Towards a Virtual University

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Abstract: We discuss a possible framework for virtualizing the delivery of university courses. With the advent of new technological innovations like high speed computer networks and multimedia computers, there is an increasing awareness that direct face to face teaching is not the only possible mode of teaching in a university system. There is a demand for preparing high quality multimedia course materials across all disciplines which can be used by learners who either cannot attend live lectures or prefer to study in an off-line mode. Our group at the University of Freiburg has developed a robust tool called *Authoring on the Fly* (AOF) for recording live classroom sessions as multimedia documents and the synchronous playback of the different media streams in such a document in an off-line setting. In this paper we discuss the facilities this tool provides for virtualizing university courses as well as improving the offering of courses in a traditional university setting. We discuss the progress we have made in high quality delivery of lectures through multimedia documents and its implications for both off-line and classroom teaching. Further, we discuss our current attempts in virtualizing the assignment submission and correction process as a follow up of the virtual delivery of courses. We also discuss the possible implications of virtual delivery of courses and creation of a virtual university from the point of view of university students, professors and administrators.

Key Words: computers in education, virtual delivery of courses, multimedia course materials, mixed mode teaching, virtual university

Categories: K.3.1

1 Introduction

It is a common opinion that networked computers, multimedia, and the internet will revolutionize university education. Lifelong learning, learning on demand, anywhere and anytime are a few buzzwords ruling the public discussion. A large number of publicly and privately funded projects have the goal of virtualizing parts of the university education using technical means. Traditional universities have begun to open themselves beyond their traditional borders and undertaken first steps in order to become at least partially open universities offering distance education. So far, in Germany there is just one university specialized in offering distance education, the Fernuniversität Hagen. No other university has gained experience in this mode of education in the past, though many initiatives recently have begun to change this situation. At the same time traditional teaching and learning is enhanced and improved by the new media. It is well known that the development of multimedia content of high quality is very expensive and time consuming. Hence, groups of professors from different universities but related subjects have started to share their efforts in developing multimedia modules to be used for teaching and learning [see Geyer and Effelsberg (1998), Holfelder (1997)].

In order to structure the vast amount of initiatives a bit, it seems reasonable to distinguish different scenarios of virtual education: We may distinguish the synchronous and the asynchronous mode of teaching and learning. In the synchronous mode a live lecture may be transmitted to remote locations, either to a remote lecture hall at another university or to personal computers of students following the lecture at home or in a student residence. For satisfactory results, this teleteaching scenario requires high-end technology and a broadband connection. There are other modes of synchronous instruction with less ambitious requirements using chat, shared applications, email etc. But the characteristics of the synchronous mode is that all members of a learning group meet at the same time in virtual space. A web-course, however, is typically run in the asynchronous mode: The learners work individually independent of time and space through a set of linked interactive HTML-pages downloaded from a web-server. They may consult a teaching assistant by email or any other communication tool, if they have questions or want to make comments. The production of a web-course of high quality is usually considered as a challenging task which is different from the traditional way of teaching at universities. One particular problem in this context is to enhance the course by assignments which resemble the usual form and content of traditional exercises given to students participating in a standard course.

We will report in this paper about a new way of virtualizing university courses and discuss the technical problems and their solutions occurring in this context. We will restrict ourselves mainly to the asynchronous mode of teaching and learning, though we have also gained a lot of experience in the synchronous mode in several ongoing projects [see Viror (2001)].

The rest of the paper is organized as follows. In Section 2, we discuss some details of the traditional teaching methods at universities. In Section 3, we discuss the electronic note-taking system *Authoring on the Fly (AOF)* and some details of how multimedia documents are generated using this system. We also discuss the implications of this system for both professors and off-line learners. We discuss in Section 4 some teaching methods that we are experimenting with using this tool. We discuss the virtualizing of the assignment submission and correction process in Section 5. Some technical problems of this system are discussed in Section 6 and finally, we discuss some future plans in Section 7.

2 Traditional Teaching

Let us first recall a few general characteristics of university teaching. Usually the teaching and learning cycle is clearly structured into three different phases, *the conceptualization phase*, *the dialogue phase*, and *the construction phase*. A series of lectures given by a university professor, sometimes in front of a large audience, is the core event supporting the first phase in university education. The students learn the concepts through attending these lectures and studying textbooks. In the dialogue phase, students consolidate the concepts they learn in the first phase. Weekly exercises guided by tutors, discussion seminars, and lab exercises are examples of activities in a university curriculum which support the second, the dialogue phase in learning. The construction phase is usually dominant during the second half of a university study and consists of project and thesis work.

