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Studying Electrical Engineering in the Virtual University*

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This paper reports on a project which was carried out by the Faculty of Electrical Engineering, University of Hagen, Germany. The goal of this project was to develop a Virtual University with all its essential features. The paper describes experiences with electronic multimedia courses, Internet-based tutoring and communication laboratories as well as the underlying technical platform which was developed for the administration of students and courses. Furthermore, a concept is presented how electronic payment systems can be used for the dissemination of learning material for further education.

INTRODUCTION

THE UNIVERSITY OF HAGEN (Fern Universität Hagen) [1] is in a unique position in Germany, since it is the only university for distance education. The university is an integral part of the regular public higher education structure and offers German degrees in the fields of economics, law, human science, computer science, mathematics and electrical engineering. The students receive the printed lectures in a two-week rhythm and have to pass assignments in order to get access to final examinations. The university has built an infrastructure of study centres throughout Germany, Austria, Switzerland and Eastern Europe, where students can meet their tutors and get access to small libraries, computers and video conferencing equipment. Besides the remote aspects of the study, the students have to spend several attendance days at Hagen to take part in seminars, laboratories and oral examinations.

The university is determined to make best use of the vast possibilities which are offered by the information technology and new media. Diverse activities have been started in the university to evaluate the route from the traditional university for distance teaching towards a new media university.

THE VIRTUAL UNIVERSITY

The project 'Virtual University' which started in 1996 and ended in December 1999 was funded by the state of North-Rhine-Westphalia. It was carried out by the Faculties of Computer Science and Electrical Engineering. Both faculties began with general considerations about which features the Virtual University would have to offer. It soon became clear, that the draft 'Virtual University' was actually less virtual than the traditional university for distance education. The reason for this is the following: in distance education there has always been a gap between teachers and students due to the geographical distance between both parties. Conversation and tutoring was carried out by mail and telephone, the first being quite slow and the second being uncomfortable because of the shifted work rhythms of students, who normally work in the evening, and teachers who have a regular working day. Hence, the advent of the Internet added completely new perspectives to the communication possibilities between students and teachers in that it introduced new asynchronous communication forms like e-mail and newsgroups. Consequently, interaction between teachers and students, and also between fellow students, has increased enormously and thus the 'virtual' portion of distance education has been reduced.

During the lifetime of the project, two technical platforms emerged from the two faculties, both being completely web-based. The major difference between these two prototypes was the method how students would get access to protected learning material. The first solution which was carried out by the Faculty of Computer Science has a portal characteristic where students have to enter their password as soon as they enter the web homepage. Although a public part also exists, this solution makes it hard for guests without an account to get information beyond general topics. The Faculty of Electrical Engineering chose a different way and used an object oriented approach where guests can navigate through major parts of the web site as long as they do not try to access protected material. Although the development efforts were divided, it was good to have two prototypes because it helped to recognize which design features were desirable.

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The platform which was developed in the Faculty of Electrical Engineering is called 'ET-Online' [2] which is a German acronym for 'Electrical Engineering Online'. In this paper we describe activities around this platform and inside the Faculty of Electrical Engineering.

CONCEPTS OF ET-ONLINE

The conceptual architecture of ET-Online consists of three layers:

- The first layer is the presentation and information layer which is accessible by everyone and provides general information, e.g. about the project, access to online resources like the library, overview of the courses and current events, and links to newsgroups and chat rooms.
- The second layer is the course layer where all electronic material is available. Only enrolled students have access to these materials. An exception is the first course unit which is available for everyone as a demo feature.
- The third level contains all communication facilities of ET-Online. A wide range of different communication tools is used like e-mail, newsgroups, chat tools, audio and video conferencing and diverse group communication tools.

At the moment the electronic courses for the traditional diploma study programme are provided in addition to the regular printed courses. In autumn 2000 a new study programme will launch, this time with completely new courses which will be disseminated only over the Internet.

One important decision was to use public and standard software wherever it is available. The technical platform is completely based on open source software like an Apache web server and a PostgresSQL database management system. The same principle applies for communication, tutoring and authoring tools. Especially in web-based education it is essential to stay clear of proprietary solutions, to be able to adapt to the fast pace at which the Internet, and communication technology in general, is currently evolving. It was not part of the project to develop special authoring features. There are enough commonly available tools like word processors, typesetting systems and multimedia software on the market which suit the needs of educational institutions.

ELECTRONIC COURSE MATERIAL

Since the beginning of the project, one main goal was to prepare course material which students can download and use either online or offline and which enhance the quality of distance teaching by including interactive and multimedia elements. One big advantage the University of Hagen had from the beginning was the existence of the book-

