A Multimedia on Demand System for Distance Education

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Abstract: This paper describes the Multimedia on Demand (MoD) System developed at Polytechnic School of University of São Paulo. MoD System brings an environment and its infrastructure for multimedia material production, storage, management and on demand or real time distribution applied to distance learning. To design of such system, it was necessary to analyse the requirement of each media and to specify the network infrastructure. We consider the development of some applications and services offered by the system, and tools for evaluation and course configuration. These development activities, and the next steps for the MoD System expansion are presented.

1. Introduction

The communication and data process technology evolution made available the infrastructure for the development, transmission and distribution of numerous multimedia applications ranging from distance education to entertainment. The multimedia distance education application can bring a lot of benefits. The educational institutions will be able to attend a large number of students and these students can stands geographically distributed. In the asynchronous communications mode (e.g., communications without synchronized presence), the remote course user can do it according to his own speed and rhythm. Moreover, if the multimedia material is well-employed, it will stimulate the user who can try some useful virtual learning experiences.

The communication infrastructure of our system is based on the ATM (Asynchronous Transfer Mode) network technology. ATM delivers presents important advantages over existing LAN and WAN technologies, including the promise of scalable bandwidths unprecedented performance and Quality of Service (QoS) guarantees, which facilitate new classes of applications such as multimedia [Alles(1995)]. Firstly, we consider only the use of asynchronous communications (World Wide Web and e-mail), but with the system growing it will also be considered synchronous communication (videoconference and the use of shared whiteboard).

2. System's Architecture

In order to offer an on-line multimedia course, it is necessary to create a client/server structure capable of, in the server side, to store, transmit and integrate all the involved media, and in the client side, to receive and adequately reproduce the educational material. The customer will use a browser and plug-ins for audio and video, already available at Internet. In the server side it is necessary to architect a system to hold all the course material.

The required media can be divided in two parts [Fluc1995]:

- Discrete media, where only spatial dimensions are involved (texts, hypertexts and pictures);
- Continuous media, that involves as spatial as temporal dimensions (video and audio).

The discrete media storage and distribution do not cause difficulties usually due to the small volume of data that these media present. For the continuous media, we must consider that the system intends to implement transmission in real time[Delo1994], that is, the audio and video data will be transmitted on demand. Although audio is a continuous media, it imposes small transmission rates, mainly when some compression technique is used, as it is shown in table 1. Digitized video presents great volumes of data, even in the case of pictures in movement or graphical animation, as shown in table 2. In spite of compression techniques (table 2.b), the difficulty in its storage and transmission requires certain cares.

The structure designed for our application uses LARC local network features, which is based on an Internet site. For this proposal we have integrated a high-speed network (ATM - 25 to 155 Mbps) with a video server,

file server, Web server and clients machines interconnected, complemented by tertiary storage specific for videos. The architecture of this system is shown in figure 1. Another machine is used to digitize (analog/digital capture) and compress the video. The digitization is necessary when the video material was produced in analog camera and is stored in videotapes (VHS,SVHS,HI8,Betacam). The video transmission presents many properties in common with other media transmission. However, there are two aspects specific for video: the great volume of data and the necessity of real-time transmission. Because the great video files volume, it is necessary to use techniques for the efficient compression to store and transmit video in the available bandwidth. Several techniques and standards for compression have been developed in the last years with the intention to reduce the required transmission rate for video signal. Among them we can mention Motion JPEG, MPEG-1[Mitc1996] [ISO/1991], MPEG-2 [Hask1997] e o H.261 [Fluc1995], those have been shown the most promising ones. Most of the compression techniques used by these standards are with losses, eliminating spaces and temporal redundancies. Therefore the picture quality reduction, usually is not perceivable [Keny1994], and the volume of data may be drastic reduced. Although some of them results in high compression and consequently, low transmissions rates, compared with the conventional analog systems, the obtainable transmission rates are still high enough for the applications over the Internet. ATM is a technology that well-accommodated this kind of media. Table 3 shows the rates gotten for each standard.

