In Search of a Smile: SMIL Indexing System for Multimedia Learning

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***Abstract* — In today's world of education, new methods and services are appearing every day. This paper proposes the usage of educational material "mashup", created in SMIL (Synchronized Multimedia Integration Language) format. A multi-user Web application for indexing and sharing SMIL presentations is described. Presentations, located on remote servers, are fetched using different protocols, analyzed and indexed using a full-text search method. Each result gives not only "the place" but also "the time" of spoken word or phrase in the course. Afterwards, the lectures can be grouped based on their content, shared and combined together into personalized Search boxes for specific courses. The placement of Search boxes on any course Web page or LMS is done by client-side technologies, which eliminates tweaking of learning systems and usage of server-side programming. An example of usage at the University of Zagreb, Faculty of Electrical Engineering and Computing is described, together with the research results obtained.**

***Index Terms* — distributed content, e-learning, indexing, multimedia, searching, SMIL**

I. INTRODUCTION

The world of learning and education is dramatically changing during the last few years. Methods and tools, which started from "conservative" CBT (Computer Based Training), moving on to Internet and Learning Managements Systems, nowadays set off to explore the usage of "Web 2.0" *buzzword*. Knowledge is being built in social networks, communities and public encyclopedias such as *Wikipedia*. *Blogs* and *podcasts* are being used as educational methods. "*Mashups*" – Web sites which combine and integrate content from more than one source create a new experience for a learner and a teacher. The need to create "your own" teaching material is slowly fading, while the skills of searching and integrating the knowledge freely available on the Internet become extremely important for both teachers and students.

Depending on the environment, it is still necessary to have a kind of conventional lecture form, which can usually be accessed online. Different methods are available for authoring of such lectures, based on their final purpose. A format proposed in this paper is SMIL [1] (Synchronized Multimedia Integration Language) - XML-based W3C Recommendation for choreographing multimedia presentations over the Internet, where audio, video, text and graphics are combined in real time. This open standardized language offers a thorough spatial and temporal control of presentation properties. Together with the features such as bandwidth control, animation techniques, multilingual support, user interactivity, accessibility and easy adjustment to user's context, it is a good solution for delivering e-learning multimedia lectures.

In today's world of knowledge, one of the key questions regarding the e-learning content is how to index, search and integrate knowledge. Teachers and students are faced with an enormous amount of information, appearing everywhere around them. Different companies are putting a lot of energy in analyzing and indexing media, for example the MARVel project [2]. Keeping in mind SMIL format specifics, especially the timing control, A Web application for distributed indexing/searching is designed and created. The indexing system is based on a full-text search method, which analyzes the entire presentation flow, together with all the associated text files, thus giving students and teachers the opportunity not only to find "where", but also "when" the desired information appeared.

This system supports the idea of Web 2.0 *mashups*, by enabling teachers to include other authors' lectures developed in SMIL in their own teaching activities. Such approach helps teachers from the same university or school to build together their educational content and decrease redundancy, but can also enable knowledge sharing between teachers who believe in open educational resources (such as MIT OpenCourseWare project [3]).

II. SMIL MULTIMEDIA LECTURES

Ease of use and a possibility to design a new set of tags provides an opportunity to create many specialized standards based on XML (eXtensible Markup Language), such as SVG (vector graphic), GML (geography) or MathML (mathematical expressions). One such markup language is SMIL, a format based on XML. When using SMIL, author is supposed to prepare the media (such as images, slides, audio/video, text, links) in advance. SMIL file consists mainly of region definition (spatial layout for different media) and detailed temporal control of playing the media (sequential and parallel delivery, absolute and relative start/end).

Interpretation of a SMIL file and chronological tree creation comprise the presentation delivery. Audio and video files are accessed either from a Web server, or from a specialized streaming server using protocols such as RTSP, which provide a much better user experience. The process of presentation delivery is shown in Fig. 1.

New SMIL specifications offer some advanced possibilities beyond basic media playing. Authors can create user interactivity elements, such as internal navigation or selection of the next presentation. New specifications also support content switching based on many different parameters (preferred language, display resolution, operating system, network bandwidth, etc.).