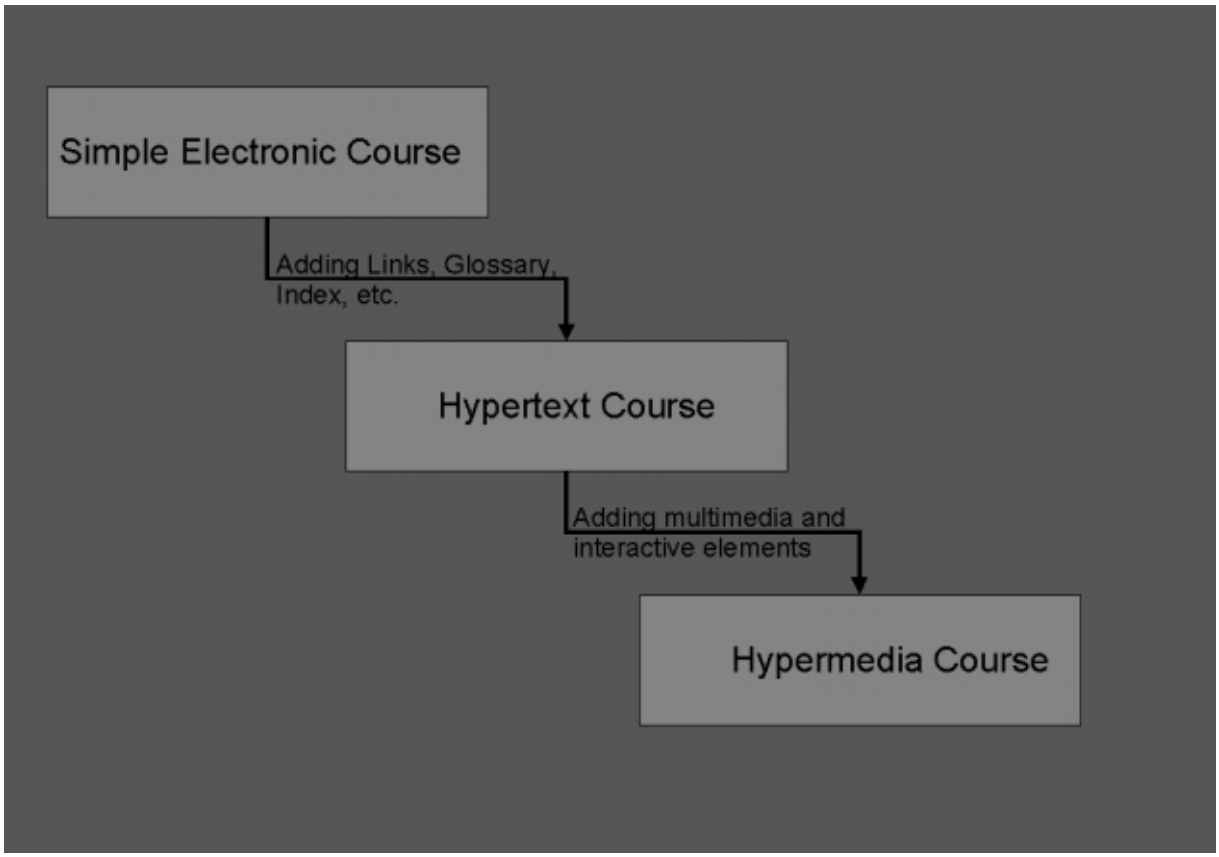

Fig. 1. Steps in creating hypermedia courses.

like lectures, which often were also available in an electronic format and could thus be used as a basis for the electronic course material.

To distinguish the new electronic course material from the printed course, added value has to be created. The first step would be to include hyperlinks into the electronic documents (Fig. 1). Furthermore, an index and a glossary can be added to further increase the value of the course material. The hypertext features allow students to quickly navigate through the electronic documents and they are able to use glossary and index as well as full text search functions to effectively look up keywords and content of interest.

In the next step multimedia and interactive contents can be added, thus making a transition from hypertext to hypermedia. While the creation of hypertext features is a rather simple task, the development of multimedia definitely is not. At the moment, there are only few teachers who are able to produce high value didactic multimedia content. Besides their original professional qualification, teachers also need competence in the fields of multimedia authoring and graphic design. In the case of web-based material the authors also have to cope with the restrictions of formats that can be displayed in HTML-pages. Hence, professional development teams for web based educational multimedia content, normally consist of several persons with special skills in the fields of graphic design, multimedia authoring tools, programming and web design. Obviously, university teachers can hardly impersonate all these listed roles, and they are either forced to make compromises concerning the quality of the learning material or pay professionals to support them in their work.

The University of Hagen has addressed these problems by supporting their teaching staff with a centre of competence, the ZFE (centre for the development of learning material in distance education). The ZFE helps and advises the university staff in multimedia projects.

The course material in ET-Online is distributed across all three stages in Fig. 1. The common electronic formats are HTML, Java, PDF, Authorware, Toolbook, Director, Flash, MPEG, etc.. There have been many experiments with diverse authoring tools and formats. Even before the Virtual University project, several faculties created multimedia CD-ROMs with authoring tools like Macromedia Authorware and Assymetrix Toolbook. Although it would be desirable to extract modules from these CD-ROMs and include them into the web-based learning material, this is not always feasible.

For example, in 1994 the Department of Communication Systems created a multimedia CD-ROM with one of the above listed major authoring tools covering issues in IT security. Today it is not even possible to import the source files into a current version of the authoring tool, which means that multimedia material worth approximately 70,000 Euro is not reusable. This examples illustrates the danger which is inherent in proprietary formats.

Although the above mentioned authoring tools are excellent when it comes to producing multimedia CD-ROMs for Windows and Macintosh platforms they have problems exporting the content in a web-based format. Web-based by definition means, that only open Internet standards are used and excludes the use of plug-ins to display special formats. Obviously, this purist approach is often not realistic, because it would leave the authors only with the formats HTML and Java. Although Java is a very sophisticated and powerful programming language, it poses considerably higher skill requirements on the authors of learning modules than the standard authoring systems. Especially rapid application development (RAD), which authoring software offers by supporting easy drag and drop features and intuitive user interfaces, is not yet possible to the same extend in Java (although RAD tools based on JavaBeans can offer similar features).

Besides HTML the Portable Document Format (PDF) is heavily used in ET-Online. PDF is not an open Internet standard, but Adobe published the specification, which allows other software companies to adapt their software to the PDF-format and develop their own tools. The biggest advantage of PDF is that the electronic documents can be printed very easily and in a high quality. This is a feature which most HTML documents cannot offer, because of missing layout features and their distributed linked nature. One major experience which could be drawn from the project is that many students still want to have a hardcopy of the lecture material and are not happy with reading everything on a computer screen. One drawback of PDF is that special tools are needed to create it.