In Germany, lecturing in front of a (sometimes large) audience is considered as the specific characteristic of university education both in the public and in the individual consciousness of university teachers. Lectures are usually of presentation type; they are very little or even not at all interactive (students in general do not ask questions or make comments in lectures); they are topical and, therefore, subject to permanent changes; they are specific both for the lecturer and the subject they teach; sometimes they are of excellent quality (renowned university teachers are often famous for their lectures). A further attribute of studying at a German university is that both teachers and students have large amounts of freedom in organizing their studies and in the choice of subjects and courses. Though quite often courses are offered at different universities under the same title, they are in general not identical. Relying on an established textbook (written by a colleague from a different university) is not a common way of teaching a course. The consequence is that traditional university courses have a clearly noticeable personal flavor.

A major aim in our attempts to virtualize traditional university courses was to maintain as much of the advantages of the traditional way of teaching and at the same time to decouple the time and space constraints, i.e., we do not want to force our students to always meet with the instructor at the same time at the same place. Our goal is not to revolutionize the traditional way of teaching through the introduction of new media or through new pedagogic ideas. Instead we have a very limited goal of facilitating those students to pursue their studies who are unable to follow regularly our scheduled classes all the time.

A basic principle of our attempt to virtualize university courses pursued in two major joint projects VIROR (virtual university in the upper Rhine valley) and ULI (combined university studies in Computer Science) is therefore to utilize the experience gained by university teachers in running traditional classes as much as possible. This has the consequence that we try to implement the model of three clearly separate stages in the learning cycle : the conceptualization phase, the dialog phase, and the construction phase also in running virtual courses.

3 Electronic notetaking

The core idea behind our method of producing multimedia documents supporting the first phase of the learning cycle is to combine the apparently distinct tasks of teaching in class and multimedia authoring into one single activity. Over the last years we have developed and extensively used an electronic notetaking system, the AOF-system (Authoring on the Fly) which allows to capture the media streams which occur during a live lecture in class or even during a telepresentation. The idea of capturing as much as possible from the classroom experience for later use is not new. Beyond simply videotaping lectures to be stored on video servers, there are several much more sophisticated electronic notetaking systems. In [Müller and Ottmann (2000)], we give an overview and assessment of those systems. The AOF-system is not just another electronic notetaking system. Instead it fulfills a number of requirements which allows the automated recording, synchronized replay and integration of recorded documents into web-based teaching and learning environments. Using the AOF-system for presentation recording results in multimedia documents of a new kind: The captured multiple media streams occurring in a live presentation, i.e., the audio stream of the presenter, the white-board action stream, the application stream, and possibly others, are synchronized in such a way that a replay using unrestricted random access and easy navigation (so called visible scrolling) becomes possible. The resulting AOF-documents can easily be integrated into web-based teaching and learning environments or put on CD-ROM for off-line use. We refer to the paper by Müller and Ottmann [Müller and Ottmann (2000)] for the technical details of the AOF-system. However, we would like to highlight two key features of the AOF-system that are crucial for presentation recording and playback.

First, the different media streams in an AOF-document are synchronized through a *master-slave* synchronization scheme. The audio stream is the master stream and the other streams like the white-board stream and the video stream are synchronized with the audio stream. Hence, while playing back a recorded presentation, the current playback position of the audio stream determines the objects to be displayed on the screen as part of the white-board display. This was a basic design decision made for the AOF-system since the lecturer's voice is the most important stream in a classroom presentation scenario.

The second key feature of the AOF-system is that the dynamics of the lecturer's annotations on a slide are preserved during the playback of a lecture. The annotations that the lecturer makes are not static screen shots. The annotations actually appear on the screen as the lecturer made the annotations during the lecture. In other words, during playback of a recorded lecture it looks as if some invisible hand is making the annotations on the screen. Hence, the dynamics of the overall presentation is preserved through synchronized audio and annotation as in a live classroom session.

3.1 Presentation recording

Presentation recording requires that the lecturer uses an electronic substitute of a blackboard or overhead projector, the electronic white-board that runs on a computer. Most presenters nowadays use PowerPoint as a presentation tool. However, this tool does not have the desired recording facility and does not support its users optimally. On the other hand, we are well aware that PowerPoint and Word are widely used, occasionally also TeXand LaTeX. Hence, the integrated presentation and recording tool should at least offer import filters for documents produced by these standard tools.