Audio Quality	Specifications	Bit Rate
Voice-quality audio	1 channel, 8-bit samples / 8kHz	64 Kbps
Encoded voice	G.728 Standard, 3.4 kHz	16 Kbps
Monophonic audio	1 channel, 16-bit samples/44.1kHz	705.6Kbps
CD-quality audio	2 channel, 16-bit samples/44.1kHz	1.411Mbps
MPEG encoded audio	Equivalent to CD quality	384 Kbps

Table 1 : Transmission rate for compressed audio and video.

	Resolution	1 minute	1 hour
a	640 x 480	1.6 GB	97 GB
	320 x 240	400 MB	24 GB
b	640 x 480	16 MB	970 MB
	320 x 240	4 MB	240 MB

Table 2: Video signal estimated values (a) uncompressed (b) compressed (bytes).

Standard	Bandwidth	Comp. Ratio
Motion JPEG	10-20 Mbps	7-27:1
MPEG-1	1.2-2.0 Mbps	100:1
H.261	64Kbps-2 Mbps	24:1
MPEG-2	4-60 Mbps	30-100:1

Table 3 : Bandwidth Requirements for Moving Pictures.

So, a special structure is necessary to deliver video. The video server has a Disk Array (multiple disks), allowing the content to be divided and stored in blocks of data. The block size must be chosen in order to

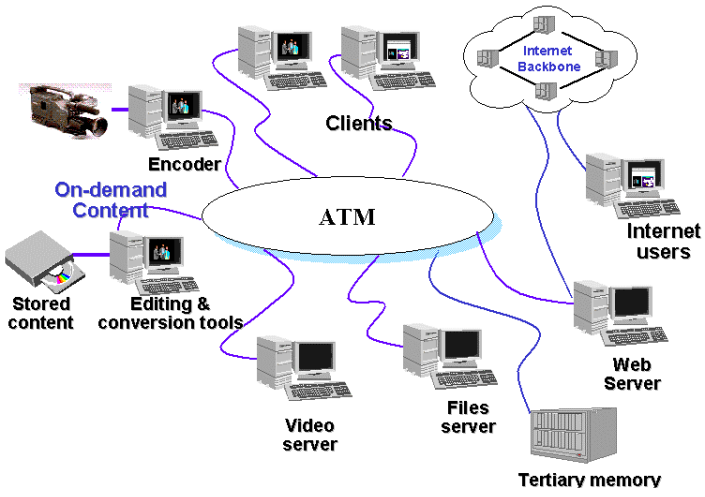

Figure 1: Multimedia on Demand System structure.

balance the efficiency of disks and the transmission.

Once established, this block size will be applied throughout the system. The blocks are stored sequentially in slots. In a typical exhibition, the disks read the numbered blocks and they deliver them to the respective customer through the network. This is called striping technique [Gemm1995], and it allows users have access to the same video in subsequent times.

The video server stores the most recently used videos, while the others are stored in a tertiary memory. A jukebox is used for this purpose. When a requested video is in the tertiary storage, the server locates the video in the jukebox, placing it in the video server for transmission to the customer. This structure is connected to the Internet by 2 Mbps communication links. The other media type are stored in the Web server.

3. Applications and Services

The infrastructure described above enable applications and services implementation and offering. These services allow to browse, select and view a large content repository, at any time. The students can retrieve audio, videos, images, technical text, exercises, simulators, and course information, that are indexes on the metadata database. The indices, that describe the media allow the multimedia material search. Until now, we have defined and implanted the following services:

- Supporting Class Material - available material that will help the students to follows the conventional course. It includes the course schedule and program, the notes, the exercises lists, the FAQs, references, the lectures slides associated by video or audio sequences.
- Digital Library - keep all the material, that can be accessed and consulted like papers, reports, documents, video and audio on demand and animations on an organized way.
- Virtual Lab - this services display a set of simulations that allow the students make some virtual practical experiences related to the courses topics.
- Seminary Room - the seminar are specific conferences about important topics, that are presented in a browser, where the conference video associated with the slides and text spoken are shown.
- On-line Course - the courses are drawing up for browser access and integrate video, audio, images, graphics, animations, text (articles, reports, notes and proposal exercises) and simulations.