An example of an electronic course is displayed in Fig. 2. The basis of the course is PDF and the author included the following interactive elements inside the document:

- *Multiple choice questions:* self-controll feature for the student
- *Successive hints for excercises:* instead of immediately showing the solution, the student first gets several hints to help him solve the problem on his own.
- *Interactive Java applets:* from inside the PDF viewer a web browser is started to display the applet
- *Online simulations:* a simulation software which runs on a university server is accessed remotely by a java applet (as seen in Fig. 2).

In this example students are supposed to print out the PDF document and use the interactive features in parallel. This course will be used in the context of a new study programme which will launch in autumn 2000 and offers a bachelor degree [3].

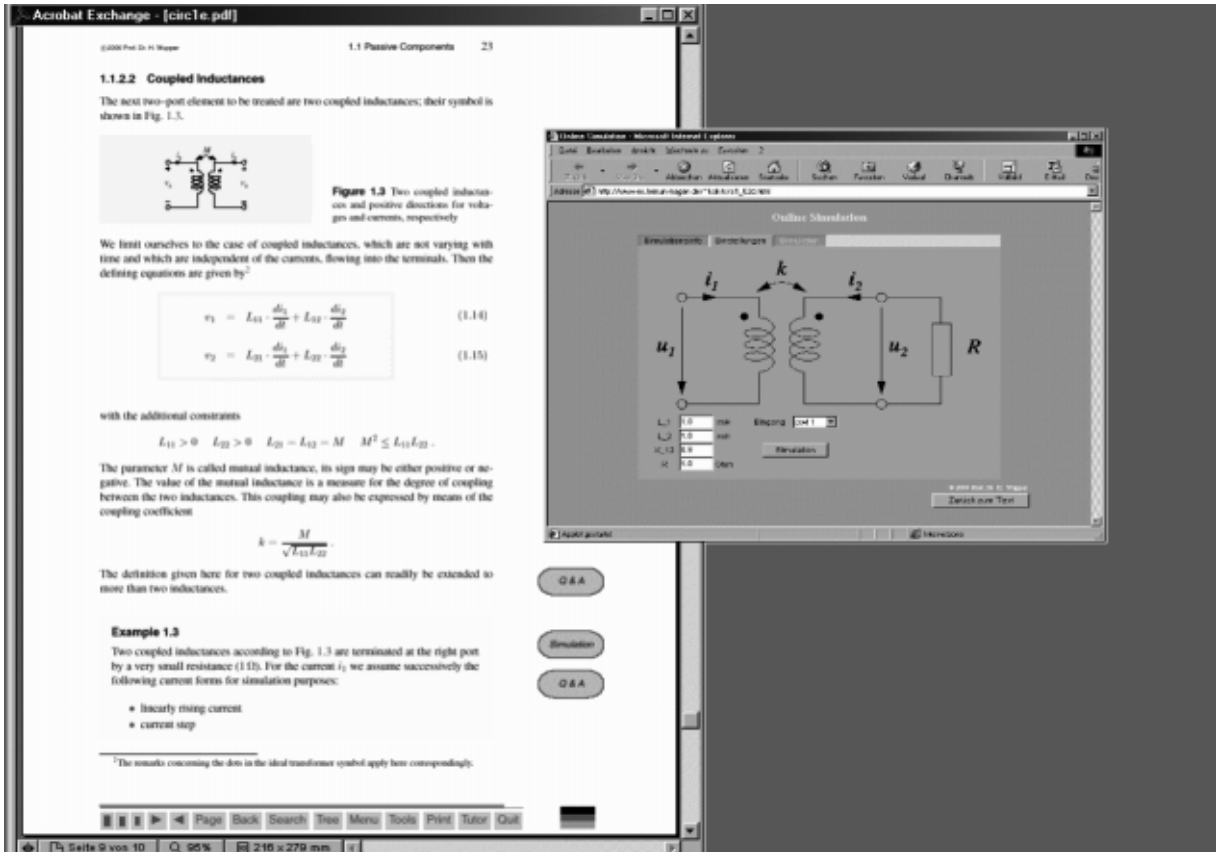

Fig. 2. An example of a PDF course with interactive features.

COMMUNICATION AND TUTORING

Web-based tutoring of students is an integral part of ET-Online and allows students to interact with tutors and other students independent from time and place [8]. The students can work wherever they want, at home, at work, at the university. Their personal computer plays a central role when it comes to accessing online course material, the library, simulation environments, general information and communication facilities. Using online communication makes distance education much more efficient since students feel less isolated. Basically, there are two forms of communication:

1. Asynchronous communication: letter, e-mail, newsgroups, BSCW-server [7], mailing lists.
2. Synchronous communication: telephone, video conferencing, chat.

Asynchronous communication is used for daily exchange between tutors and students and among fellow students. Particularly newsgroups are very popular. The advantage of asynchronous communication is that the communication partners need not to be online at the same time. Synchronous communication, in contrast, serves to realise meetings and discussions where immediate interaction is necessary.

Tutoring with newsgroups

Because newsgroups play an important role in the Virtual University at the moment, they are described in further detail here. A newsgroup is a discussion forum with a defined topic. At the University of Hagen every course has its own newsgroup. To get access to a newsgroup a software called Newsreader is needed. Newsreaders are part of the popular web browser distributions like Netscape Navigator and Microsoft Internet Explorer but they are also available as standalone products. The newsgroups are held on a news server to which the students have to connect with their Newsreader. Once they are connected they can request a list of all newsgroups the server supports. Students have to select the newsgroups for their courses from this list and subscribe to them. This allows them to have instant access to the newsgroups the next time they start up their Newsreader.

The value of a newsgroup is often directly related to the number of students enrolled for the course. When there is not a sufficient number of participants in the newsgroup it is unlikely that a useful discussion will occur. The advantage of newsgroups is that students can help each other with problems and the tutor only has to intervene when he notices that the discussion is going in the wrong direction. Another advantage is that all questions are public and normally only have to be answered once in the newsgroups. If, for example, students would send e-mails directly to the tutor instead of using the newsgroups, the tutors of some courses would have to answer

hundreds of e-mails a week which would be clearly overwhelming. Thus, by giving his answers in the newsgroups the tutor is able to reach all students at once.

