REAL-TIME CONTENT CREATION FOR MULTIMEDIA DIDACTICS

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INTRODUCTION

In order to solve the inevitable problem of lecture overlaps, to reduce problems of mobility, and, more generally, to promote the concept of Flexible University, the *Politecnico di Milano*, has developed flexibile tele-teaching systems that enable large numbers of students to remotely attend lectures as they take place, and to review previous lectures in an off-line fashion. In particular, PdM designed (and is currently using) advanced teleteaching facilities within the EC-sponsored “Blueprint for Interactive Classrooms” project [1]. Such facilities are ergonomically sound for lecture-stile presentations to large number of students [2,3]. They are based on two video contributions: the lecturer’s video and an additional video stream that accommodates presentation slides or an Over-Head Camera (top view of the desk) or a video contribution from a PC, a VCR, a DVD player, a codec, etc.

In this paper we propose a system that uses this teleteaching setup for effortlessly generating multimedia didactic content in real time. The goal of this system is twofold: a real-time creation/indexing of multimedia presentations to be accessed off-line through web-terminals connected to the University Intranet; and an implementation of novel tele-presence delivery mechanisms for the "virtual classroom" lecture delivery scenario. All this will allow educational institutions to update hypermedia didactic servers "on the fly" (with no re-editing needs), or to deliver a multimedia lecture while it is being given. Real-time didactic content creation is crucial for the development of Flexible Universities as it allows Academic Institutions to create didactic archives with modest effort and cost.

REAL-TIME CONTENT CREATION

A lecture is characterized by a highly asymmetric exchange of information between speaker and attendees; therefore its delivery is traditionally organized in a strongly sequential fashion. This need of a timeline makes the video of the lecture the backbone of this type of didactic presentation, which needs to be indexed in order to enable random access. The interaction with the lecturer, especially with larger classes, is usually limited to an exchange of questions and answers. Conversely, what is strongly encouraged is the interaction with the didactic material that the presentation is supplemented with. The additional didactic material that should supplement the lecturer's video is typically made of presentation slides, lecture notes, browsable hypertexts, virtual laboratory sessions (software sessions that enable students to validate concepts and experiment with them) and tests. A very flexible way to deliver additional didactic material is through a second video stream, synchronized with the first one, which could come from an Over-Head Camera (OHC), a VCR, a DVD, a codec, the video output of a PC, etc. In particular, the OHC gives the lecturer very natural and powerful means for showing all sorts of material without the burden of having to author it with specific software. In fact, lecturers often use an over-head projector to show transparencies. With an OHC it is also possible to show book pages, drawings, pictures, etc.

One key-aspect of a lecture-style didactic presentation is in the indexing of the multimedia material, which turns out to be particularly simplified. In fact, the indexing can be done using the didactic material itself. One quite straightforward way to insert index marks is to associate them with slide changes. Alternative indexing mechanisms could be associated to source switching, or scene changes in the additional video source. For example, when the OHC is used as an electronic blackboard, scene changes in specific sub-areas of the video could be used for triggering the insertion of a new index mark. However, real-time requirements on content production impose constraints on the type of material that can be displayed and on how it can be used by the lecturer. It is this crucial to design a student interface with limited and pre-assigned functionality.

SETUP AND SPECIFICATIONS

In order to produce meaningful specifications and conduct a preliminary study of its ergonomics, our system for the generation and the delivery of multimedia didactic material was first implemented as a mix of different technologies (html, java, AVI, etc.). The system was comprised of two basic elements: a student application (player); and a lecturer application, for automatically indexing the multimedia presentation. In its preliminary basic layout, the **player** displayed two video streams: a low-resolution one for the lecturer and a medium-resolution one for the OHC, while a series of slides appeared on a separate frame. The player also included simple browsing tools and controls, and enabled an indexed random access. Synchronization between data flows was guaranteed by specifically developed Java applications. The **lecturer application** was developed with a twofold goal: to convert a PowerPoint presentation into a series of pictures, and extracting index marks from slide titles; and to assist the lecturer during the slide presentation while keeping track of times of slide change. The extraction of index marks and time of slide change is essential to enable random access to the presentation.

