Narrowband versus Broadband for Tele-education : a Critical Evaluation

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ABSTRACT :

In the present article the authors will analyse the need for tele-education and define the resulting pedagogical and technical requirements. As an example, the Summer School of the NICE project will be discussed. The NICE project aims at interconnecting different advanced European telecommunication platforms, through the organisation of several distributed pan-European events, such as telemeetings and teleconferences. The Summer School is a yearly event, in which students all over Europe are connected with a few main lecturing sites, through a broadband network. In a weeks time, the students get an overview of the state of the art in the field of advanced broadband communications.
This article will focus on the technology, results and pedagogical aspects related to the Summer School, and compare them to similar tests led within Belgacom that were performed over ISDN with commercially available equipment. This comparison will allow us to spot the strong and weak points of both narrowband and broadband tele-education events, from the point of view of supporting the learning process of the student. Hints for future improvements will be formulated.

1. Introduction

The "Belgacom Learning and Development Academy", aims to provide all employees of Belgacom with the required training when and where they need it. Also after business hours a lectures programme in the field of business and telecom, and a high level technical postgraduate is organized.

As the 26000 employees of Belgacom work all over the country (see Figure 1), it was decided to start with tele-education in order to increase the efficiency of the training programmes. For this, state of the art narrowband teleconferencing equipment is used.

Belgacom, project leader of the NICE project, has co-organised this year the ABC summer school, a broadband teleconference. Both experiences put Belgacom in a unique position to compare narrowband and broadband technologies from the viewpoint of tele-education efficiency and to get acquainted with both technologies.

2. Rationale

In Figure 1, a map of Belgium is shown. The main Belgacom regional centres are indicated. Travel to a classroom in Brussels implies a waste of time and does not favor "on the job training". Moreover, the lectures organised after business hours can only be attended by the employees in Brussels.

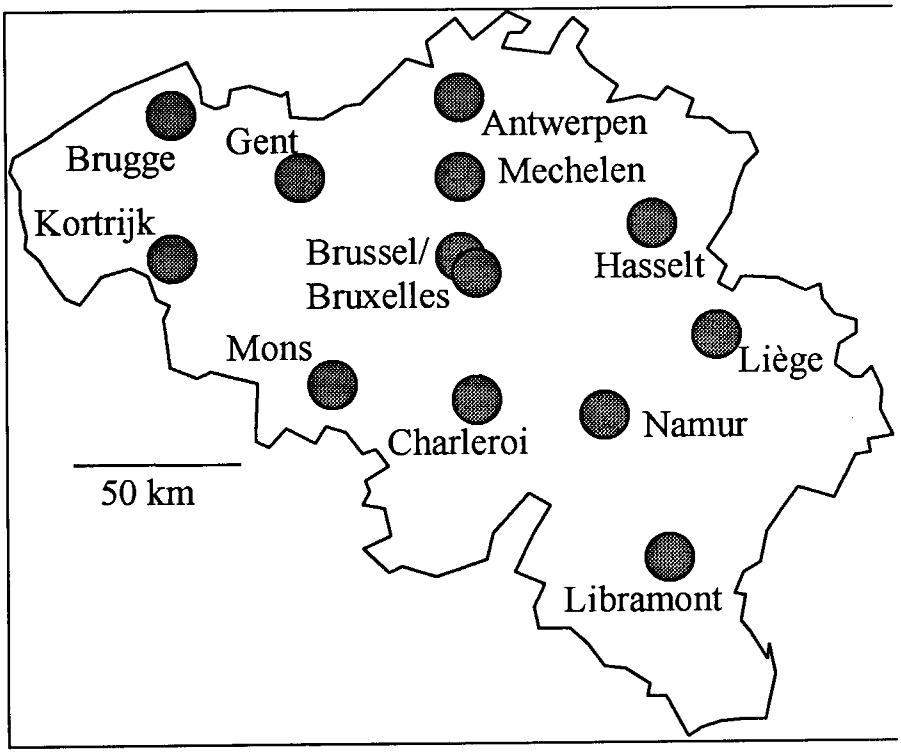

Figure 1 : map of Belgium with the main Belgacom centres

For both reasons, Belgacom decided to install state-of-the-art teleconferencing equipment in its centres and to start with tele-education.

3. Pedagogical assumptions

A real time N-way video/N-way audio application was adopted, based on a quick survey of the literature(1) and previous experiences in the field of distance learning. This can be alternated with groupware interaction between students and the lecturer. Real time visual and auditive interaction between lecturer and remote audiences, is mandatory for a successfull pedagogical process.

A "traditional" classroom setup is used, i.e. a contents expert presents a lecture in front of a (remote) audience. This is perfectly acceptable for teaching specialized technical and business oriented matter.