A disadvantage of newsgroups is that students do not dare to ask 'silly' questions because they think it could have an effect on their final grade. The tutor himself has the possibility to put questions into the newsgroup when he feels that many students are having a common problem but it has not been mentioned yet. A good tutor would interact with the newsgroup in a way that he does not dominate the discussion but provides just enough moderation to lead the discussion in a fruitful direction.

The ET-Online Assistant

The ET-Online Assistant is an HTML front end for the database (Fig. 3) and offers the students a personalised view of relevant information and data. It must be noted that all private student data is encrypted before it is sent through the Internet (SSL encryption).

The students have access to the following features:

- *Access to personal data.* Here the students have access to their private data like address, telephone number, e-mail address, etc. This information is essential for university staff who want to contact a student. The students can also choose if they want to be included in contact and mailing lists for their enrolled courses.
- *Results from assignments.* Here the students can check the points they received for their individual assignments.
- *Course list.* The students get a personal list of their courses, including information about the tutor and the possibility to directly go to the homepage of the course.
- *Contact list.* The contact list allows students to see if any fellow students live in the same geographic region. This allows the students to build work groups.
- *List of tutors and mailing lists.* Here the students get a list of all their tutors and their e-mail

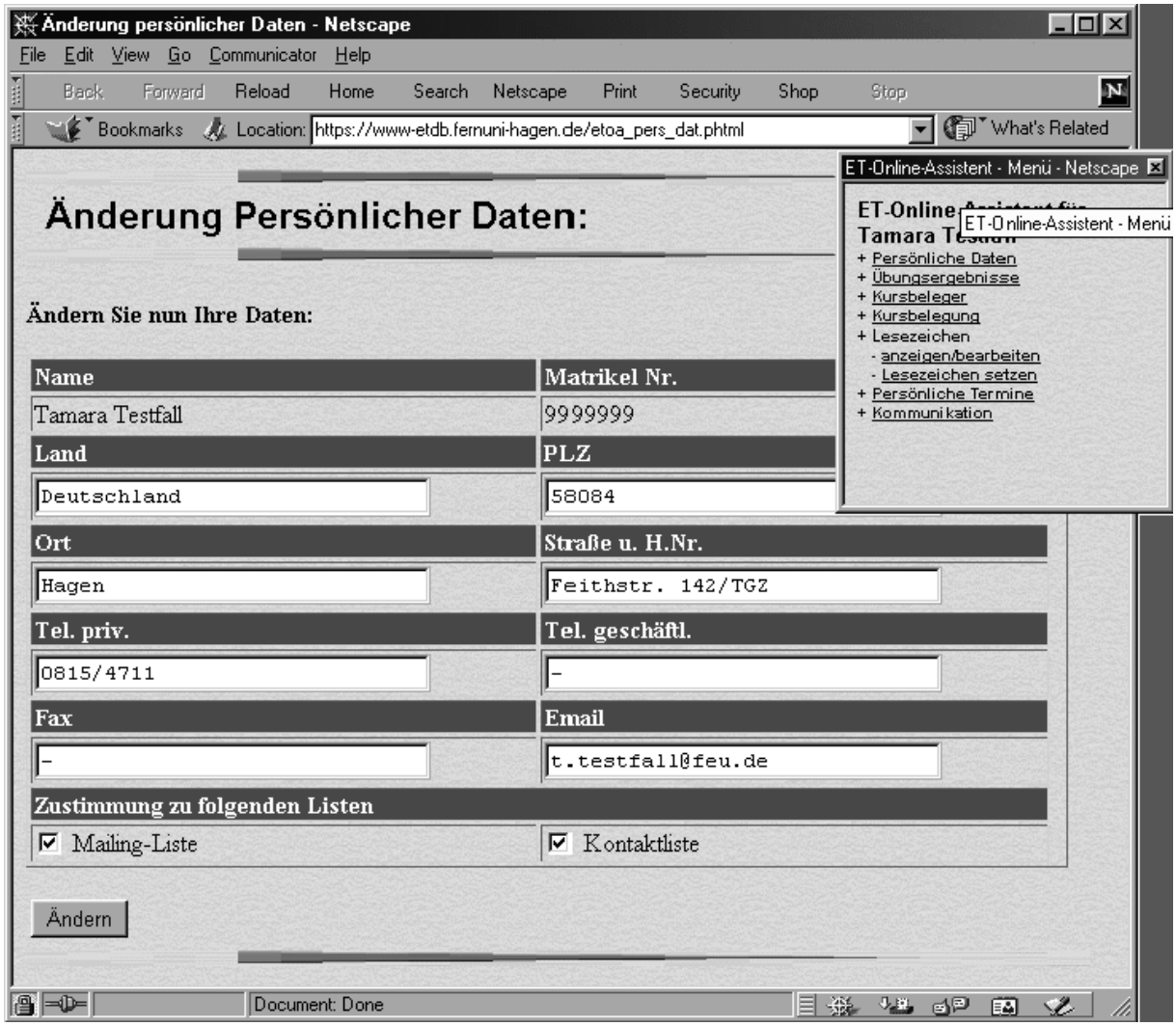

Fig. 3. The ET-Online sssistant.

addresses, as well as all course-specific mailing lists.
- *Personal dates.* University staff has the possibility to enter dates divided in several categories into the database. The students get a personal list of dates which are of interest for them.

SPECIAL EVENTS

Although the University of Hagen is a university for distance education, students normally have to spend several days a year at Hagen for special events like oral examinations, seminars and laboratories. Especially for students who have to travel a long distance it would be helpful, if parts of these attendance duties could be transformed to 'virtual' events. This would mean that students would have to take less days off from work and would have to spend less money on travelling and hotel costs.