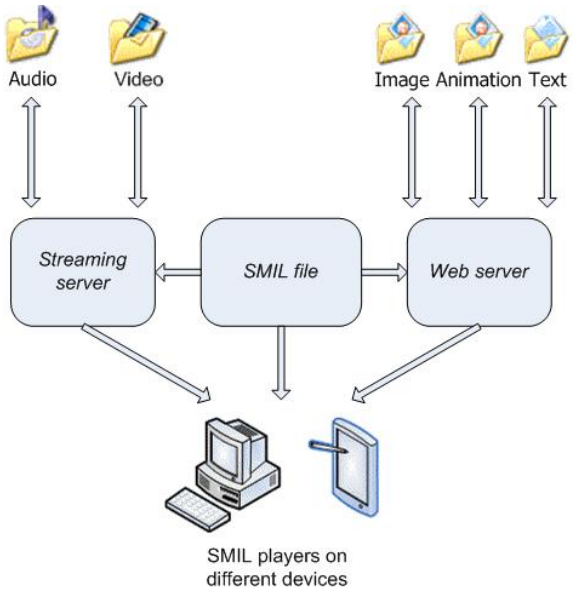

Figure 1. SMIL presentation delivery

This kind of decision making ensures better user experience. Courses which are international but offered in only one language can be easily translated to the mother tongue of the students. SMIL format is also recommended as a means of creating accessible content, as explained in Techniques for Web Content Accessibility Guidelines [4].

SMIL format can be successfully used in creating e-learning content intended for later use, as shown in Fig. 2. Live lectures can be recorded once, either with audio only, or with a full video. Audio and video are integrated with slides or images shown in a lecture, supplemented with other media. Additional content can be created in formats such as HTML or PDF, and put on the course Web server, or important links to Internet resources can be proposed for more in-depth learning. Captioning is provided as a translation to different languages and to help people with special needs [5], but also for another important purpose: full-text presentation indexing.

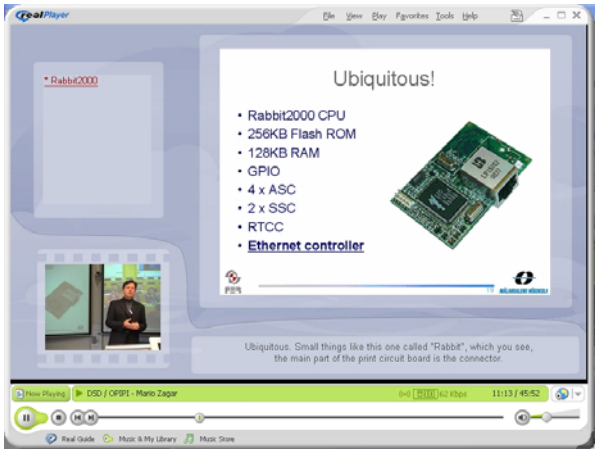

Figure 2. A lecture with different elements

III. INDEXING SYSTEM

A. *The concept*

It is always appropriate and recommended to split the learning content into smaller chunks to ensure better understanding of a lesson and keep the concentration on a suitable level. However, even if desired information is structured into a 10-minute lesson, it can still be hard to find it in a multimedia presentation. Using SMIL format specifics the analysis of which in most cases defines the exact time when an element appeared, the desired information can be found in a click of a mouse.

In designing this system, full-text search method has been used. SMIL file format itself, text/XML, allows access and indexing from "outside" applications, while Flash, one of SMIL proprietary alternatives stores the data in binary form and direct indexing is not available.

Let's take a look at two parts of the system from teacher's (administrator) and student's (user) side.

B. *Teacher's experience*

The administrator side is used for submitting/editing the content and managing personalized search boxes. Since the system is designed as an open Web application, each author (teacher, teaching assistant) can create his/her account and have administrator permissions for the content. After creating an account, the user is offered two possibilities: managing the content or managing the personalized search boxes.

Contents

A content defines sets of SMIL presentations that a teacher submitted for indexing and searching. Every content item can consist of one or more folders located on a server, which a teacher would like to index. The content is not dependant on search boxes and can be added to the system without any limitations.

A content item can be either public or private. If a content is marked as public, it is available to all the teachers. In this way, teachers can include public lectures from other universities, which are relevant to their course. Exposing students to different knowledge sources proves to be very important, especially in our, IT profession.