We now sketch as a specific example, how content acquisition in Computer Science is currently carried out. Part of the activity concerns the joint programming of animations and simulations to be used both during live presentations in class and for inclusion into web-based teaching material to be used in simulation mode by students. Here, in particular, collections of animations and simulations for the areas of *Algorithms and Data Structures*, *Computer Architecture*, *Computer Networks*, and *Multimedia Systems* have been produced. This material has been used partially in live lectures at one of the participating universities which have been recorded using the AOF-approach. The AOF-system has been used to record quite a number of whole courses (on Multimedia Systems, Network Technology, Algorithm Theory, Algorithms for Internet Applications, Algorithmic foundations of Bioinformatics, and others). The recorded documents are finally put on CD-ROM and distributed to students. Moreover, a series of lectures by experts in various fields (Computer Science, Archeology, Biology, Medicine and others) have been recorded; some of them are bundled together in a new kind of multimedia textbook on *Algorithm Design Principles*, [see Ottmann (1998)]. So far we have recorded about 500 hours of live lectures, mainly on topics in Computer Science.

3.2 The lecturing experience

We decided early in our project that the best way to produce multimedia documents on university courses is to record live classroom lectures. Though it is possible for a lecturer to give a lecture just for the multimedia recording, from our experience most lecturers present their best lectures when there is a real audience in front of them. Hence, we recorded the live classroom lectures that are presented to our students on campus.

It is possible to produce multimedia documents from live lectures if the lecturer finds the tools easy and comfortable to use. Moreover, the tools should provide some advantage over traditional teaching tools in order to make this mode of delivery of teaching materials attractive for the lecturer. If the tools are difficult to use or they provide little or no advantage in presenting the material to a live audience, very few lecturers would prefer such tools.

The AOF-system is a very attractive alternative to the usual teaching through transparencies or through a tool like PowerPoint. The slides for a lecture can be prepared either using the AOF tool itself or by using standard text processing software like latex and dvips. Once the slides are loaded in the AOF-system, a list of all slides with their titles appear in a window. This gives the lecturer the facility to access any slide randomly. Moreover, when the lecturer usually annotates the slides during the lecture, all the annotations are stored on the image of the slide. Hence, the lecturer can show all previous annotations on the slides when a slide is chosen from this list. The AOF tool provides excellent support for annotating a slide including free hand drawing, erasing facility, different fonts and colors. In particular, the free hand drawing facility is extensively used by most lecturers for writing on the slides and drawing diagrams. The lecturer can introduce new slides into the AOF document and add new materials on these new slides through free hand drawing. The new slides are included in the index of slides instantaneously. This facility is lacking in presentation tools like PowerPoint as it is not easy to introduce a new slide in an appropriate place in the existing document. The presentation screen of the AOF-system is shown in Figure 1. Hence, the AOF-system provides the lecturer with an attractive tool for presenting a standard classroom lecture.

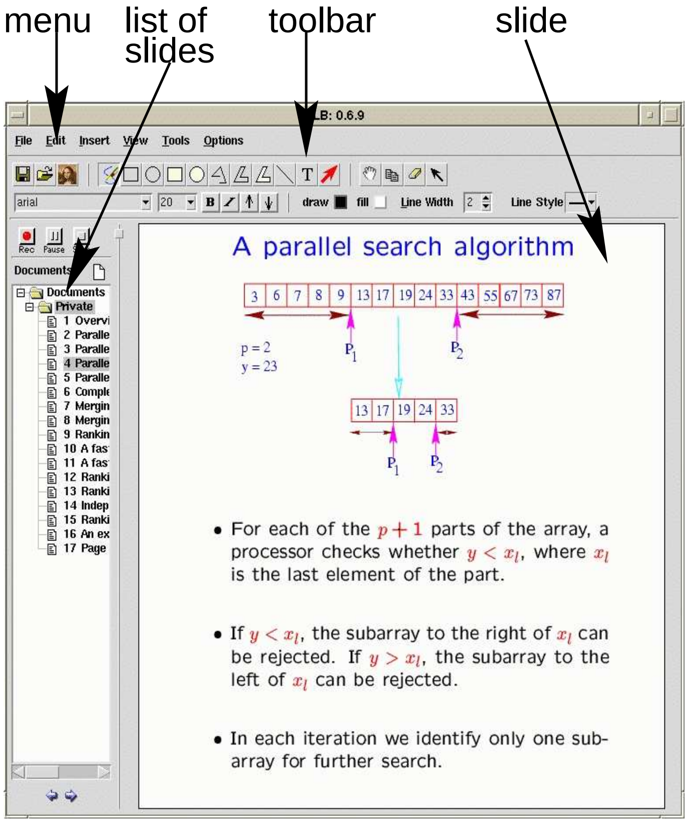

Figure 1: *The presentation screen of the AOF-system. A list of all the slides appear at the left and the toolbar is at the top.*

From our experience, the quality of all the presentations that we have recorded are extremely high due to the fact that the lecturers are comfortable with the AOF presentation tools and they prefer to present lectures to a live audience in a real lecture.

