

# Multimedia-based Distance Education on the Internet: Challenges and Experiences

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## Abstract

Providing multimedia-based courses over the Internet is a challenging task. Technological requirements are far more binding than for simple HTML based courses as in traditional web-based teaching. Low-cost multimedia technologies, in particular technologies for video production and delivery over the Internet, have just become available. Established rules and recommendations how to use those technologies effectively are still missing. In this paper, different approaches to the production and delivery of multimedia-based courses are outlined and illustrated by examples. A specific focus is set on videos as the main instructional medium. The examples are taken from real courses that have been produced for an Internet-based study program leading to a master's degree in Business Informatics. This program is provided by a virtual organization. Experiences reported are based on course material for that program. Technological restrictions in today's tools and ways to overcome those restrictions are discussed. All facets of producing lecture videos require a significant phase of learning and getting acquainted with the technology. A learning curve could clearly be observed.

## 1 Background of the Work

Most educational programs require the physical presence of students at the location of the institution providing the program. This can be a barrier for some types of potential students, for example people who work in a job, people in the third world for whom the cost of living in an industrialized country and the travelling expenses are prohibitive, handicapped persons, and many others.

Distance education has been tried for many years as an approach to overcome some of these problems. Although there are successful programs and institutions, major drawbacks have always been the media used for instruction, the communication channels, and the way teachers and students interact.

In recent years, paper as an instructional medium and postal communication have been substituted by remote online presentation and communication forms. In Europe, advanced multimedia technologies for higher education have been investigated in research projects and prototypical courses over the past 10 years [e.g. Bodendorf, Grebner 1998]. Most of those approaches, however, required expensive installations like videoconferencing rooms or special studios and networking equipment. Some lived only as long as public or private funding was provided.

Today, Internet based technologies have become available and matured to a degree that distance education can be put on a new foundation. In contrast to the aforementioned multimedia projects, commonly available Internet services and tools nowadays provide useful features which are very attractive for the creation of distance education programs. Educational institutions can provide content and teachers can interact with students independently of their geographical location. Theoretically everybody who has a computer and Internet access can take part in Internet based distance education. In practice, however, there are a number of problems to take into consideration.

In this paper, an approach to distance education based on multimedia and Internet technologies is described. This approach has been applied in the development of a master program in Business Informatics [Kurbel 2000]. The rationale underlying this program is "virtuality". Students study at home or at their workplaces, and they communicate via Internet. The same applies to the teachers and their organizations. They are also distributed, i.e. residing at different physical locations. In this way, a worldwide community of students and teachers is interacting in the World Wide Web.

Providing multimedia-based courses over the Internet is a challenging task. Technological requirements are far more binding than for simple HTML based courses as in traditional web-based teaching. Low-cost multimedia technologies, in particular technologies for video production and delivery over the Internet, have recently

become available. Established rules and recommendations how to use those technologies effectively are still lacking.

In the subsequent sections, different approaches to the production and delivery of multimedia-based courses are outlined and illustrated by examples. Specific attention is paid to videos as a major instructional medium. The examples are taken from real courses of the "International Master of Business Informatics" (MBI) program provided by the Virtual Global University (VGU). VGU is a virtual organization [Davidow, Malone 1992] founded by a network of professors from distinguished European universities. Experiences reported are based on course material produced and used in that program.

## 2 Multimedia Techniques Employed in the MBI Program

Many courses and programs in today's virtual education are still text and paper based. We will refer to those as "traditional" virtual courses and programs. For the master program underlying this paper, multimedia technologies above the text-based level are playing a major role in the instructional design. The following technologies and instruction modes were chosen for the MBI courses.

### 2.1 An Experimental Video Course

Our first trials to approximate the look and feel of a real lecture in a real classroom were videos taken in a lecture hall and provided for viewing. With powerful video processing and encoding tools (like Media Studio Pro<sup>1</sup>, Windows Media Encoder<sup>2</sup>) and easy-to-download video players (e.g. Windows Media Player<sup>3</sup>, RealPlayer<sup>4</sup>) available today, video recordings were the primary choice as media type for MBI courses. Watching a lecture recorded in a real or simulated classroom comes close to listening to a real lecture. Slides, blackboard writings and other types of illustrations are recorded here along with the speaker.

