TELEMATIC SERVICES OVER ATM NETWORKS: THE CASE OF TELETEACHING

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Abstract. In this paper we present various tele-teaching scenarios over ATM network infrastructure. In each scenario we present the standards which we use, the logical components, the demand in resources (network resources and equipment) and its special characteristics. Main result of our experiments is that broadband networks offer many capabilities for high quality Teleteaching and generally speaking high quality Telematic services.

Keywords. Teleteaching scenarios, ATM, Broadband networks, Evaluation of Teleteaching

INTRODUCTION

Today we can register a growing public interest in the Internet and especially in the World Wide Web. At the same time, the computer networks are becoming increasingly fast with the use of new technologies. Furthermore Asynchronous Transfer Mode (ATM) based networks, which offer speed up to 622 Mbps, are installed and new capabilities like Quality of Services (QoS) are available to applications. These achievements make possible the implementation of tools that offer tele-teaching capabilities over networks with QoS characteristics.

In this paper we present various Teleteaching scenarios over ATM network infrastructure. During each scenario we present the standards which we use, the logical components, the demand in resources (network resources and equipment) and the special characteristics of each scenario. In the following paragraphs we present three Teleteaching scenarios: Point-to-Point over Native ATM, Point-to-Point with the use of TCP/IP over ATM infrastructure and Multipoint with the use of TCP/IP over ATM infrastructure.

This work has been done in the context of the project ATMNet of the Greek Secretariat of Research and Technology[1]. The ATMNet project is the first large-scale attempt for the introduction of ATM technology in Greece. This project aims to interconnect the local ATM networks of Greek Universities with the public ATM network of the Hellenic Telecommunication Organisation. The result of the above interconnection will act as a test-bed for study and research on the following areas:

- Interconnection of private ATM networks with the public ATM network
- Interoperability of alternative technologies (for example IP networks, Frame Relay)
- ATM standards for administration, control, and routing
- Quality of ATM services
- Quality of Advance telematic services with multimedia characteristics

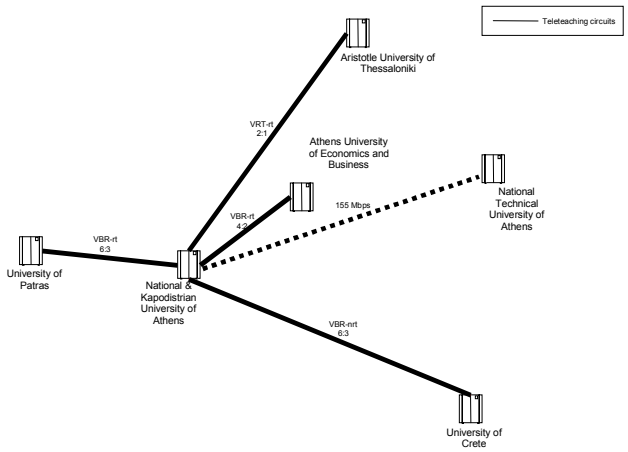


Fig. 1 Teleteaching test-bed

The ATMNet project will install telematic services (videoconference, CSCW - Computer Support Collaborative Work, Teleteaching and Telemedicine) in order to evaluate the quality of those services to the end User. The above evaluation will be based on the design and the implementation of various experiments on the implemented test-bed. Figure 1 displays the Teleteaching test-bed, which consists of 6 points, which are connected with ATM virtual circuits.

[1] Greek Secretariat of Research and Technology: http://www.gsrt.gr

The rest of this paper is organised as follows: We present some motivation factors for the use of Teleteaching in second section. In the third section we describe the Teleteaching application. The fourth section presents the Teleteaching scenarios, which we use during our experiments. Finally, the fifth section concludes our paper.

MOTIVATION

Teleteaching could be regarded as the process of learning with the use of Telematics that is the combination of telecommunication, information and multimedia technology and its services. In such a scenario:

- All the interactions among trainees, trainers and instructional material, which are essential for the instructional process, can be implemented
- The information and the knowledge, which are essential for the instructional process are accessible and readable
- The place, time and the pace of learning are flexible

Teleteaching has as target the development and promotion of special methods and techniques for the increase of the quality, the effectiveness and the suppleness of the learning.

The Teleteaching has two main results:
1. The educational: The improvement of the existing learning methods and the development of new learning methods.
2. The technological: The provision with new distance learning methods with the use of Information and Communication Technologies (ICT).