Laboratories

The curriculum of the study programme in the Faculty of Electrical Engineering includes several laboratories. At the moment, students have to attend these laboratories locally in Hagen which means, that they have to take time off and travel to Hagen. During their presence in Hagen the students work on two to three laboratories a day.

At the moment there are two labs which are implemented as web applications, hence making them operable across the Internet.

Laboratory 'Channel Coding'

In the laboratory 'Channel Coding' students get access to exercises which are generated with the help of a database. All input and output features are implemented in HTML, thus allowing that the exercises can be accessed from a simple web browser (Fig. 4). All student interaction is logged into the database, which helps the tutor of the lab to see at which stage students currently are and if they need help. All entries from the students are checked by the database which also grants access to the next part of the lab when one part is solved successfully.

Although students are not yet allowed to carry

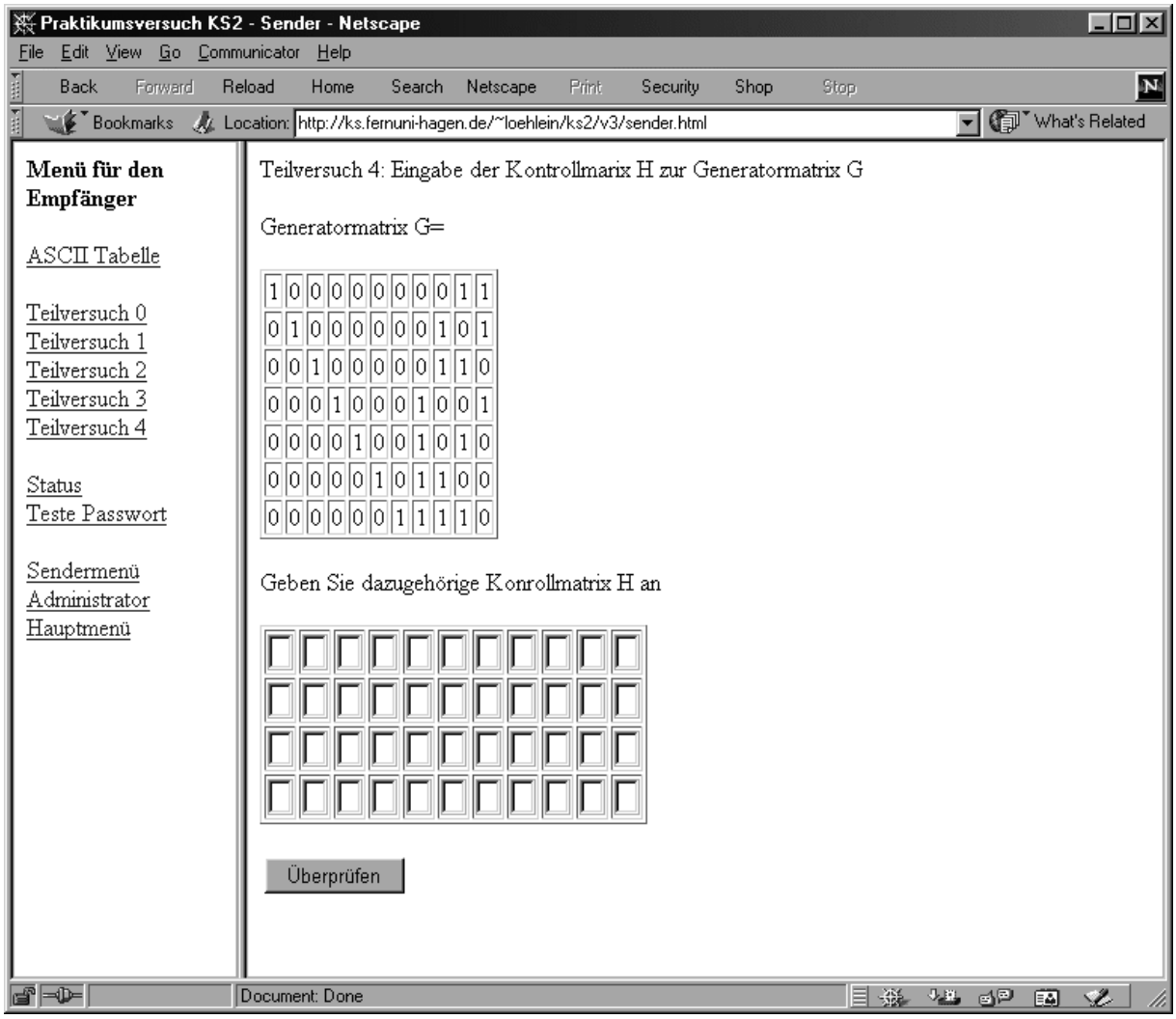

Fig. 4. Laboratory 'Channel Coding'.

out this lab from home, the majority stated that they would have liked to do so.

Laboratory 'Real Systems in the Virtual Lab'

This laboratory is still in the prototype stage and not yet available for students. The laboratory is developed by the Control Systems Engineering group and is part of a project that is carried out in cooperation with two other universities (see also [4–6]). Instead of simulating an experiment, the students have access to a real robot which is installed in the basement of the university. Simulation is a proper way to complement control education, but in general it cannot replace experiments on real plants. Since simulation is only as good as the model, experimentation has the advantage of making the user aware of phenomena that are hard or impossible to simulate. With remote experimentation unique or expensive equipment can be shared between different universities. Since a wider range of laboratory resources can be made accessible, the students have the choice between more experiments. They can use the Virtual Lab at any time and at any place and save travel time and cost.

The students have the task to remotely operate a robot and adjust controller settings to achieve a given behaviour (Fig. 5). A video and audio stream with configurable data rate is transmitted from inside the lab over the Internet and the students can switch between two camera angles. After the robot has run through a given path, the measured data is displayed inside the web browser. Now the students have to make adjustments to adapt the robot to the desired behaviour.