3.3 The off-line learner

We now discuss what the off-line learner may experience as a user of the multimedia documents. The AOF-system is designed to facilitate the learning process of an off-line learner and takes into account two key points : **(i)** an off-line learner of the system should get the experience of a live classroom lecture and **(ii)** the off-line learner should be able to browse through a lecture in the same way she[1] browses through a book or printed material.

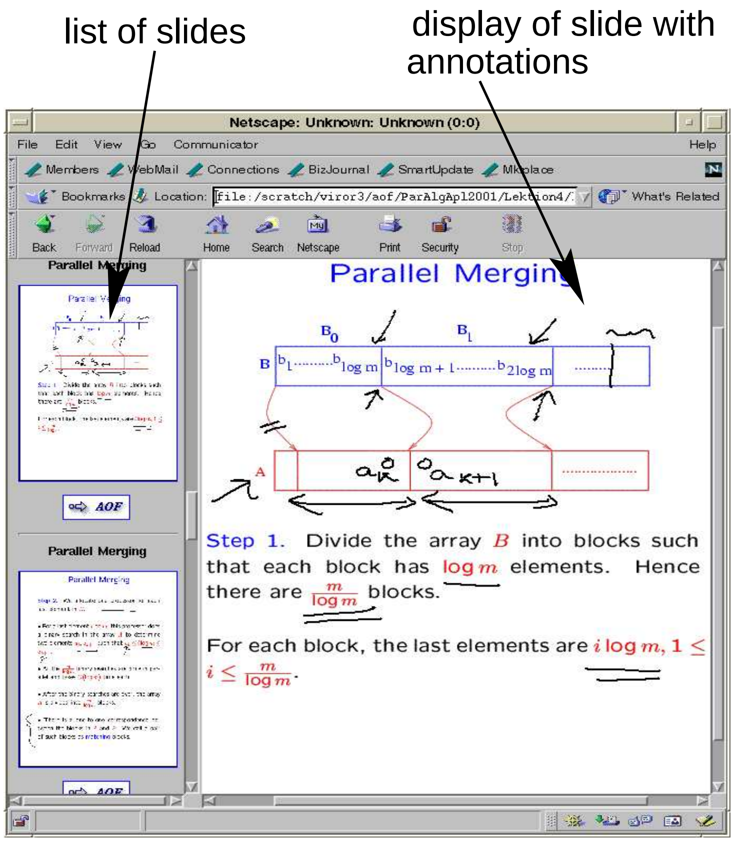

Figure 2: *The AOF playback screen. A list of all the slides in the module appear at the left. Each slide has an AOF icon below it. The off-line learner can click on the icon to jump to any slide.*

[1] We refer to a student as well as a lecturer in the feminine gender to avoid repetitions of the term he/she.

When the AOF player is launched by an off-line user for viewing a lecture, all the slides of the lecture appear in a separate window to the left of the screen. Each slide has an AOF icon below it so that the learner can directly jump to that slide if she wishes. There is also an audio control window which can be used to start or stop the audio or to go back and forth through the audio stream.

The first requirement is satisfied through the synchronized playback of the streams in the multimedia lectures. The usual AOF document contains only