On the Contents page, users can view and edit SMIL content already submitted to the system, or submit a new one, like in the Fig 3., which shows the list of submitted content.

Figure 3. Submitted content

Different protocols can be used to access the presentations on remote servers, depending on the availability: HTTP, WebDAV or SFTP. When the content is created or edited, the system automatically connects to the server and shows the server directory tree to select the content for indexing.

Personalized Search boxes

Different content put together for use in a course is called a Search box. A teacher can decide which content should be available in the box, which is especially suitable for educational purposes, as the selected content can be different for each course. In addition, this approach enables content inclusion from other, related courses. This information is encrypted in order to deny access to the box from other pages and to keep private content from being "stolen". Teachers can adjust the search box color set to fit the design of the page in which the box will be included.

Once a search box is created, the teacher is given a small HTML code snippet to include dynamically created JavaScript using PHP. It can be inserted in any of the course pages, such as a special course search page, any of the content pages, a course page in LMS, etc. An example of the search box is shown in Fig. 4.

The reasons for using this method are security measures regarding fetching the data across domains. The most elegant way for communicating with the search engine would be the use of XMLHttpRequest (the base of Ajax applications), but at this time it is not possible to use this object as a means of communication to a remote server in a pure way. After analysis of different workarounds for this problem, dynamic JavaScript on-Demand solution was chosen. It is cross-browser compatible and works in all most popular browsers nowadays. In the future, with increasing system complexity, different new solutions will be examined, like JSON or the new W3C solution (currently in Working Draft). This document, called Enabling Read Access for Web Resources **[6]**, should enable usage of XMLHttpRequest across domains, thus providing an elegant solution to this security obstacle.

C. *Student's experience*

The user side is a personalized search box, incorporated into any web page by using the code generated after the ssearch box had been created. Users can enter the desired word or a phrase, and the results they get will be organized into content groups (previously set by the teacher). Each result contains a precise moment inside a presentation in which the given word or phrase appears, a link to the presentation and a button for seeking the exact moment of appearance.

Figure 4. A search box within an LMS

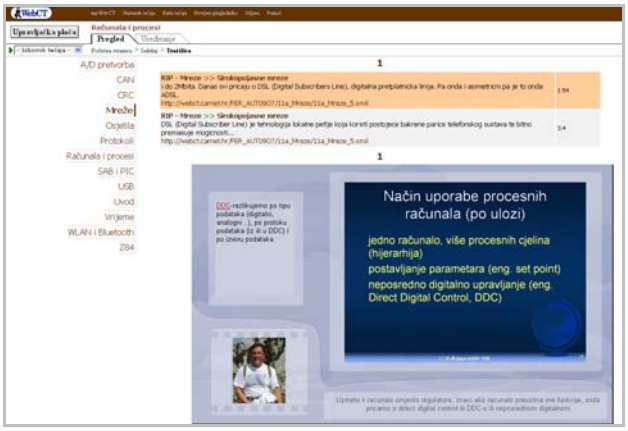

Figure 5. A search box incorporated into WebCT LMS

A box in WebCT LMS with search results and a presentation is shown in Fig. 5.

As usual, the query can consist of one or more words. Quotes, AND/OR logical operators and asterisk (*) are also supported.

In the process of searching, the list of all contents available for this search box is created. Swish-e engine is called, this time to search the previously indexed content. The content which is about to be searched can be changed in the search menu on the left.

The returned results include a small text excerpt, time of appearance in the presentation and a link to the presentation. By clicking on the link, specified SMIL presentation is accessed and presented inside the Web page. RealPlayer API JavaScript functions are used to communicate with the player [7]. By pressing the *Seek* button, the presentation will continue from the moment in which the phrase in SMIL presentation appeared. Students can watch the presentation while continuing to perform queries in the search box.

D. *System architecture*

The system is based on open technologies: it is written in PHP, runs on Apache Web server. The administrator side is designed as a classic Web application, together with Smarty templates used for page layout and PostgreSQL database to store the data. To improve the user experience, XMLHTTPRequest was used as a way to communicate with the server without the page refreshing. Administrator side schema is shown in Fig. 6.

The system fetches the content from remote servers, using HTTP, WebDAV or SFTP protocols. After analyzing the accessed SMIL content, the text is sent to an Open source indexing engine called Swish-e [8].