Teleteaching has the following main goals:

- The development of learning environments and methods suitable for the use of information technology to different learning environments
- The improvement of the organisation environment, in which these new methods are applied, and the quality and manageability of the multimedia applications and the real time services
- The encouragement achieved is recognising the quality characteristics obtained through teaching with the use of new ODL (Open and Distance Learning) technologies and services

The last years we notice a shift in the training delivery. As you can see in Figure 2 at year 2000 the 50% of the training delivery will use computer technology. This gives rise to the need to implement tools that support Teleteaching (asynchronous learning, synchronous learning and Computer Support Collaborative Work for Learning - CSCW/L). In the asynchronous distance learning the student selects the time, the duration and the pace of the lesson. During the synchronous lesson there is live interaction between the participants (the teacher and the students). The CSCW/L functionality includes application sharing, bulleting boards, chat, e-mail and sharing workspace.

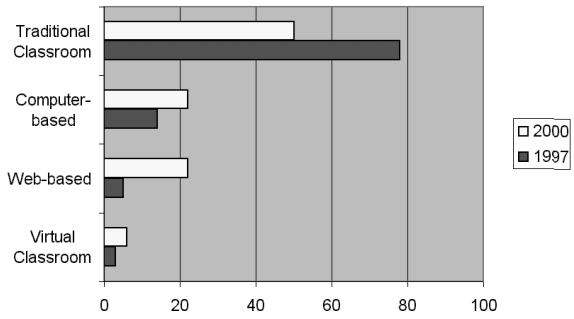


Fig. 2 Shift to Training Delivery

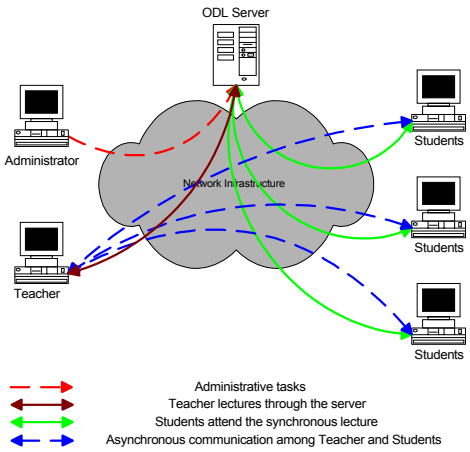


Fig. 3 Synchronous Distance Learning

In this paper we present Teleteaching scenarios which offer synchronous distance learning services. In Synchronous Distance Learning (Distance Learning with the live presence of the Trainer) the lecture takes place on predefined time. The Trainees attend the lecture, hear the Trainer and have the ability to interrupt the flow of the lecture in order to submit a question. The Trainer has all the necessary authority to control the flow of the lecture (like as in a conventional lecture). For saving network resources, every Trainee can see only one participant every time (the Trainer, or a Trainee that submits a question), as result it is not recommended the use of classic videoconference for the implementation of Synchronous Distance Learning. The educational material of the lecture can be distributed to the Trainees either before the beginning of the lecture and be stored locally, or during the lecture (something that may invoke problems if the network infrastructure is not sufficient to support the real time transmission of the data during the Synchronous lecture). The Figure 3 displays a scenario of Synchronous Distance Learning.

TELETEACHING APPLICATION DESCRIPTION

Figure 4 displays the logical topology of our Teleteaching application. For the implementation of the Teleteaching application different components must be used. First of all a

network infrastructure must be available for the communication among the end points which participate to Teleteaching scenario. Central point of a Teleteaching application is the Multipoint Control Unit (MCU), which is responsible for the transmission of multipoint audio, video and data.

Recommendation	Network	Date	Title
H.310	ATM	11/99	Broad band and audio-visual communication systems and terminals
H.320	ISDN	03/96	Narrow-band visual telephone systems and terminals equipment
H.321	ATM	03/96	Adaptation of H.320 visual telephone terminals to B-ISDN environments
H.322	LAN	03/96	Visual telephone systems and terminal equipment for local area networks which provide a guaranteed quality of service
H.323	LAN	11/96	Visual telephone systems and terminal equipment for local area networks which provide a non-guaranteed quality of service
H.323 version 2	LAN/ATM	02/98	Packet-based Multimedia Communication Systems
H.324	Telephone	03/96	Terminal for low bit rate multimedia communication
T.120	-	07/96	Data protocols for multimedia conferencing

Tab. 1 Major recommendations which are used by Teleteaching applications

In order to participate someone in a Teleteaching scenario, must have the appropriate equipment. This equipment can be a desktop multimedia PC with the appropriate hardware and software (in the case of single user) or a Teleteaching room (in the case of a class). In order to ensure interoperability among equipment of different manufactures, the transmission the data must follow some international recommendation or standards, which define the encoding of the audio, video and general speaking the encoding of the data. Table 1 displays the major recommendations, which are used by Teleteaching applications (and not only).