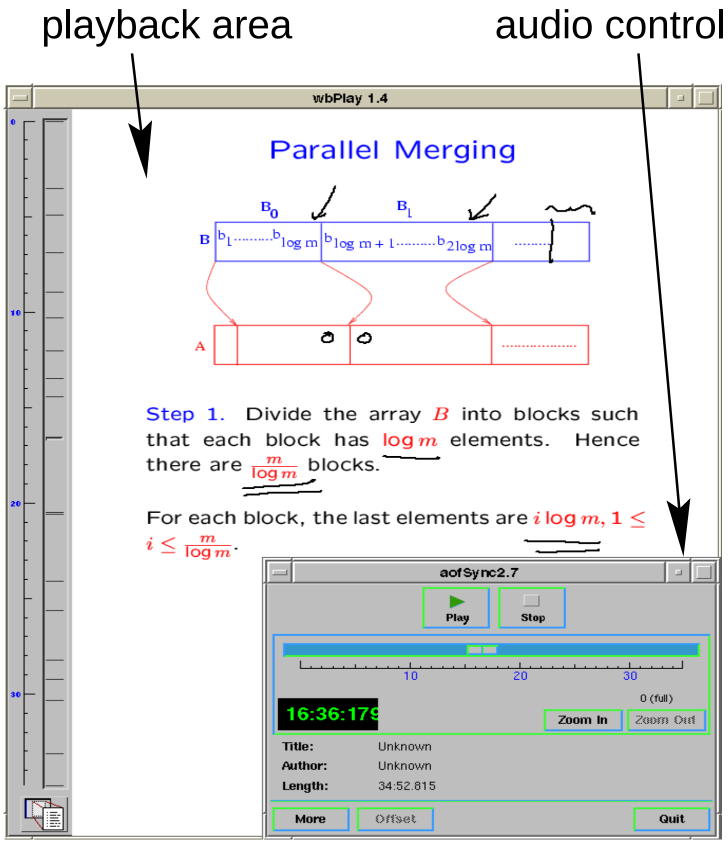

Figure 3: *The actual playback of the same slide as in Figure 2 is shown with the audio control. Note that some of the annotations have not yet appeared at the time when the screen shot was taken.*

two streams, the white-board stream and the audio stream. Since the important parts of a lecture are the lecturer's voice and the slides and annotations on those slides, it was decided that the video image of the lecturer is not an essential stream for the multimedia document. On the other hand, it is possible to record the video stream and include it into the AOF document at the cost of a larger multimedia document. When the off-line learner plays back a multimedia lecture, the white-board stream appears on the screen and the lecturer's voice is heard synchronously.

Hence, the experience of the off-line learner is almost the same as the experience of a student who attends the corresponding live lecture. All the annotations that the lecturer makes on the slides are exactly synchronized with the lecturer's voice. The playback screens of the AOF-system are shown in Figures 2 and 3.

The second requirement of the facility to browse through a document is implemented in the AOF-system at the slide level. In other words, the learner can directly jump to a particular slide whenever she chooses to do so. Since the audio stream is synchronized with the white-board stream, the learner can listen to the lecturer's description of the slide directly. Hence, this facility gives the learner an opportunity to review any part of a lecture as many times as required and learn the material at her own pace.

4 Teaching methods

We have earlier emphasized our point of view that the AOF-system is not based on any pedagogic ideas, rather it is a tool to facilitate virtualizing university teaching and it can be tuned to the specific needs of a university teaching scenario. However, we have experimented with a few ideas in order to use the system to the maximum benefit of the lecturers and the students at our university. We will discuss a few of these ideas below.

4.1 Mixed mode teaching

The AOF-system not only facilitates teaching of courses in a distant education mode, but it also helps organizing and offering very high quality courses in a traditional university setting. From our experience, a lecturer spends a lot of time for the preparation of a lecture even if she is offering the course several times. On the other hand, if the lecturer uses the multimedia course material from a previous offering of the course, she can put her effort to improve the course in two different ways.

First, the course can be offered in a mixed mode using part of the previous recordings and partly through live lectures. The lecturer will have the choice of retaining a part of the course which she thinks was well presented in a previous offering. She can concentrate on adding new material through live lectures in order to improve the overall content of the course. The second advantage is that she can devote more time to prepare high quality tutorial materials.

Hence, a series of recorded lectures on a certain subject opens a new way of teaching a course: Instead of teaching the whole course again, one may switch to a hybrid, partially virtual mode. Only those parts are presented in a live lecture in class which differ from the previous presentation. The unchanged part is distributed to students on CD-ROM and/or made available in the local computer pools for self-paced study. The presentation is accompanied as usual by (weekly) tutorials and exercises. In this way we have run the course on Computational Geometry already once.

4.2 Modularizing a lecture

The second idea we are currently experimenting with is the breaking up of the material in a lecture into small self-contained modules. From our experience, students can learn materials well in a live lecture if the material is presented in a modular fashion. It is easy to keep concentration and understand the ideas in a smaller module instead of a long lecture.