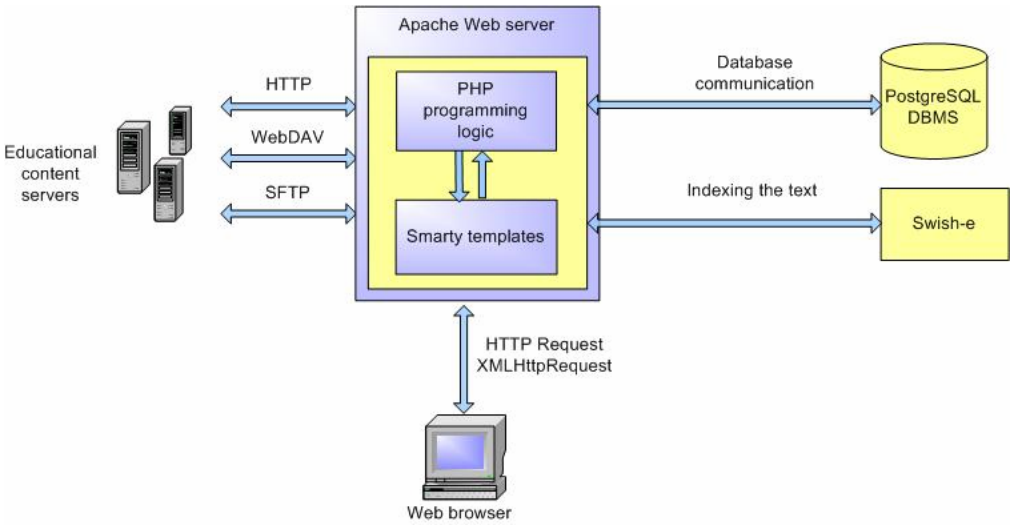

Figure 6. Administrator side schema

The schema of the student side is different, because of the search box dynamic creation on any desired server (LMS, CMS or a simple Web page). It is shown in Fig. 7.

Due to the fact that most LMS/CMS's do not allow the use of server-side scripts because of safety precautions, client-side technologies were used. JavaScript code which displays and handles the search box is dynamically generated in PHP (on the search server) and sent to the Web page. In this way, searching and returning the results is also handled. One of the advantages of such approach is that the search box can be inserted anywhere on the desired page, thus creating a whole with the other elements already existing on the Web page. Therefore, the search box can fit the page layout and design completely.

E. Temporal SMIL analysis

SMIL analysis starts with finding all submitted or updated content which needs indexing. The list of SMIL presentations is updated, while keeping in mind that edited files must be analyzed and indexed again.

After fetching the SMIL file, an analysis is performed. SMIL Meta data are stored in the database and used when the search results are displayed. In the temporal analysis, only text resources are important. If the moment of appearance is an absolute value, it is not necessary to calculate anything. If the value is relative, which means that it depends on the beginning or ending of another element, it is necessary to find the absolute time of appearance. Considering the SMIL document format, which is a tree consisting of nodes, this task is performed by recursively traversing all the nodes which are (directly or indirectly) connected to it. Once the absolute time and duration have been calculated, those values are stored until the end of file analysis, to reduce the duration of other, possibly related, element analysis.

Content indexing is, like analysis, also asynchronous, and performed subsequently. The text which is to be indexed is stored in a database, so a way to send it to the Swish-e indexing system must be provided. This is done by submitting a feed of XML files, generated from the database, readable by Swish-e.