The above setup allowed us to test the effectiveness of such lecture generation/delivery mechanisms and, most of all, to agree on a set of stable specifications for the development of a more advanced system. The final setup of the system was recently developed within the EC-sponsored OCCAMM project [4]. This work involved, in particular, the Politecnico di Milano, TILAB (Telecom Italia Laboratories), and Philips, Eindhoven. The result, in fact, is not just a fully single-stream MPEG4-compliant [5] version of the above system, but a system that integrates other services such as access control and protection of the intellectual propriety.

The importance of access control in tele-education applications is related to a variety of needs. The most important one is, indeed, dictated by the Academic Institution's necessity to motivate potential students to enroll to courses and pay the required tuition. Equally important is the need of the lecturer to know how many and what kind of students will, in fact, remotely attend the lecture (on line or off line), in order to assess the quality of the presentation and decide its content. Finally, in order to grant on-line students a certain degree of interactivity with the lecturer, there has to be a limit in the number of on-line attendees.

The current version of the system was developed as a testbed for the OCCAMM Project. The system, in fact, incorporates the latest encoding/decoding technologies, combined with state-of-the-art mechanisms for the management of the intellectual property. The system is made of three main components:

- **Service Centre:** includes a Multimedia Server, which makes the content accessible to remote users and hosts all the software required to manage content delivery (e.g. streaming); and a web site to select the lecture to view or to establish an on-line connection with the classroom during a live lecture.
- **Capturing Station:** consists of a set of utilities to prepare the content for distribution and use. These utilities include an encryption system, and a set of MPEG 4 encoders.

It also includes the teacher assistant GUI and the streamer, both based on Active X. The teacher assistant helps the lecturer channel all the audio-visual information generated during the presentation.

- **Student terminals:** client PCs are installed at the *Scientific Media Production Center* of the Politecnico di Milano. These terminals are equipped with smart-card readers, web browser, MPEG-4 player, Intellectual Property Management and Protection System (IPMPS) etc. Additional clients are also able to access the system from remote locations (e.g. home) through the Internet.

SYSTEM ARCHITECTURE

In the OCCAMM version of the tele-education system the content is encrypted by an IPMPS, which consists of a server (IPMPS License Server), and a client. The server is responsible for the creation, the management and the distribution of the licenses to the Client PCs. The Client resides on the Client PC (player) which communicates with the IPMPS License Server. All communications with the IPMPS (client and server) are secured.

The multimedia server of the **service centre** makes the content accessible to remote users. The server hosts all the software required to manage content delivery and, in particular, streaming software. The server can be accessed both locally and remotely. Local clients are connected through the local intranet, which benefits from a wider bandwidth. Users located outside of the local intranet may access the content in an off-line fashion. Downloading mechanisms allow remote users to view a scaled-down version of the lecture, in spite of the very limited bandwidth available. The service centre includes a web site (see Fig. 3) where the user can select previously recorded lectures to be viewed or establish an on-line connection with the classroom during the actual lecture. This web site contains a schedule of the on-line lectures that it will be possible for registered users to access; and a list of all previously recorded lectures, which can be accessed and browsed at ease by registered students in an indexed fashion.

The **capturing station** consists of a set of utilities to prepare the content for distribution and use. These utilities include an encryption system, and a set of MPEG4 encoders. All the content prepared by the Production Station is streamed onto the LAN through the Multimedia Server. The capturing station can be functionally divided in two basic components, each of which may reside on a different machine: the teacher assistant GUI and the streamer, both based on Active X. The teacher assistant manages the channeling of all the audio-visual information generated by the lecturer during the presentation. Exactly like the preliminary (Java-based) system, this information consists of two video streams, one (lower-resolution, normal frame-rate) of the lecturer or other video material; and one (higher resolution, lower frame rate) of the slides of a computer presentation or the output of an OHC. The slides have a twofold purpose, to provide the lecturer with a trace of the presentation, and to enable an automatic indexing of the lecture. The teacher assistant converts the slide presentation into a format (JPEG) that can be easily incorporated into an MPEG4 streamed file, and generates a series of indices (slide titles) that will be time-stamped as the lecture progresses. The GUI provides the lecturer with standard tools for controlling the presentation, such as buttons for slide change control, for switching between video contributions, to begin, pause or end the presentation, to force a video contribution to pup-up on the student terminal, etc.