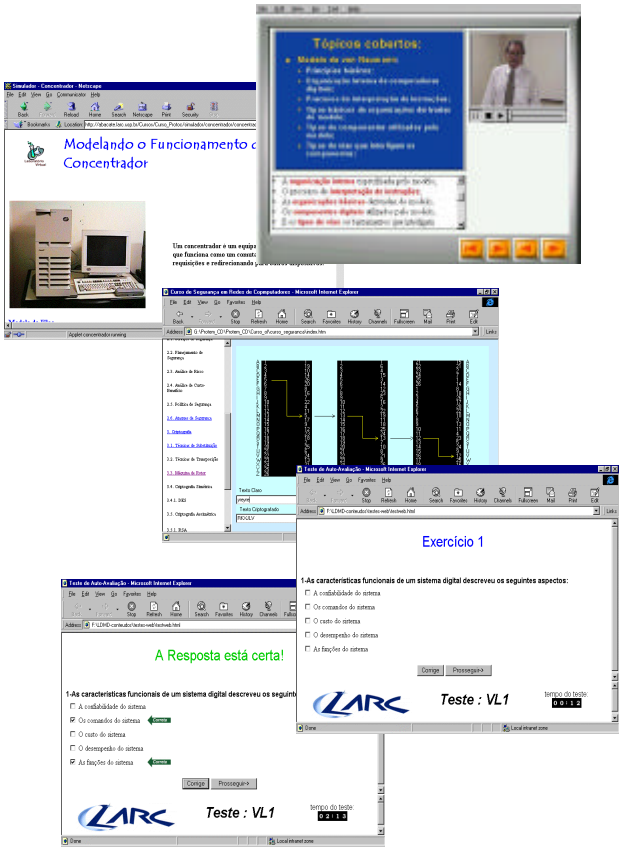

Figure 2: Services interfaces.

Nowadays this services are offered to the Electrical Engineering (Computer Area) Program of Polytechnic School of the University of Sao Paulo. Supporting Class Material make a communication line between students and professor, where they can change information. The professor put all the relevant material and information on a specific Web server area where these material must by shown through html pages. The students have permission to access this area and ask questions about doubts by e-mail service. Video or audio class are recorded and stored at video server and can be retrieved from the Digital Library by the students for a review. The ATM network high bandwidth capability allows to view full screen video with pause, stop, fast-forward and rewind functions running over the program like a local VCR.

Special attention have been sent to the Virtual Lab according to the large benefits reached by the simulators that we have observed. The simulations, that are implemented using JAVA language, intend to show virtually a real working system. This activity help students to comprehend the concepts, given a practical experience. This courses integrated all the media, producing a very interesting material, and consequently we have obtained very good result from the students. Their performance evaluation is made by a "Modular Evaluation System" that check automatically the testes proposed and indicates the topics that must be reviewed.

To run this services its necessary to develop the multimedia material. With this proposal we have mounted a studio that have the tools, equipment and software adequate for this production. All these services have restrict access to assure system security.

4. The Network Growing

In order to provide the above services for people geographically distributed, it's necessary to expand the system. LARC are engaged in four other project that, when implanted, will enable to distribute distance learning material over expanded area. On these projects will be considered the use both asynchronous communications (World Wide Web and e-mail), and synchronous communication (videoconference and the use of shared whiteboard and workspace). Following we present the main goal from each one.

- **DSN Project -** this project has developed research to the integration solution between the Internet and the CATV, the management of the integrated system and the distance education applications distributed over it.

- **Poli-Virtual Project** - this project intends to create a high-speed network (ATM) backbone linking all the Polytechnic School departments. It forecasts a central site that will have video servers and tertiary memory for storage of the educational material. Associated to this site there will be a studio for the production of the multimedia material and a videoconference room. On the departments it will be implanted the sites to receive data from the central studio, and each department will have a videoconference room. The system structure is showed at figure 3.

