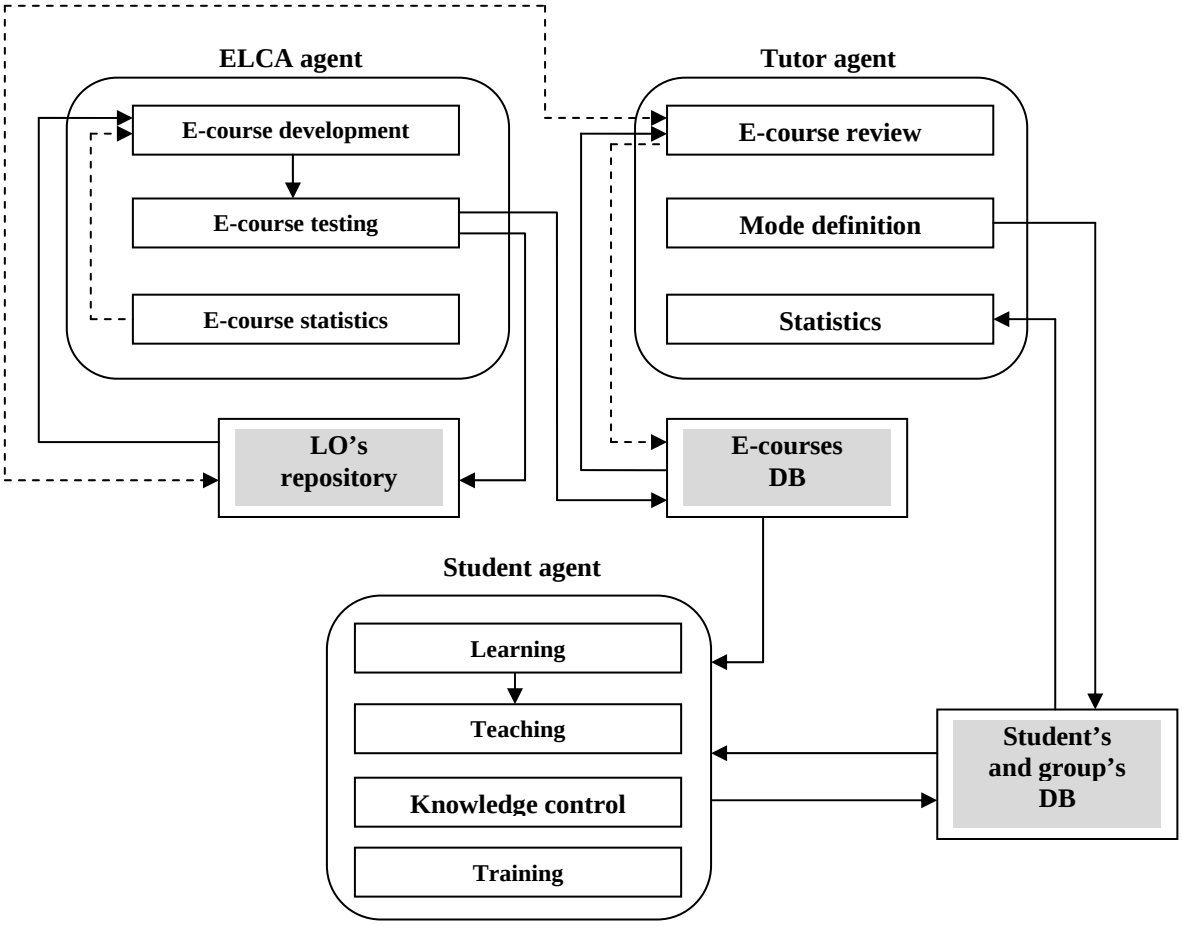

Figure 1. Learning management system architecture

Learning objects and their metadata are saved in LO's repository and can be used by ELC author to develop e-learning course. Developed and tested ELC is saved in e-course's database. A tutor after reviewing offers it to students and/or groups of students. Students can use e-learning course for learning, teaching, knowledge control or training. Student's and group's database includes information about students and groups of students, as well as a protocol describing a work with e-course.

The main functions provided by **ELCA agent** are e-learning course development and testing. A process of an e-course development based on CBA consists of the five stages: 1) define a goal and objectives of the e-course; 2) develop the e-course scenario using information about LOs and their metadata saved in a repository. Usually a scenario of an e-course is represented as a graph with LOs as vertexes and edges show the connections types between them [Zaitseva L., Bule C., 2011]; 3) select necessary learning objects from a repository and check them. An analysis and reviewing of the selected learning objects is performed during this stage to find out whether they fully correspond to the goal and objectives of the e-course, as well as to make a decision on each LO: to use it with no modifications; edit it adapting to the e-course requirements; develop fully new LO(-s); 4) modify the selected LOs, develop new LOs and test them. Modifications can be as follows: add new information to LO, remove unnecessary information according to the e-course author and/or represent existing information by means of other media; 5) integrate LOs into the e-course according to the scenario developed in the stage 2. The next step is testing of the e-course in general. Afterwards it is placed into e-course's DB. If during and ELC development the new LOs were created or modified the existing ones, author can save them in a repository.