Three **student terminals** are installed at the *Scientific Media Production Center* of the Politecnico di Milano, each in a separate viewing room. Students that intend to view on-line or off-line lectures may do so after a preliminary identification and validation process. An authorized student is able to browse a lecture catalogue and get the appropriate license to connect to an on-line lecture, or view a specific recording. A number of additional student terminals has been set up from remote locations outside the University Intranet, and are able to access the didactic material through the Internet in an off-line fashion. A student wanting to

access the lecture content go through an authentication process based on a smart card. Students who require the low-speed remote access to the service, are assigned a smart card for this purpose and a smart-card reader.

FIELD TESTS

The system proposed in this paper is being extensively tested "on the field" at the Politecnico di Milano by a fairly large core of students (approx. 200) of Electrical Engineering and Computer Science. The testbed course is on Image Processing, and it involves local students and remote students from the city of Como. Right after the end of the lecture, the multimedia presentation is automatically made available in the didactic server for off-line delivery. A new version of the system, able to provide real-time delivery, is currently being finalized and will be available for field testing soon. Preliminary feedback from the users confirm the didactic effectiveness and flexibility of the system.

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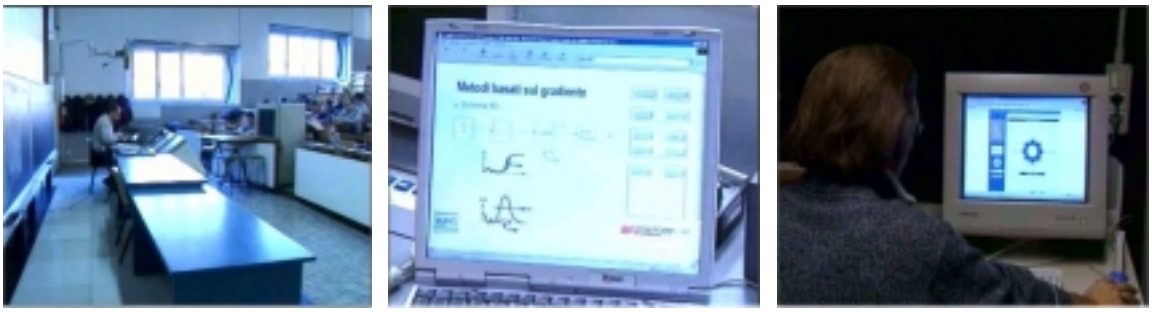

Fig. 1: A view of the classroom (*left*): the lecturer's videos come from the OHC and a front camera; a view of the teacher assistant SW (center) while it is being used by the lecturer; and a view of the student's station (*right*) while it is being accessed by a student.

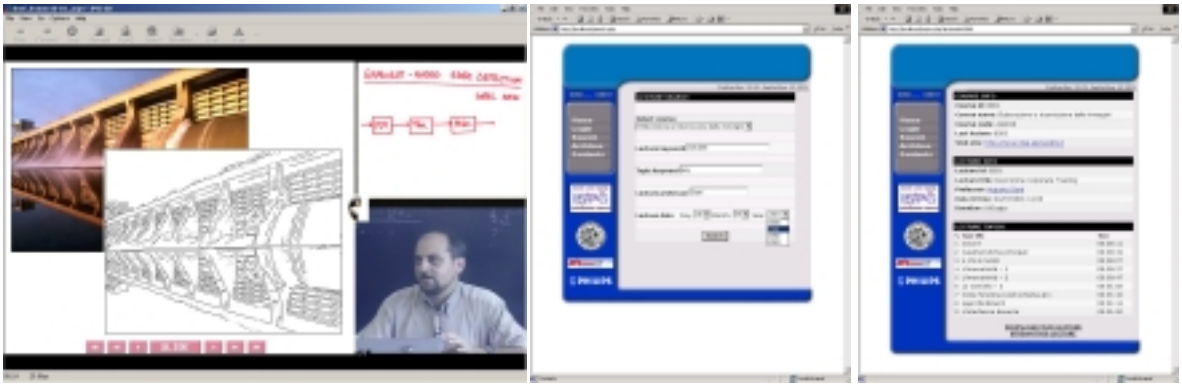

Fig. 6: From left to right: a snapshot of the student interface; of the didactic server's search engine; and of the didactic server's content browsing window.