Video files are not downloaded completely before playing but transmitted in a streaming format. This is clearly an advantage since video files tend to be very large. However, even with a streaming format severe restrictions regarding the data transmission rate are in effect (see section 3). Therefore the size of a video window is normally kept small so that the file to be shown will need less space and the audio and video quality finally reaching the viewer is still acceptable.



Fig. 1: Demo of a recorded lecture video<sup>5</sup>

<sup>1</sup> <http://www.ulead.com/msp>.

<sup>2</sup> <http://www.microsoft.com/windowsmedia>.

<sup>3</sup> <http://www.microsoft.com/windowsmedia>.

<sup>4</sup> <http://www.real.com>.

<sup>5</sup> The figure shows Prof. Dr. Karl Kurbel, European University Viadrina Frankfurt (Oder), Germany.

The limited size of the window on the monitor's screen is a problem when both the person giving the lecture and the material used for illustration are recorded in one video. While a small window of, say, 9 x 6 cm, is sufficient to see (and hear) the speaker explaining things, it may be too small to allow the user to recognize what is written on the transparencies. For transparencies with large fonts like in figure 1, the one-window approach may still be all right. However, when online computer screens are recorded in this way, nothing will be readable for the viewer any more.

## 2.2 Multimedia Courses Based on Video plus Presentation Material

The aforementioned problem can be avoided if the person giving the lecture and the material used for illustration are presented separately. Production of this type of video is more complicated since now the two components need to be synchronized. The video showing the speaker is recorded with a camera. If the camera is not a digital but an analog one, the recording has to be digitalized afterwards for further processing.

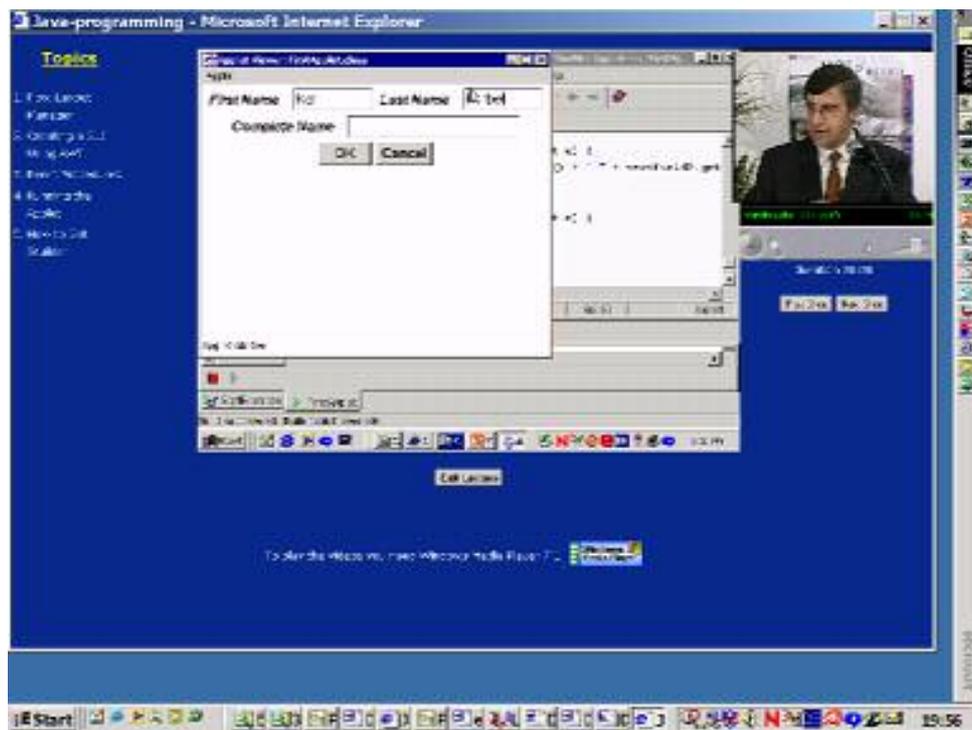


Fig. 2: Video with online screen recording<sup>6</sup>

When computerized presentations are used, for example Powerpoint slides, a different technique for recording the presentation material can be employed. Since slides do not move like a person speaking does nor change continuously, they can be converted to a sequence of static files, e.g. GIF files. Since GIF files are smaller than videos, less bandwidth is needed. In return the window size on the screen can be increased significantly.