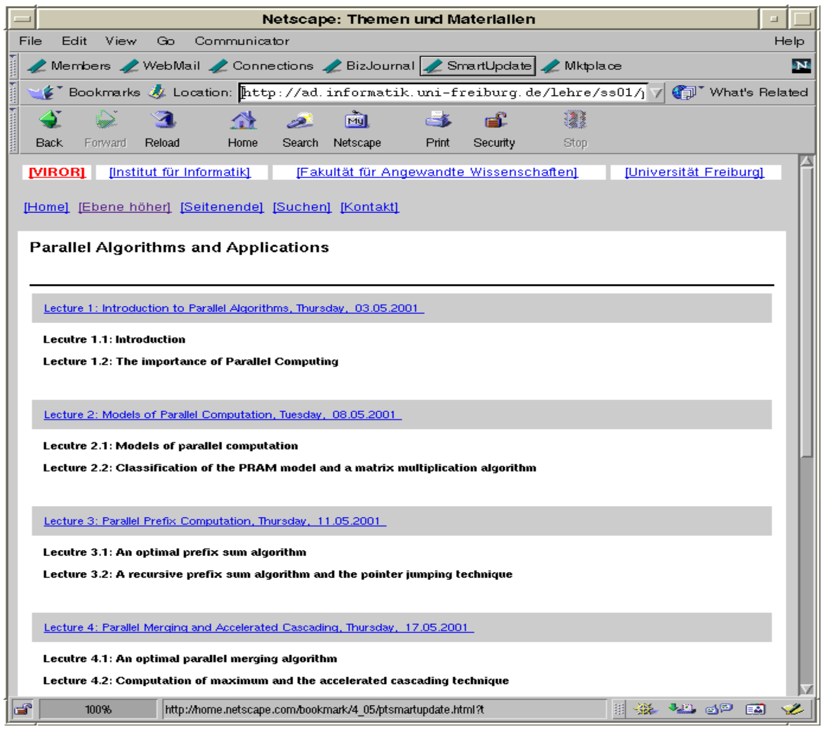

Figure 4: *The web pages for the course* Parallel Algorithms and Applications. *This page shows the overall structure of the course, title of each lecture and the modules in a lecture and links to individual lectures.*

This is also very useful for an off-line learner as she can concentrate on a small multimedia document for learning a few key concepts before progressing to the next document.

The AOF-system is ideally suited for breaking a lecture into such smaller modules. The lecturer prepares the slides for each module separately and once a module is presented, the recording can be stopped and started again for the next module within a short time. Also, the lecturer can prepare exercises for each module separately and this allows the students to learn the material in a module thoroughly and test their understanding through attempting the exercises based on that module. The splitting of a lecture in smaller independent modules is shown in Figures 4 and 5.

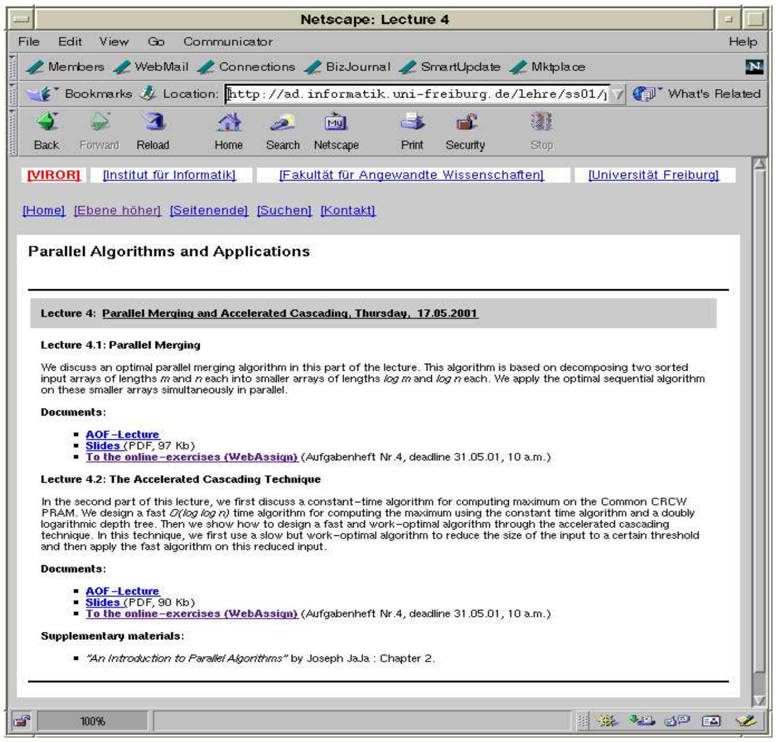

Figure 5: *The web page of Lecture 4 for the course Parallel Algorithms and Applications. There is a brief description for each module and links to the AOF document, PDF file and exercises on the WebAssign system.*

In summary, the AOF-recording technique may open a new and cost effective way of utilizing the teaching and learning experience of university professors for establishing a time and space independent way of learning. The next step will be, not only to virtualize the first phase of the learning cycle, the conceptualization phase, but also the second phase, the dialogue phase, i.e. to run also assignments in off-line mode. We have already made some progress in achieving this goal as we discuss in the next section.