The function „E-course statistics" allows author to get information about students work with ELC. After analyzing it author can improve a quality of an e-course by making some modifications, for example, adding more detailed representation of learning information with new examples or specifying a text of a task.

The **Tutor agent** provides the following functions:

- E-course review. Before making an ELC available for students tutor has to test it and evlauate it's correspondance to goals and tasks of a subject taught as well to make a decision on expoliting it without any modifications or make some amendments, for example, add more examples, questions and/or tasks. In the last case a copy of an e-course with tutor made changes is saved in e-course's DB.
- Mode definition. Depending on a chosen strategy of an ELC using [Zaitseva L., Bule C., 2011] tutor can set paramateres of a course exploiting that are usually specified for a group of students. For example, an ELC is supposed to be used for totally unassisted learning, training or knowledge control. For knowledge control (KC) it is possible to determine KC method, a number and difficulty levels of tasks, etc. [Zaitseva L.V. et al, 1989].
- Statistics. This function allows a tutor the possibility to get the detailed information about student work results.

The **Student agent** ensures a work in four modes for students:

- Learning. This mode gives student a possibility to learn independently any course that is available in e-courses' DB, using Teaching, Knowledge control and/or Training.
- Teaching. The mode provides an e-course teaching that was assigned by a tutor according to developed scenario.
- Knowledge control (KC) is used to test and evaluate students' knowledge and skills level. If the mode is assigned by tutor, a student answers questions and performs tasks according to set control parameters. If the KC is chosen by student to test own knowledge and skilss level (self-control) then he/she can choose as well a number of tasks, difficulty level and detailing of comments.
- Training is supposed for mastering skills on tasks solving on chosen or assigned by tutor topic. In this case it is the best practice to provide detailed comments on every student action.

Learning management system includes also various supplementary program components (modules) to ensure learning and teaching functions, namely: module for choosing tasks from similar ones to ensure that students get different questions during learning process; module for generating input data and calculating results while tasks performing and solving calculation assignments and others.

4. TECHNOLOGIES FOR LEARNING MANAGEMENT SYSTEM IMPLEMENTATION

Considering complexity of e-learning system architecture, it is implemented based on a multi-layer structure, which is standard for modern business software. System itself is based on web technologies since it is the most efficient way to deliver content. As well they have developed dramatically recently and allow simple processing of all kinds of information used in e-learning process. Client side is a browser-based user interface with all functionality needed to show all e-learning components for user, while server side contains all processing logic and databases/repositories.

Client side realized by using current web technology standard: Ajax, which allows dynamically changing content depending on input and reducing processing requirements on server, and considering increased requirements for security, Secure Socket Layer (HTTPS protocol) is a "must have" technology. To design user-friendly interface (UI) cross-browser integration framework should be used – jQuery [jQuery, 2013], Prototype/Scriptaculous [Prototype, 2013; Scriptaculous, 2013], MooTools [MooTools, 2013], Dojo [Dojo, 2013]. One of the most optimal frameworks for client side is MooTools, which ensures such an UI rendering that it looks the same on every popular browser currently on market.

Server side implements business logic and DBMS system. Considering a length of a life-cycle of software, five to seven years, technologies used in business logic implementation must be solid, i.e., have long history of support and without major changes in syntax through version history and with a big enough community of developers, like Java, .Net, PHP. Therefore server side logic is performed on Java, which has efficient integrated environments also there are a lot of frameworks available. As well one of the advantages is that almost everything is for free, so development costs are highly reduced. Taking into account that OSGi container [OSGi, 2013] is used for different modules, the GlassFish Java server [GlassFish, 2013] was chosen for providing a performance of LMS. OSGI allows separating some logic and functionality, and also dynamically adding new content to server.

To ensure data storage in repositories DBMS PostgreSQL is employed since it it's free, open-source, highly customizable and has powerful tools for data managing and processing inside database [PostgreSQL, 2013].

5. CONCLUSION

The component-based approach to develop learning management system allows reducing time and other resources consumption. Since this approach is based on the reusable components using to create a new product it also facilitates the whole process. In case of LMS implementation the benefits of CBA are for both the system itself and e-courses that are developed in it. Thanks to it and used technologies (OSGi) existing modules can be easily modified and the new ones added, and the same situation is with learning objects from available repositories that are treated as components for an e-course.

As further work we plan to enhance the existing LMS by using modern technologies as well to transfer already developed e-learning courses into the improved learning management system.

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