If a realtime program presentation, for example a demo of a CASE tool or an ERP system, is shown and discussed by the lecturer, a video containing the presentation material is recorded by means of a screen recorder (e.g. Screen Corder<sup>7</sup>). In fact, static images like Powerpoint slides can also be recorded in this way. Figure 2 shows a screendump of a video-based course from the MBI program where both the lecturer and the presentation material are recorded and played in separate windows.

## 2.3 Audio-based Courses with Presentation Material

Video production is a non-trivial task requiring experience and plenty of time. Low transmission rates are hampering the delivery of videos over the Internet. One way to bypass part of these problems is to use only an audio track instead of an audio-visual presentation of the speaker. Sound can be used nicely in combination with Powerpoint slides or other presentations to form something like a "narrated slide show". Like in a real classroom,

<sup>6</sup> Showing Prof. Kurbel in the MBI course "Java Programming".

<sup>7</sup> <http://www.matchware.net/sreencorder2/default.htm>.

the speaker explains the things illustrated on transparency or slide; however, he or she is not visible. This is clearly less "lively" than a video accompanying the presentation material but a lot easier to produce.

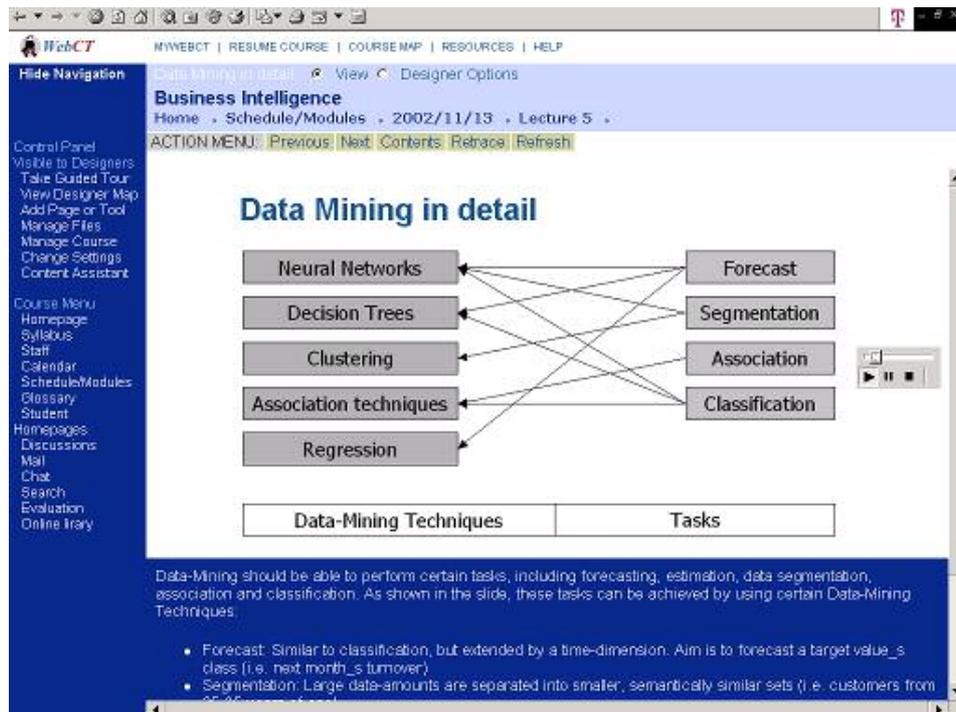


Fig. 3: Audio track and Powerpoint slides<sup>8)</sup>

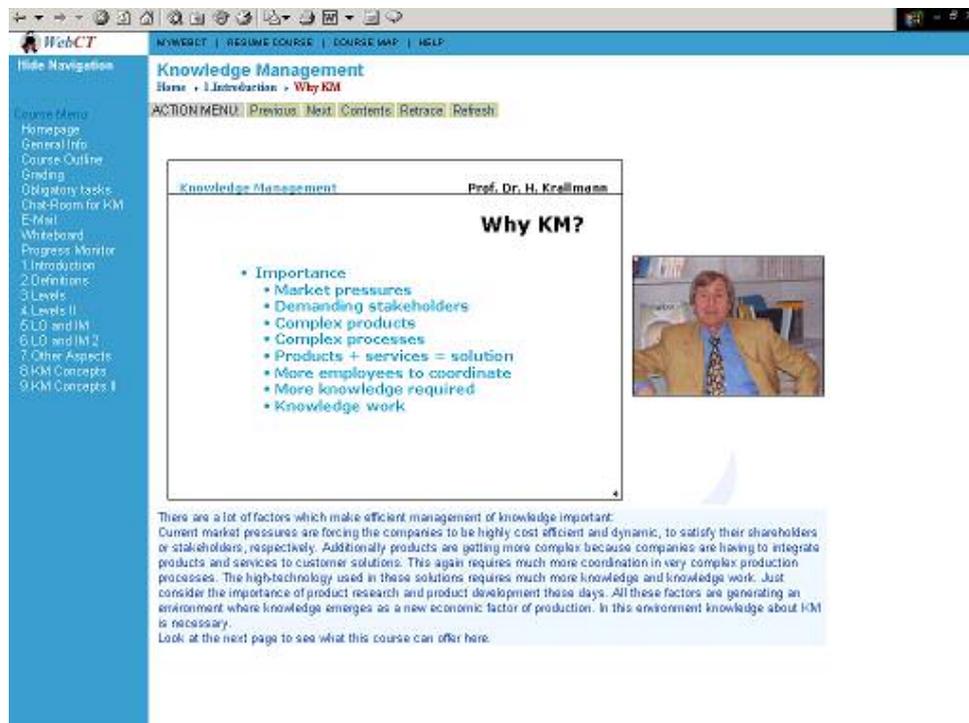


Fig. 4: Audio track, slides and text annotation<sup>9)</sup>

<sup>8)</sup> Showing material of the course „Business Intelligence“ by Prof. Dr. Karagiannis and Prof. Dr. Alfred Taudes from Vienna, Austria.

Just listening to an audio track may be tiring for the viewer. More than in a video-based course, there is some risk that the viewer may miss important points which are discussed by the lecturer but perhaps not stressed sufficiently. For this reason, audio-based courses can be enhanced by supplementing the lecturer's monologue with text passages transcribing the speech in full or in parts. Figure 3 illustrates this approach by a screndump from another MBI course (for obvious reasons without sound in the proceedings version). A text transcription is provided below the slide.

To make this type of presentation appear more personal, a picture of the lecturer can be included in the web pages as in figure 4. An alternative way is to start each lesson with a short video introduction by the lecturer and then present the actual content of the lesson in an audio track and static slides.

## 2.4 Hypertext-based Courses

This type of course follows the traditional text-based approach. Structured course material is used as in a conventional distance education program. However, all material is provided electronically and can be viewed with a browser. Hyperlinks connect text, graphics, and exercises in a meaningful way. Video clips and voice annotations may be included as well. Figure 5 shows a screndump of a hypertext-based course from the MBI program.