The role of an MCU is to collect the video and audio streams of all the participants and transmits to the participants only one video at a time, mostly the video of the professor during Teleteaching.

With the use of gateways, users with different equipment (equipment which follows different standards) have the capability to participate to the same virtual classroom. For example with a H.320 to H.323 gateway, users with H.320 equipment have the capability to participate to a H.323 based Teleteaching lesson.

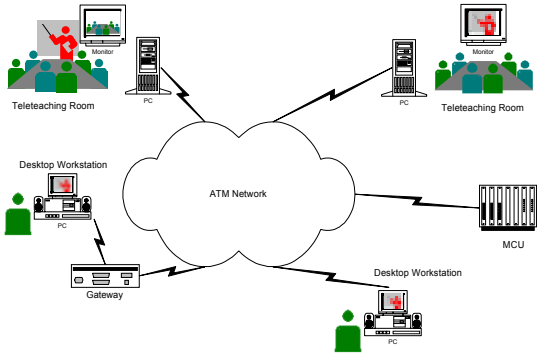


Fig. 4 Logical Topology of the application

TELETEACHING SCENARIOS

In this paragraph we present various Teleteaching scenarios over ATM networks. More particularly, we present the following Teleteaching scenarios:

- Point-to-Point over Native ATM
- Point-to-Point with the use of TCP/IP over ATM infrastructure
- Multipoint with the use of TCP/IP over ATM infrastructure

Point-to-Point Teleteaching scenarios

This is the simplest scenario of Teleteaching. In this scenario one group of users communicates with an other group of users. The workstations in each point are using the appropriate software and communicate through the network.

Point-to-Point over native ATM. In this scenario the applications use the ATM infrastructure and protocols in order to transmit data (video audio and application sharing data). In this scenario the transmission of video and audio is based on ITU H.323 version 2 standard and more particularly on the Annex C of this standard. The application sharing capability during this scenario is based on the ITU T.120 standard. The ITU recommendation H.323 version 2 upgrades the recommendation H.323 version 1 (Visual Telephone Systems for LAN with a Non-guaranteed Quality of Services). The Annex C of the H.323 version 2 defines videoconference over native ATM. With the use of H.323 version 2, we ensure interoperability between ATM and IP network without the use of gateways. In this scenario we investigate the new capabilities that the native ATM protocols offer to Teleteaching. Figure 5 displays the

architecture of the point-to-point tele-teaching scenario over native ATM. During this scenario the video encoding is based on H.261 and H.263 standards and the audio encoding is based on G.711, G.722 and G.728 standards. The quality of the transmitted video is FCIF / QCIF with frame rate 30 fps. The required bandwidth for the implementation of this scenario is 768 kbps.

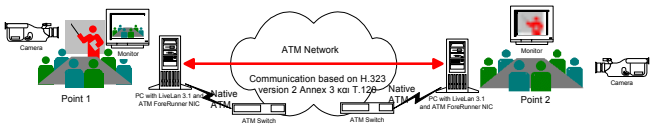


Fig. 5 Point to Point Over Native ATM

For the implementation of this scenario each point must have the following equipment:

- Access to ATM network with ForeRunner[2] ATM adapter
- PC with the PictureTel[3] LiveLan 3.1 videoconference tool installed

During this scenario we investigate the capabilities of the native ATM to support Teleteaching. The use of native ATM has the advantages that during the Teleteaching lesson, we have the capability to reserve the appropriate network resources and provide specific Quality of Services characteristics to applications.

Point-to-Point with the use of TCP/IP over ATM infrastructure. In this scenario we use tools and technologies that are the same with those for typical Teleteaching over TCP/IP networks. More particular we use the ITU H.323 standard for the transmission of the audio and video and the ITU T.120 standard for application and data sharing. During this scenario we investigate the capabilities and the benefits of using the ATM network infrastructure for the implementation of tele-teaching scenarios which are applied for a long time over IP networks. In addition, this scenario is easily implemented, because there is not need for special servers such as MCU. Figure 6 displays the point-to-point tele-teaching scenario with the use of TCP/IP over ATM infrastructure. During this scenario the video encoding is based on H.261 and H.263 standards and the audio encoding is based on G.711, G.722 and G.728 standards. The quality of the transmitted video is FCIF / QCIF with frame rate 30 fps. The required bandwidth for the implementation of this scenario is 400 kbps in each point.