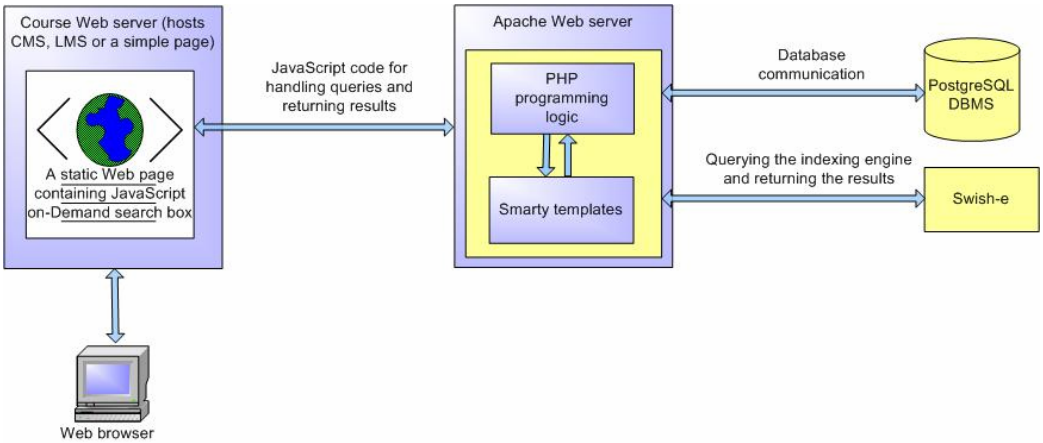

Figure 7. User side schema

IV. SMIL AND STUDENTS

The learning model and indexing system described above is used at University of Zagreb, Faculty of Electrical Engineering and Computing, where the lectures for Computing courses *Open Computing, Computers and Processes* and *Microcomputers* are developed in SMIL. A very big number of students, around 180 – 220, usually enroll to these courses. With a serious shortage of professors and teaching assistants, it can be quite hard to spend time in live discussion about some interesting themes such as open systems or usage of microcontrollers. So, the asynchronous lectures are proposed to students. In this way, they can learn in advance, better understand the real-time lecture, while the lecture can be focused on discussion or some special theme details. All the audio was transcribed for three reasons:

- to help hearing impaired students,
- to be translated for international university cooperation,
- to be used in a SMILSearch indexing system.

The audio is accompanied by lecture slides, occasional video clips and different types of additional educational material (more detailed explanations, schemas, links, etc). Such presentations were divided into smaller parts of about 10 minutes, to ensure better student concentration and easier understanding, and supplemented by learning activities such as quizzes and discussions. The courses were placed on WebCT LMS [9] (in the process of migration to Moodle LMS [10]).

Presentations of all lessons were submitted to SMILSearch engine, divided into groups based on the main course topics. For each course, a personalized search box was created, containing the content groups relevant to the course. For students' convenience, some related themes from the other course were also put in the Search box. Search boxes were placed on the course Web pages using the JavaScript provided by the system, along with the list of lectures, divided into topics. In that way, the students could view the lectures regularly, but also find any of the information relevant for them at a given moment.

During the course *Open computing* in 2006./2007. summer term, students' achievement at the final course exams was observed, in correlation with tracking their usage of online lectures in SMIL. 189 students were included this statistics, as they were taking the course in a "standard" way, with laboratory exercises and a final exam (some more students were taking the course in a form of a bigger practical assignment, without an exam). Students were invited to use the online asynchronous lectures previously prepared, but it was not obligatory in any way.

The statistics contains the data only for three summer exam opportunities (there are more opportunities to pass the exam in the autumn). Out of 189 students, 97 (51.3%) at least once tried to watch the lectures. Exam pass percentage for students watching the lectures was 80.4%, while exam pass percentage for students who didn't even try was 58.7%,

Correlation between percentage of students who have passed the course and number of viewing the lessons clearly shows that students who have taken the time to learn managed to pass the course before the summer. Student's who weren't learning online had a 59% pass, those who were watching online lectures altogether less then 150 times had a 79% pass, and those who were watching the lectures more than 150 times had a 84% pass (Fig. 8.).

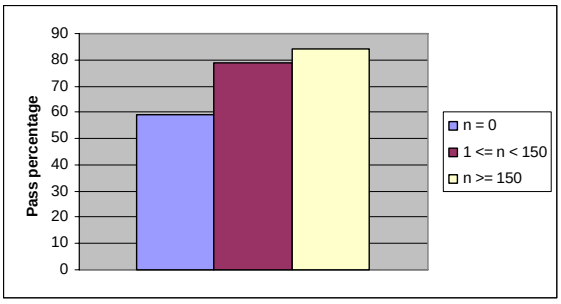

Figure 8. Pass percentage based on the number of viewing online lectures

The graph in Fig. 9. shows the average number of viewing the lessons for each of the final course grades.