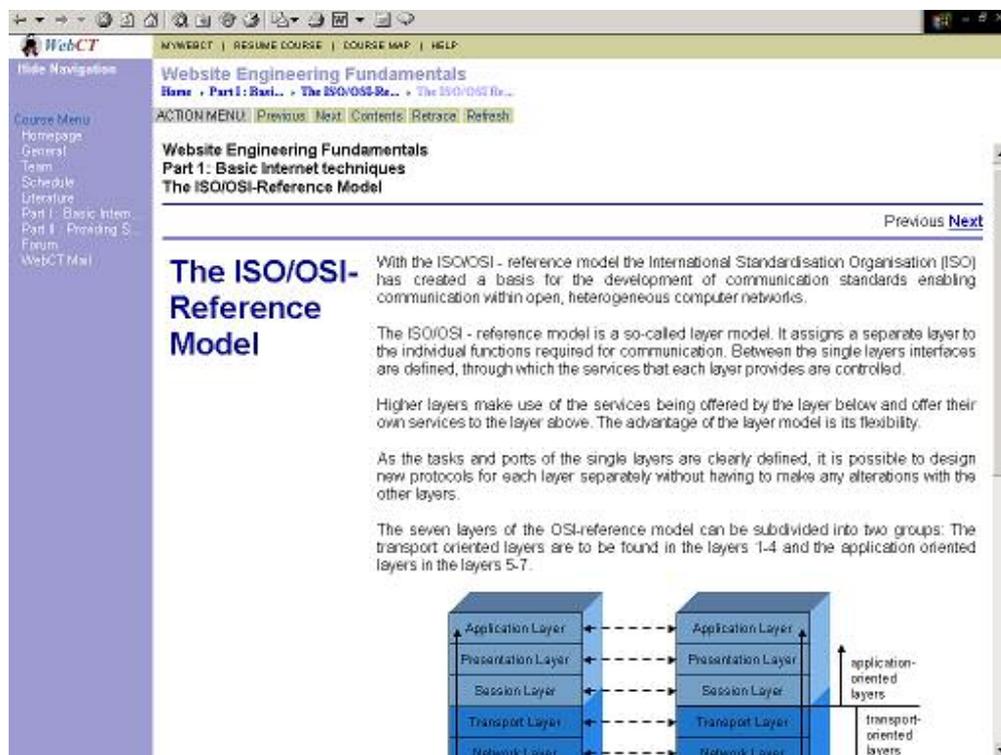


Fig. 5: Text document (HTML)<sup>10</sup>

## 2.5 Courses Using Animation

Enriching text-oriented or audio-based course material by animations is a good way of making the content more interesting and keeping the student's attention. Animations of different types are used in several of the MBI courses. Content-specific animations are occasionally employed to illustrate certain concepts, for example, the flow of calculations in material requirements planning (course "Enterprise Resource Planning and Beyond").

On the other hand, entire courses can be based on animation technology. Figure 6 shows two screenshots of a course where Macromedia Flash<sup>11</sup> is used for the production and presentation of course materials. Obviously the

<sup>9</sup> Showing Prof. Dr. Hermann Krallmann, Technical University of Berlin, Germany, in course "Knowledge Management".

<sup>10</sup> Material by Prof. Dr. Stefan Eicker, University of Essen, Germany, from course "Website Engineering Fundamentals".



## 2.6 Textbook-based Courses with Multimedia Techniques Incorporated

An increasing number of textbooks comprises not only written and printed text but also supportive features provided on the website of the author and/or the publisher [for example, Griffin, Ebert 2002; Laudon, Laudon 2002]. Nowadays the support goes far beyond additional exercises or examples not given in the book. Some books have a complete learning environment in the Web, providing videos, audio clips, and interactive exercises.

Selected courses of the MBI program are based on web-supported textbooks, thus enriching the traditional text-based approach to virtual education with built-in multimedia features.

## 3 E-Learning User Interface with Two Video Streams

From a technological point of view, video-based courses are the most advanced ones in VGU's multimedia mix for the MBI program. Following the paradigm of lecturing and visualizing, the user interface of the Virtual Global University's video-based courses as it is presented to the student is outlined in figure 7. The crucial part of the web page is the Media Player in the upper right corner. In this corner a video of the lecturer is running in a streaming compatible format.