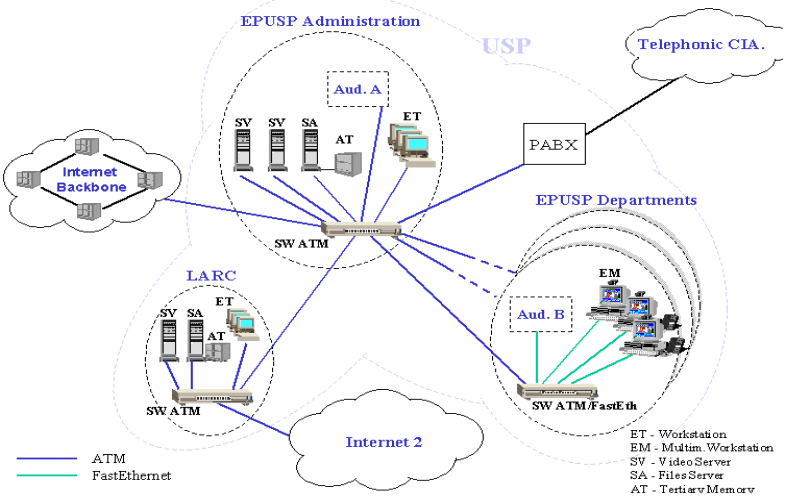

Figure 3: Poli-Virtual System structure.

- **RMAV-SP Project (Internet 2)** - this project is part of the Brazil Internet 2 project, that aim to create the backbone for the **Internet 2.** Due to Brazil's geographic extension, in order to implement this challenge twelve metropolitan consortium were created and the infrastructure implementation is being

done by steps. In the São Paulo consortium is deploying a ATM backbone linking five educational institutions (two of them are medical institutions), two telecommunication company and one research support foundation. The interconnection of this eight participants, that is showing on figure 4, will be

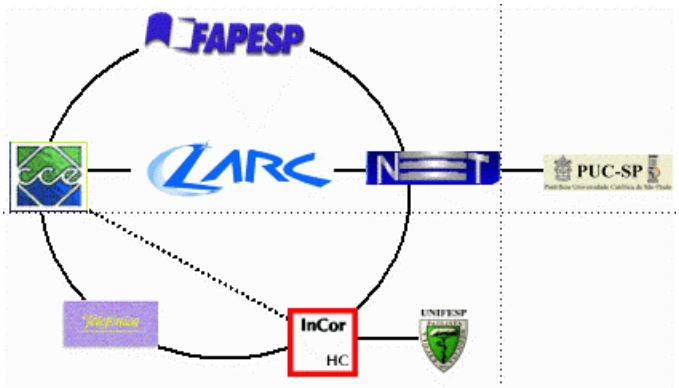

Figure 4: RMAV-SP (Internet 2) project structure.

utilized for research on network security and management, education and medical applications, and for the distribution of distance education and medicine applications over the city. When all the consortium have implanted their network, the interconnection over all the networks will be made, constituting Internet 2 over the country.

- **São Paulo State Project** - this project proposes to interconnect through ATM radio links (from 25 to 155 Mbps) eight university *campus* over São Paulo state. The interconnect cites are shown at figure 5.

Figure 5: São Paulo map shown the location of the interconnected universities.

Supported by all the expansion described above it will be possible to offer distance learning course to a large audience distributed all over the country.

5. Final Consideration

The efforts spend in these project represent our trust that the distance education will be very important way to transmit technical information and intellectual experiences over the world. Although the infrastructure are coming, the multimedia material production for distance learning require a lot of care. It is important to establish appropriate and efficient pedagogical method [Bres1999] and have a tool that can manage the course[Gonz1999]. It is unavoidable to work with a multidisciplinar team of professional, that can help the professor to place his ideas in the best way and produce dynamics, interesting and challenging courses.

At this moment, we are working in a secure mechanism for multimedia material distribution. This mechanism considers cryptograph, integrity and access control.

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