Virtual seminars

Virtual seminars can be held by setting up a video conference between two or more locations. The multicast backbone (MBone) offers a cost-effective solution for realising seminars over the Internet. The MBone is an overlay network based on the Internet which allows efficient usage of network resources by using multicast transmission. Participants who want to take part in a MBone conference must make sure that their LAN is connected to a multicast enabled router. In Germany normally only universities are connected to the MBone.

There are several software tools available, most of them can be downloaded from the Internet for free. Typical MBone software packages include video- and audio-conferencing tools, a shared whiteboard and a chat tool.

In Fig. 6 a screenshot from a typical MBone seminar is displayed. This example shows a conference between Hagen and Munich. Prior to the seminar the students could choose whether they wanted to come to Hagen or Munich. The students at both location took turns in presenting their

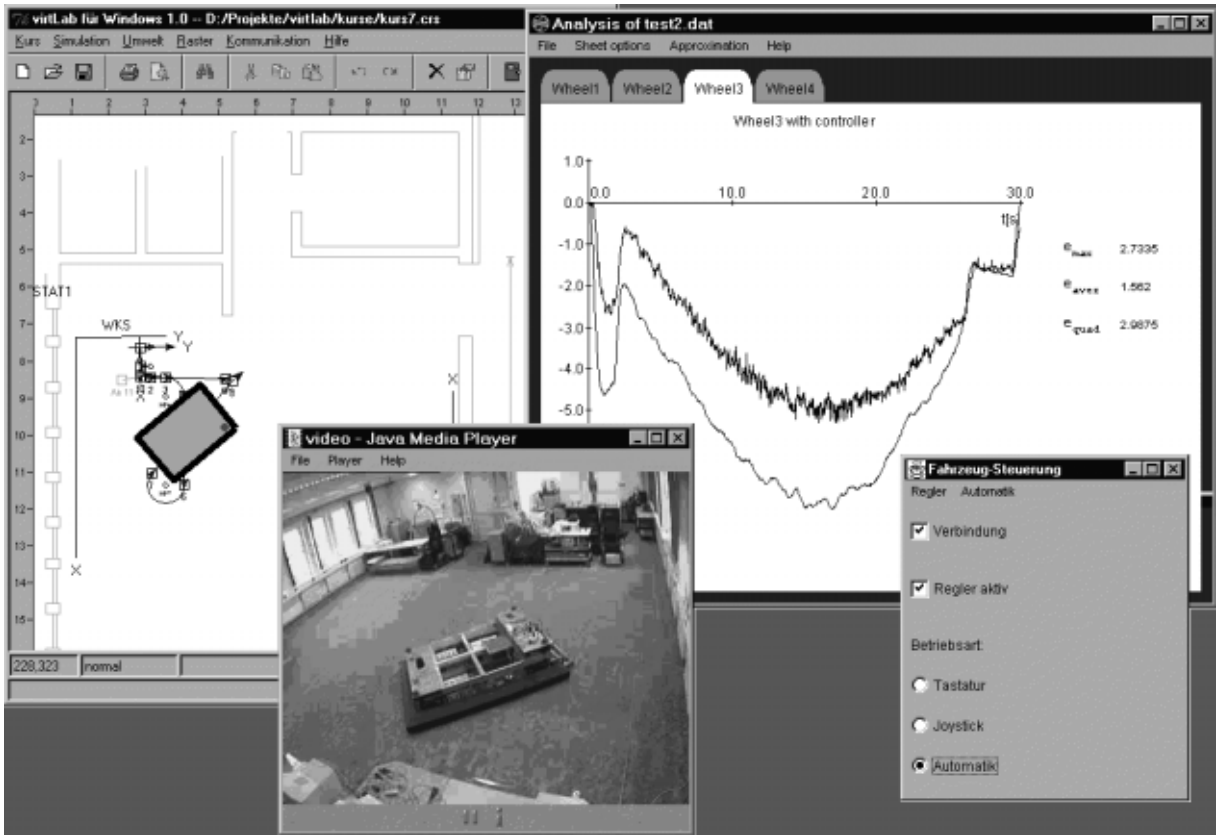

Fig. 5. Laboratory 'Real Systems in the Virtual Lab'.