The area left of the player is used to show visual materials accompanying the lecturer's explanations. In the simplest case these are text slides, tables, diagrams, charts, etc., similar to information that would be written on a blackboard or an overhead projector in a conventional lecture. In addition there are controls for user interaction with the course page, for example starting the lecture, advancing or going back to a certain topic, etc.

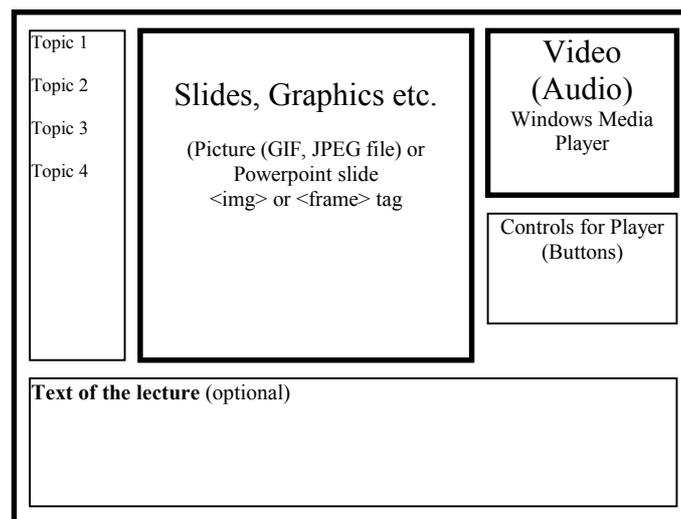


Fig. 7: Functional diagram of a course page [Kurbel, Pakhomov 2002]

Basically there are two different approaches to provide visual material plus video lecturing for such a course. The first way which is fairly easy to achieve is to split up the lecture in separate topics and store the respective video clips in separate files. If the topics are associated with slides, then each topic, including the video clip, will be started separately.

Although this solution is easy from a technical point of view it is not always feasible to split up a lecture in such a way. Moreover, only static images can be used as accompanying visual information. Displaying online recordings of program runs, for example, or videos shown by the lecturer is not feasible in this way.

One possible solution for this problem is to use a pop-up window in which the second video runs. However, this is uncomfortable, requiring time for connecting to the media server and for preloading/buffering some video data.

In some situations it is better to use two synchronized video clips. Sometimes this is even the only possible solution. One example is the production of multilingual content. Here it is advisable to separate a video file with

visual material from sound files in which different languages are represented. This solution saves space on the hard disk, proportional to the number of languages and to the size of the video file.

In the general outline of a course page as shown in figure 7 the area for visual material can be used for displaying a video stream as well. How this is achieved will be discussed in section 5. For the student there is no difference in the graphical user interface no matter whether static files or videos are displayed. Technology dependent peculiarities are hidden behind the user interface.

## **4 Producing Video-based Courses for Delivery over the Internet**

Subsequently we will take a closer look at how to make lectures available on video for a global audience. The fact that students can be distributed worldwide implies not only different time zones but also a variety of different qualities of Internet access. Some people have very fast access but others have to cope with slow dial-up connections.

As a consequence, unless everybody is served with the smallest common denominator (i.e. the least audio and video quality), different versions of the lecture videos have to be designed for different target groups. For VGU's video-based courses the following categories of users are considered.

### **4.1 Very Fast Internet Access**

The best video and audio quality is obtained when the Internet connection speed effectively reaching the viewer is above 300 kbps (kilobits per second). This is the case, for example, with ADSL (asymmetric digital subscriber line) connections promising a nominal speed of 800 or 1,500 kbps, or with computers directly connected to a network by dedicated lines and a LAN (local area network) as it is the case in large companies, universities, and the public administration sector.

The frame rate used for the lecturer's video is 25 fps (frames per second) in this version. The size of the window in which the video runs is 320 x 240 pixels. The second window, containing Powerpoint slides or screen recordings, has 800 x 600 pixels, implying that the viewer's screen must have a resolution of at least 1152 x 864 pixels.