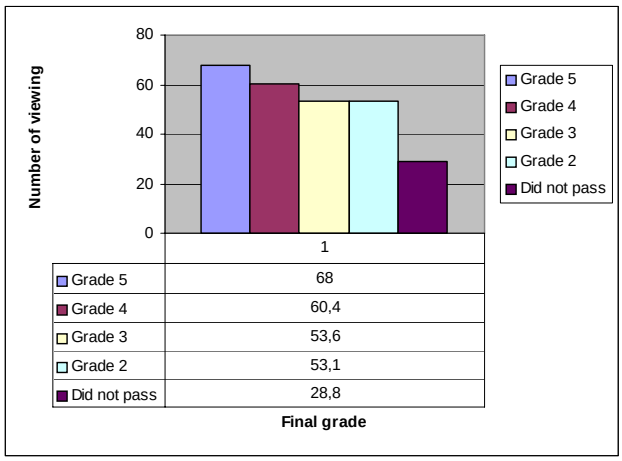

Figure 9. Average number of viewing lessons based on the final grade

The last graph in Fig. 10. shows the average grade related to students' persistence to learn online. Those who were learning with the online lessons from the beginning to the end of term got better grades than those who decided to "give up" during the term, or started to learn just before the exam.

Statistics shows that standard lectures enhanced by online lectures in average provide better grades and higher possibility to pass the course. The fact that almost a half of the students didn't even try to learn online points out that students are not used to e-learning yet, and should be more encouraged and motivated to use it, with all benefits it brings.

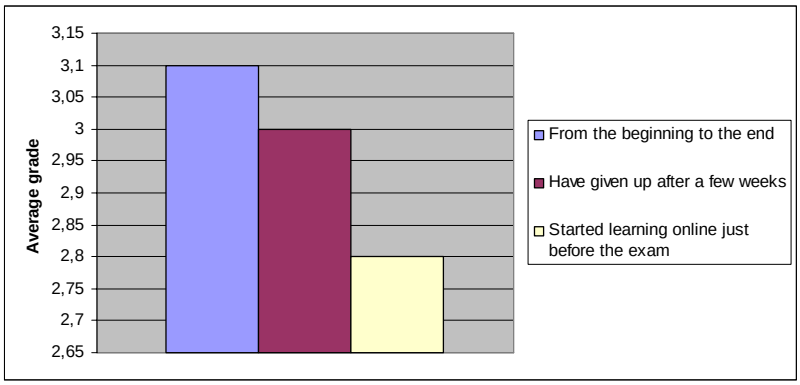

Figure 10. Average grade based on the period spent in the course

V. CONCLUSION

This paper presents the SMIL format, a W3C recommendation for delivering multimedia presentations over the Internet. Such presentations can be successfully used in e-learning to deliver educational materials, especially if there is a need to compile different media, for instance, in delivering asynchronous lectures in schools or universities.

SMIL format is used to create multimedia lectures for computer science courses, in order to enable access to the lectures anytime and anywhere. To improve such lectures, a global indexing system for SMIL searching is designed and created. The system is based on a full-text search, supports indexing of different content groups submitted by different users – teachers. The content is fetched using various protocols and analyzed according to SMIL timeline specifics. Teachers can subsequently create personalized search boxes consisting of different content groups and include them in the course Web pages.

An important part of the system is the ability to share presentations among the teachers and include these in the course CMS or Web page. In that way, collaboration between teachers is encouraged and students gain profit by acquiring knowledge from different sources.

Although the system is functional and currently used in education, ideas for improvement and future development are always around. To make the learning environment more complete, more formats could be submitted for indexing, such as Web pages, PDF files or digital books based on XML. The next step would also be the support for learning objects (IMS/SCORM packages) to provide better conformance to standards and norms. At present, creating learning objects containing SMIL presentations is very hard because of media integration and security measures. In addition, the system could support various new protocols for fetching the presentations, such as SCP. Support for Timed-Text Authoring format **[11]**, a W3C Candidate Recommendation for delivering timed text on the Web will be implemented.

The usage of SMIL presentations and indexing system is shown on the example of University of Zagreb, Faculty of Electrical Engineering and Computing. Everyday experience shows that there is a great need for such systems, especially in educational institutions. Enormous amount of data surrounds the students (as well as the teachers!), and finding the way through the "information forest" is a matter of great importance. A system which helps finding the right data in completely asynchronous multimedia lectures improves the quality of e-learning content delivery.

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