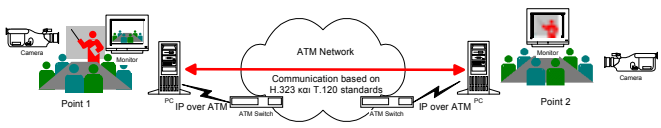


Fig. 6 Point to Point with the use of TCP/IP over ATM infrastructure

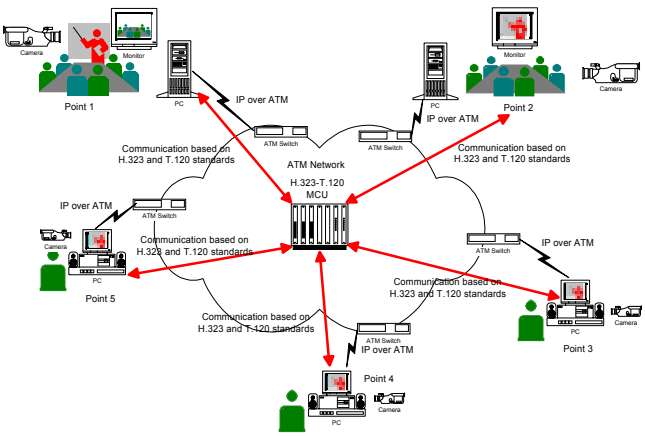
For the implementation of this scenario each point must have the following equipment:

- Access to ATM network with an ATM adapter
- PC with the H.323 compatible videoconference tool installed

During this scenario we investigate the capabilities that the ATM infrastructure offers to already implemented solution of Teleteaching over IP networks.

Multipoint with the use of TCP/IP over ATM infrastructure
In the case of multipoint Teleteaching, an MCU acts like the central point and all the participants are connected to it. With the use of multipoint Teleteaching all the points participate to a Virtual Classroom and the participants communicate with video, audio and data.

Figure 7 displays the architecture of the multipoint tele-teaching scenario with the use of TCP/IP over ATM infrastructure. This scenario uses the same standards with the above-described scenario (ITU H.323 and ITU T.120). This scenario differs from the point-to-point scenario because this scenario needs special equipment, a MCU which acts like a reflector. The MCU collects the video and audio of all the participants and transmits to the participants only one video at a time, mostly the video of the professor during Teleteaching. During this scenario the video encoding is based on H.261 and H.263 standards and the audio encoding is based on G.711, G.722 and G.728 standards. The quality of the transmitted video is FCIF / QCIF with frame rate 30 fps. The required bandwidth for the implementation of this scenario is 400 kbps in each point. During this scenario, we have to pay special attention to bandwidth requirements in to MCU connection due to the fact that the required bandwidth to the MCU connection is n*400 kbps, where n the number of the participants to the multipoint lecture. In this scenario we investigate the advantages of using ATM infrastructure for multipoint Teleteaching, where the demand for high bandwidth is crucial (especially to the MCU network connection).



[2] Fore Systems Corporation, http://www.fore.com
[3] PictureTel Corporation, http://www.picturetel.com

Fig. 7 Multipoint with the use of TCP/IP over ATM infrastructure

For the implementation of this scenario each point must have the following equipment:

- Access to ATM network with an ATM adapter
- PC with the H.323 compatible videoconference tool installed

In addition during this scenario, we use a H.323 compatible MCU in order to support the multipoint capabilities of this scenario.

During this scenario we investigate the capabilities that the ATM infrastructure offers to already implemented solution of multipoint Teleteaching over IP networks. The use of ATM virtual circuit for the implementation of network connections between the participants and the MCU offer the appropriate bandwidth for the implementation of this Teleteaching scenario.

CONCLUSION

During each of the above scenarios the appropriate network resources are allocated with the implementation of ATM Virtual Path or Virtual Circuits. During the scenarios we have made various performance measurements and we have drawn conclusions about the use of ATM on Teleteaching. Main conclusion of our experiments is that broadband networks offer many capabilities for high quality tele-teaching and generally speaking high quality Telematic services.

This work is done during the ATMNet project of the Greek Secretariat for Research and Technology. The goal of this project is the internetworking of local ATM networks of Greek Universities with the public ATM network and the demonstration of Advance Telematic Services over this network.

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- Aristotle University of Thessaloniki
- Hellenic PTT

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