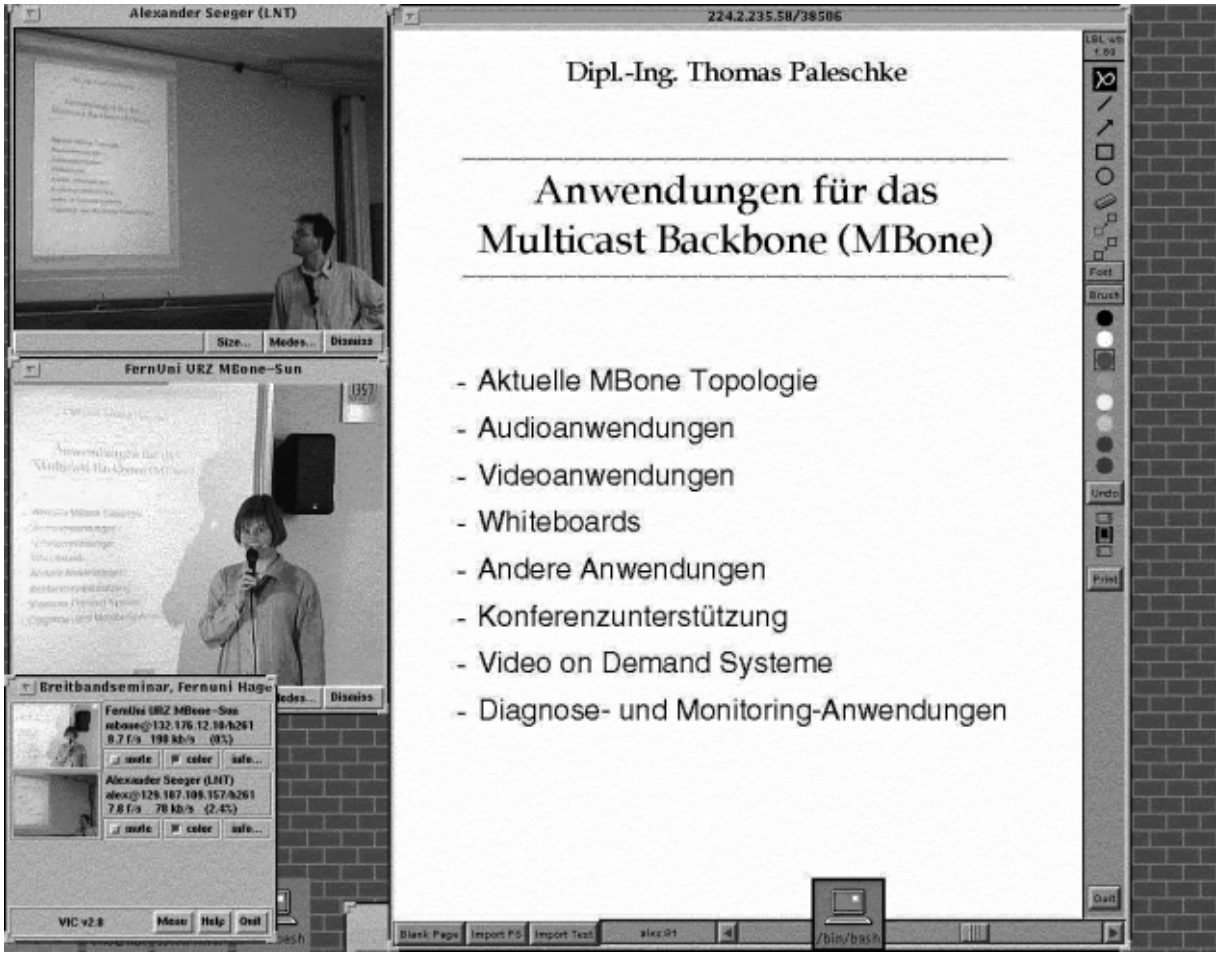

Fig. 6. MBone Video Conference.

contributions. The slides were presented in the whiteboard which could also be edited in real time. The video camera was operated in a way that it either showed the presenter or the audience. Between two presentations a microphone was passed around the audience to allow a discussion between the two locations. The event was coordinated by two moderators, whose main task was to manage the discussions. Students at a number of other sites could passively participate in the seminar (as watchers).

The experience with this kind of virtual events is that the organisational overhead is quite large. If the number of participants who benifit from such a distributed event is high enough to justify this additional overhead, a virtual seminar is a viable alternative to a traditional seminar.

Oral examinations

The university offers its students the possibility to carry out oral examinations by video conference systems. One way to realise a video conference has been presented above. A solution that is better suited for private persons and study centres not connected to the MBone is to use ISDN video conference systems. In Germany a single ISDN channel offers a data rate of 64 kbps. Professional ISDN conferencing systems like ProShare can bundle two channles to get an overall data rate of 128 kbps. It is not advisable to go below this bundled data rate because the quality will not be sufficient. With a simple point-to-point connection the costs for half an hour video conference are still within acceptable bounds.

For a legitimate oral examination the procedure has to be supervised by a trusted person, who certifies the correct identity of the student and assures a correct procedure. This can be achieved in several ways:

- the examination is carried out at a study centre;
- the examination takes place at another university;
- the examination is carried out at a Goethe Institute or a German embassy.

For examinations which result in 'passed/not passed' the remote aspects of the procedure normally have no noticeable effect on the result. This is different when the students get a grade. Often students are able to extract hints from the professor's body language. Since the perception of such fine cues is mostly lost through the video conference, students should be aware that the result can be worse than in a normal examination

situation. If the students are well prepared, though, they will not have to rely on such hints anyway.

THE TECHNICAL PLATFORM

To allow effective administration and personalisation ET-Online had to be based on a database system. In 1996 it was a natural decision to combine a web server and a relational database management system into a two-tier Internet solution. The work started by modelling all relevant features in an Entity Relationship Model. With the help of the ER-Model the database system was implemented and two views of the system were integrated.

The complete system is based on the following technical components:

- an Apache web server, currently running on a SUN workstation;
- a PHP scripting module as an extension to the web server;
- and a relational database management system PostgresSQL, currently running on a Linux PC.

The architecture is displayed in Fig. 7. All software components are freeware, and there have been no technical problems so far with the system, which currently administrates approx. 4000 students and 100 staff members.

The administration front end (Fig. 8) allows the teaching staff to enter and search for student data such as registration numbers, addresses, e-mail addresses, points for assignments, etc.. The front end is completely based on HTML which allows the staff to access the database from any web browser. There are several roles supported in the database: administrators, developer, user, guest, tutor, secretary, etc. A user only gets access to functions according to his or her assigned role.