### **4.2 Fast Internet Access**

The second best video and audio quality is delivered to viewers who have an Internet connection close to 300 kbps, i.e. an effective data rate of 225 kbps. Compared with the first version, the frame rate of the lecturer's video is only half as high. Through trial and error and during a long learning phase we found that a frame rate of 12 fps is the best compromise between quality and bandwidth requirements, maintaining both clear focus and smoothness of the lecturer's movements. The screenshot of figure 2 above was taken from a video with these settings.

### **4.3 Fairly Fast Internet Access**

Users with an Internet connection of above 100 kbps are served with a video version that provides still fairly good video quality; however, some errors from automatic compression may show. For example, when the lecturer moves fast, the quality of the video decreases. In the worst case (very fast movements), the video may even exhibit small gaps.

The quality of presentation material accompanying the video is not affected. When GIF files are used, the resolution can be kept at 240 x 180 pixels as in the previous version for 300 kbps.

### **4.4 Moderate Internet Access**

This video version is for students who have an ISDN (integrated services digital network) connection to the Internet, i.e. a transmission rate of 64 kbps. The video quality is a little below the 100 kbps version but still on an acceptable level. Sensitivity against fast changes of the pictures (e.g. moves of the lecturer) is the same as in the 100 kbps version.

Some reduction in size had to be put into effect regarding the window for presentation material. Powerpoint slides and other material is now displayed at a resolution of 176 x 132 pixels only.

#### 4.5 Slow Internet Access

In order to serve persons with a modem dial-up connection, low-end videos with fewer frames per second, 8 fps, are produced. Although this is only one third of the frame rate of normal Internet videos, the visual appearance is still reasonable if no rapid changes of the pictures occur. Since a lecturer normally stands or sits at a desk but does not jump up and down when being recorded, the effect of reducing the frame rate is merely that movements appear slowed down or with delay. The modem speed expected for this version is 56 kbps.

#### 4.6 Very Slow Internet Access

It may be questioned if multimedia-based courses make sense for students who can access the Internet only through a 34 kbps modem -- and how long such connections will survive in the future. However, there are major parts of the world where this type of Internet connection continues to exist (or is yet coming into existence).

In our experiments we found the solution to be similar to the variant described in section 2.3 (audio-based courses with presentation material). By giving up the video component in favor of an audio track we achieved a version with very good quality of sound and presentation material. Although the user is expected to have at least 28 kbps available, this type of course runs even with a data rate as low as 16 kbps.

### 5 Integrating Separate Video Streams: Fundamental Problems

Creating course pages like the one in figure 7 proved to be difficult due to severe restrictions imposed by the tool used (Windows Media Player). The object model of the Windows Media Player provides little of the functionality needed to run two videos in asynchronized manner. Even if more connection bandwidth is available than required by the sum of the bit rates of two video streams, one cannot expect that the bandwidth will be divided in proportion to the bit rates of the streams, nor even equally. The methods and properties available to the developer do not support tasks like controlling the stages of client-server interaction and (re-) distributing connection bandwidth among two players adequately.

This shortcoming implies that two video files will rarely start playing simultaneously even if they have exactly the same parameters (e.g. resolution, codec, file size). The synchronization task is thus left to the producer of a course.

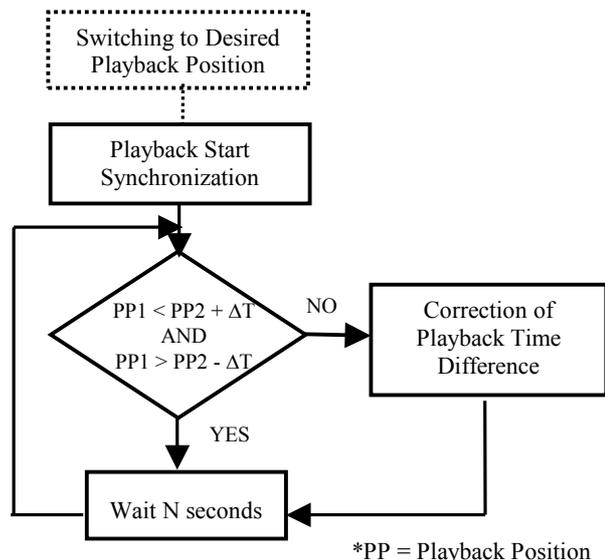


Fig. 8: Synchronization algorithm

To guarantee proper appearance and behavior of video-based courses we developed and implemented an algorithm for synchronizing and monitoring two video streams. It has components as shown in figure 8:

- Synchronizing playback start,
- Monitoring synchronized playback of two videos,

- Corrections if synchronization is off,
- Setting two players to specific positions on demand.