5 Virtualizing assignment submission and correction

In a traditional university teaching scenario, when a student masters a teaching module, she solves assignment problems based on the material

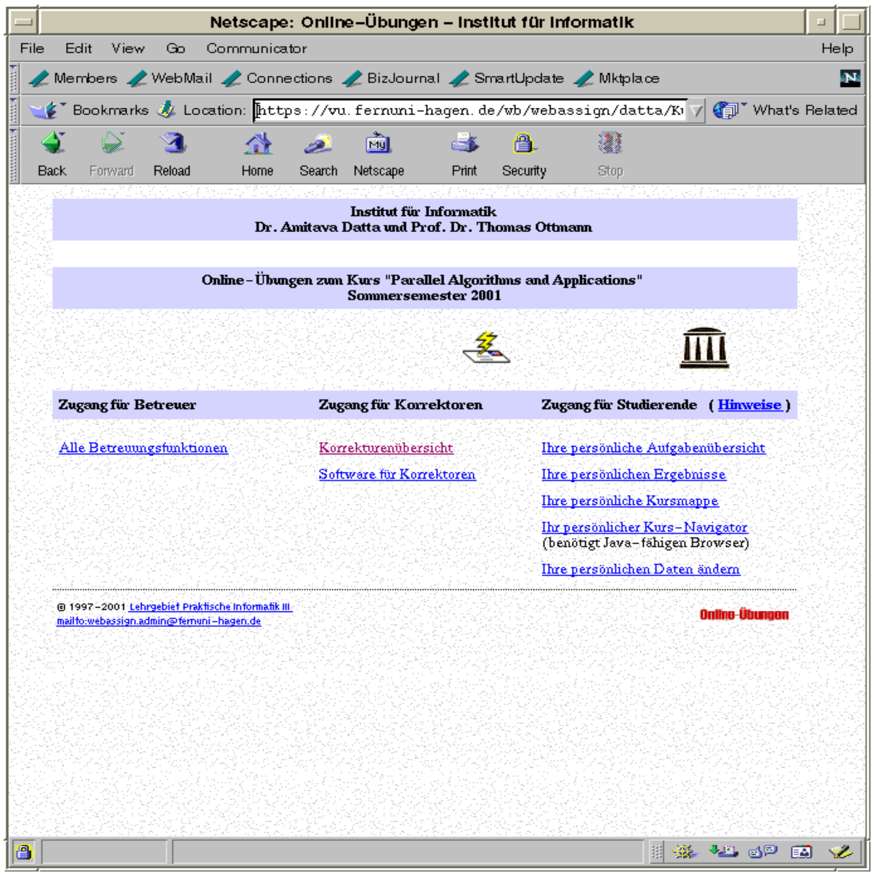

Figure 6: *The front page of the WebAssign system. The page shows links to various submission and management pages.*

and understands the material more thoroughly by comparing her solutions with that of the lecturer. We call this as the *dialogue phase* of the university learning cycle. We are currently attempting to virtualize this phase as well.

In a traditional distance education scenario, students submit their written solutions for the exercises by mail. Then a tutor corrects the submissions and sends the solutions back to the students with comments. This cycle of submitting and correcting assignments obviously has a large amount of latency. Also, for a course with several hundred students enrolled in the distance education mode the management of the assignment correction process is a formidable task. It is much better to have a tool that supports electronic submission and correction of assignments. It is still better if the tool manages all the submissions and stores the marks for the submissions in a systematic way.

The WebAssign system developed at FernUniversität Hagen is an excellent tool with all these facilities integrated into a single web based system. A student can remotely submit assignments as text or postscript documents once she has access to the system by acquiring a login and password. She can view all her submissions and marks anytime. The tutors have similar access to the system through a web browser. A tutor can correct an assignment, add comments, assign a mark and publish the corrections on the web. Each student can access the corrections and check the marks. There is no extra work on the tutor's part for managing and storing the submitted assignments. The front page of the WebAssign system is shown in Figure 6.

We are currently using the WebAssign system for assignment submission and correction in two of our courses, *Geometric Algorithms* and *Parallel Algorithms and Applications*. Though all our students are enrolled as regular students and they attend lectures in campus, we are experimenting with the system for integrating it into our overall framework for virtualizing the delivery of university courses. Right now, the web pages for these two courses are organized in a hierarchical fashion. At the top level is a page with descriptions of the course content, links to various contact details for the course and a link to a page with the teaching materials. The page for teaching material has a link to the multimedia document for each lecture. There are several multimedia modules for each lecture and there are links to the PDF files, exercises in the WebAssign system and the multimedia documents for each of these modules. Hence, the students can study each module and attempt the exercises following the links. We plan to use the same structure of the html pages in the CD-ROM for the course. An off-line student will be able to connect to the WebAssign system in the same way.

Hence, the WebAssign system is a possible tool for virtualizing the second phase of the university teaching, the dialogue phase. From our experience, an assignment management tool like this is essential in virtualizing the assignment submission and correction cycle.