THE ET-ONLINE SHOP

The new possibilities for digital multimedia contents, online services and student support account for the great potential of the Internet for distance education. In the last few years, more and more chargeable digital products and services are being offered over the Internet and its relevance as a commercial medium becomes greater. A crucial factor for the success of the business processes over open networks and therefore for the success of electronic marketplaces are the electronic payment systems, which are specially designed to answer the problems of payment transactions over insecure networks [9]. In order to enable secure payments they have to possess not only the features of the conventional payment systems but also some security features, which are realised using strong cryptographic techniques. Applying electronic

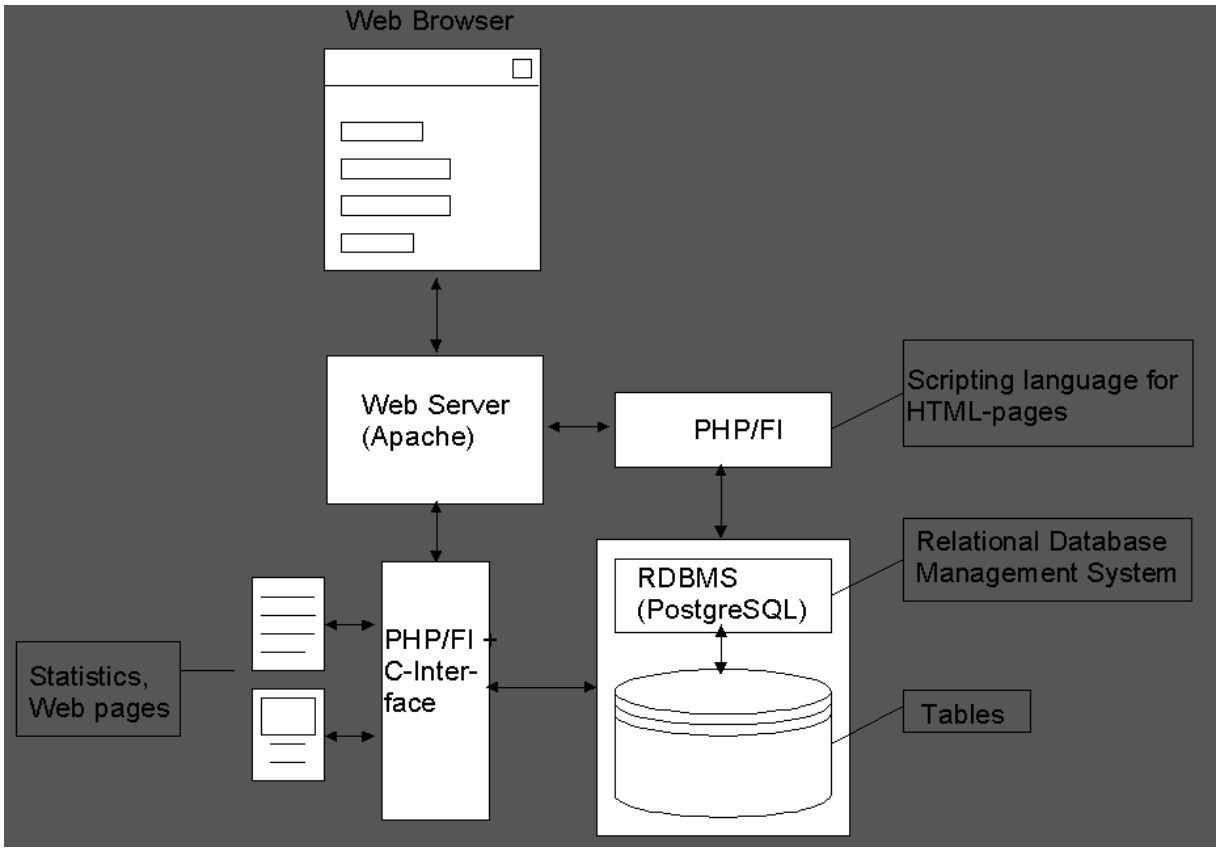

Fig. 7. Platform architecture.

Fig. 8. Administration front end of the database.

payment systems in online learning environments can make distance education more efficient and flexible.

The concept of the Virtual University at the University of Hagen includes not only conventional university level education, but also further education primarily addressed to people who have already acquired their university degree. The students are basically interested in a simple method of finding the material, a clear and unmistakable description of the topic, and an insight in the material in order to get a representative impression of its quality and quantity. In order to receive the material immediately, they are also interested in fast and reliable payment systems. Paying online electronically and getting the desired learning material instantly meets both the requirements of the students and the university [10].

Payment methods

We have analysed and compared some of the electronic payment systems designed for open networks. The systems Ecash and CyberCoin, currently provided by Deutsche Bank and Dresdner Bank, are well suited for this purpose. They are cash-like systems and have some of the attributes that makes cash attractive (acceptability, guaranteed payment, absence of transaction charges, anonymity) and allow efficient accounting of very small amounts (under 1 Euro). In ET-Online we have realised a prototype of an online shop (Fig. 9), in which a part of the offer (courses, animations, assignments) of the Faculty of Electrical Engineering can be bought online. Students can choose the material they want online; they can also pay online and download the material instantly. The purchase and payment process only takes a few seconds.

Online payments supplement the offer of the Virtual University by replacing the traditional transfers with transfers which now can be performed fast and conveniently over the Internet, enabling instant delivery of instruction materials and services. Applying electronic payment systems brings advantages both for the students and the educational organisation: more flexible teaching and learning systems, efficient administration and enabling of new kinds of offers, such as participation on chargeable online seminars and events (multicast video conferences), online enrolment for courses, chargeable database queries, etc.

At the moment the ET-Online shop is only a prototype and is not publicly available because the sale of university lecture material is not yet officially allowed in Germany.

SUMMARY

In this paper the Virtual University concept of the University of Hagen was presented. The activities in the Faculty of Electrical Engineering

Fig. 9. The ET-Online shop.

and around the ET-Online platform have been described. The ET-Online platform was part of the project 'Virtual University' and is currently becoming an open source product, and will be offered to three different educational institutions this year. The Faculty of Electrical Engineering will base its new bachelor study programme which is about to launch in autumn 2000 on ET-Online, and completely new web-based courses are currently being created.

During the four years of the project lifetime, experiences in many aspects of Internet-based teaching have been made. These include experience with authoring tools and diverse electronic formats. Furthermore, communication, tutoring, and special virtual events like online laboratories, virtual seminars and online oral examinations have been described in detail.

The project described in this paper is only part of the university's activities. At the moment the University of Hagen is making a concerted effort to combine all the different projects and prototypes into one Virtual University which will be ready for the European and global education market.

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