### *Synchronizing the Start of two Players*

Since two players hardly ever start at the same time a method of ensuring synchronized start is needed. The source of the problem is actually different data compression algorithms in the codecs used.

One video file in a course page as outlined above originates from screen capturing with Matchware Screen Corder 2.0<sup>13</sup> and is translated into a streamable format with the Windows Media Video V7 Screen codec. The conventional camera recording is compressed with the Windows Media Video V8 codec.

Because of the particularities of these codecs a procedure is needed which checks the states of the players. When the first one is ready to play its video, the procedure checks the state of the second player and waits until the second one is also ready to start.

### *Monitoring Synchronized Playing*

Once playback has started it is necessary to check at regular, possibly short intervals if the two videos are still in the correct positions. The playing times can be measured in seconds or frames from the start of the files. If a difference is detected and if that difference exceeds a certain limit a procedure is started that eliminates the time lag of one player.

### *Correcting Differences in Synchronization*

This procedure pauses the player that is running ahead and checks playback of the late player. This is done until the slower player has approximately caught up with the other one. Then the first player is released to continue playing.

One serious problem, however, needs to be observed. Due to various reasons the players can change their states (like playing, pausing, buffering, etc.) between individual calls of the procedure and even during the execution of the procedure. Reasons for this may be, for example, actions by the user, reaching a marker in the video file, or a state change in the connection with the Media Server. Therefore additional monitoring of the states of the two players not only at the beginning but also during playback is very important. Otherwise the procedure can crash or the user's web browser can get frozen.

### *Setting two Players to the Same Position*

As indicated in figure 7 the user may jump directly to a specific topic of the lecture forwards or backwards by clicking on a control on the left-hand side. In such a case both video files have to be advanced or set back to the desired positions in a synchronized way. Once this is achieved both players have to continue or start playing at the same time. This is basically the same problem as ensuring a synchronized start of the two players in the first procedure, so that procedure can be adopted and reused.

## **6 Experiences and Conclusions**

Since multimedia technologies at low cost or even for free have just recently become available, reliable experiences and recommendations how to use them are still lacking. Therefore the settings chosen for the above video versions had to be largely gained from trial and error. The same is true for specific tools employed. For example, our video versions are being compressed with the Microsoft Media Video V8 codec. As an alternative, the MPEG-4 V3 codec might be considered. The quality achieved with either codec appeared to be the same at first sight. However, after some trials we found specific parameter settings that gave the Microsoft Media Video V8 codec a clear advantage over MPEG-4.

All facets of producing lecture videos require a significant phase of learning and getting acquainted with the technology. A learning curve could clearly be observed. In the beginning of our efforts, the time to produce a sequence of video and audio material for a 90-minute lecture took almost two weeks elapsed time after the video

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<sup>13</sup> <http://www.matchware.net/>.

had been recorded, keeping two persons completely occupied. After one year of production and hands-on experience with videos, this time has decreased to two days (still keeping two people busy).

The multimedia versions outlined above were tested and tried from locations all over the world. The ADSL version basically ran without problems in Germany. It was possible to view the ISDN version in locations in the Middle East (Dubai) and in India, for example. Slow access versions were available all over the world. The author saw the slow-access version (56 kbps) in a normal home in a mid-size town of Central India and was able to listen to the low-end version (28 kbps), in good audio quality, in a small village of the same area. Nevertheless, coping with small bandwidths and keeping quality at an acceptable level at the same time is a matter of trade-offs.

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