6 Technical problems

Using the computer as a means for teaching and presentation of content is fairly obvious for lecturers for whom the computer is the standard everyday working tool. This is true for computer scientists, physicists, and many others, but certainly not for most colleagues from the humanities. We have tried to encourage people from nontechnical areas also to participate in (synchronous) teleteaching experiments and recorded their lectures using the AOF-system. A large rear-screen interactive white-board has been used as a presentation tool. While experienced users are able to master the variety of the available tools, it turned out that the human-computer interface is by no means ideal for such an application. Moreover, the role of an accompanying video of the speaker (talking head) is different when teaching a technical subject like Computer Science and a nontechnical subject like Archaeology.

Our experience with the AOF-system shows that this tool is very robust and suitable for presentation recording from a live lecture. However, we would like to improve the system further to make it more user friendly and attractive for university professors to use it. One of the features we would like to introduce in the system is a facility to edit a multimedia document easily. It is only human on a lecturer's part to make some wrong statements in a live lecture. All lecturers would like to edit their multimedia lectures in order to remove such mistakes from their presentation recordings in order to provide a correct and polished version of their lectures to an off-line audience. Currently the AOF-system allows one to edit a multimedia document, but the process is slow and tedious. This is due to the fact that deleting a part of the audio stream makes the white-board stream asynchronous with the audio stream. Hence, it is necessary to edit the white-board stream carefully to make it synchronized again with the audio stream after such deletions.

A simple and easy to use tool would make this editing simpler and then if necessary, a lecturer would be able to edit her recordings with relative ease. We are currently working on incorporating such an easy editing facility in the AOF-system.

7 Future plans

The ultimate aim of virtualizing university courses is the creation of a virtual university. The students will be able to choose their courses for study from a wide range of available virtual courses to complete their curriculum. However, the creation of a virtual university of this kind is by no means easy. Though we are convinced that students would like to have a facility to study off-line and to choose their courses according to their interests, there are several issues related to university teaching and administration that need to be changed. This requires a rethinking of the way present day universities and professors teach their courses and give credit to the students for passing a course.

If a student takes a course not from her own university where she is enrolled, she must be certain that she can use the credits earned in the course for her academic record. Currently, this is no problem, because either courses are purely local (though they may incorporate multimedia material produced by a colleague from another university), or they are offered under the joint responsibility of several university teachers, each one responsible for the accreditation of the course at her university. However, for a virtual university evolving from traditional universities to be accepted by students, it is absolutely necessary to assure that credits students earn at some university are accepted at the others in comparable curricula. This requires a consequent modularization of studies and the implementation of concurrent tests instead of punctual examinations. The principle 'who teaches also takes the examination' has to be implemented and accepted, a principle which is at least partially against the German university tradition. That is, a university teacher has to accept that a student has the freedom to choose from different offerings for the same course; she cannot force a student to take her own course simply because she will take the (final) examination.

We noticed that the exchange of lectures in the synchronous teleteaching scenario is not widely accepted. Teachers see an imported course as a competition for their own offerings and they want to avoid this competition. Therefore, the exchange of courses between universities seems to work without any problems only in those (rare) cases where they contribute to an enlargement of the spectrum of courses at a site where no local competent teacher for the respective subject is available. Students, on the other hand, appreciate this possibility of enlarging their spectrum of courses. They are willing to accept even technical deficiencies in the transmission technology, if this is the only way of acquiring the desired knowledge.

Joint research seminars, however, are a widely accepted form of inter-university cooperation in teaching. The preferred method to run such a seminar is the synchronous teleteaching scenario. Our experience shows that it is mandatory to explicitly introduce the participants of such a seminar into the tools and, furthermore, to formulate the appropriate way of using the available tools explicitly as an additional teaching and learning goal of such a seminar.

The development of multimedia modules of relatively fine granularity (like a single animation or simulation, a few interactive web pages) makes slow but constant progress. Our project partners in other German universities share the experience that the production of multimedia content of high quality is fairly time consuming and takes much more effort than estimated. Most of the project partners plan to contribute to a repository of such modules (stored in the ARIADNE knowledge pool system) which then can be used by all members of the universities during their (traditional) lectures. The method of recording whole courses by a note-taking system, like the AOF-system, will probably be restricted for the near future to computer science and closely related areas. We have done the first serious experiments to teach a (recorded) course in a hybrid manner, that is as a mixture between live lectures and tutorials accompanying recordings distributed to the participating students. So far students mainly take the recordings of lectures as a very convenient way to prepare themselves for the final (punctual, oral) examinations. We recommend the reader to check the list of recorded lectures and to install some of them locally in order to get an impression of what is already available [see Viror (2001)].

It seems to be clear that any change of the traditional teaching and learning method at German universities into the direction of time and space independent, teacher independent, self-paced learning requires a change in the teaching and study behavior of university professors and students alike.

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