In Figure 2, a possible learning traject for a typical postgraduate course is shown.

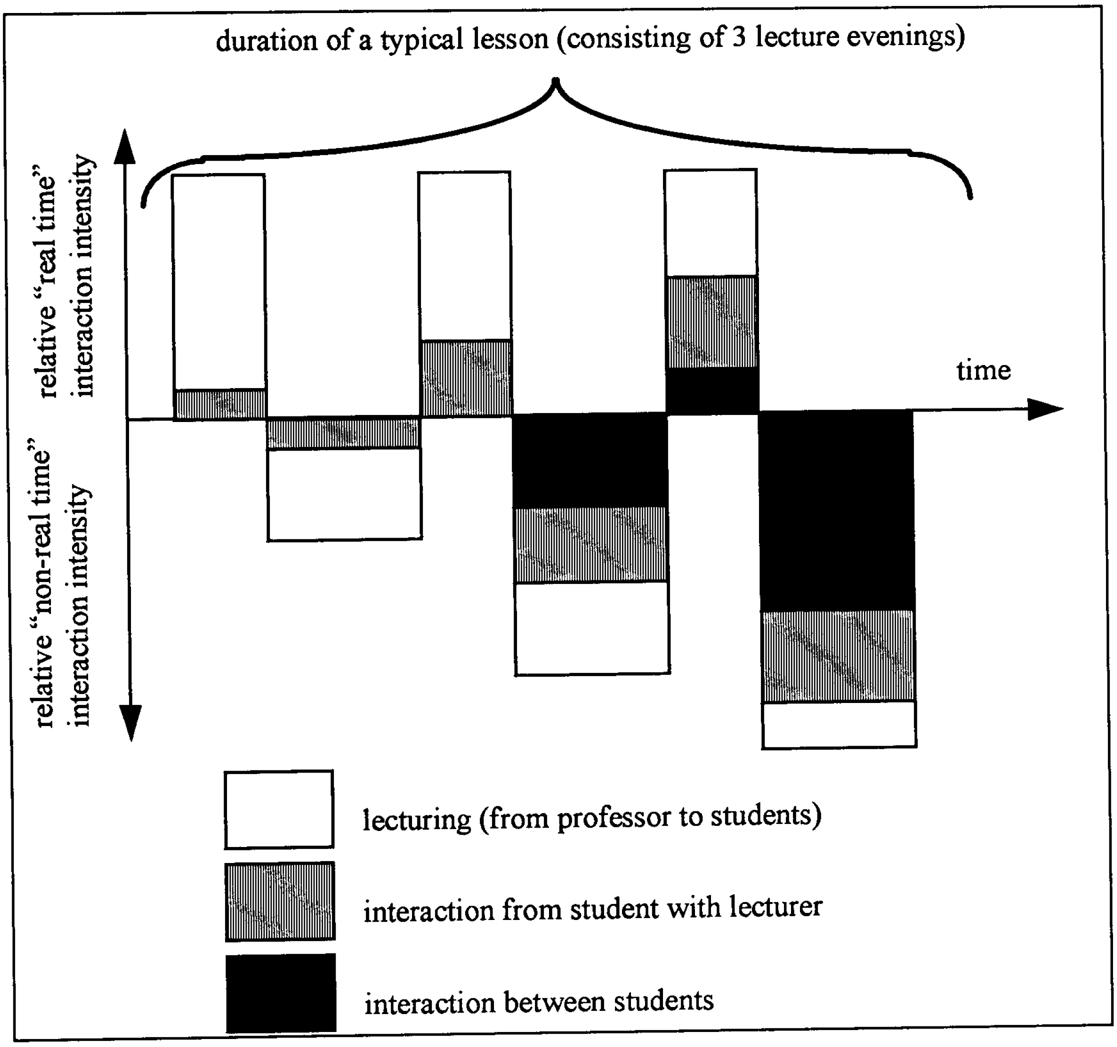

Figure 2 : learning traject model in function of time showing the different types of interactions between the students and the lecturer.

The contents expert is not necessarily a teaching expert. The lecturer also frequently disregards the remote audience, causing loss of interest. A carefull combination of technological and pedagogical "tricks" are designed to minimize this effect.

4. Model for distance learning architecture

4.1. Functional model

A model, presented in (2), for describing functionally any kind of teleconference, has been applied to the NICE summerschool. Figure 3 shows the adapted model for the Belgacom narrowband tele-education projects. Defining all functions and their relations, helps to create an environment allowing lecturer and students to concentrate on the pedagogical process, minimizing the interference with unfamiliar technology.

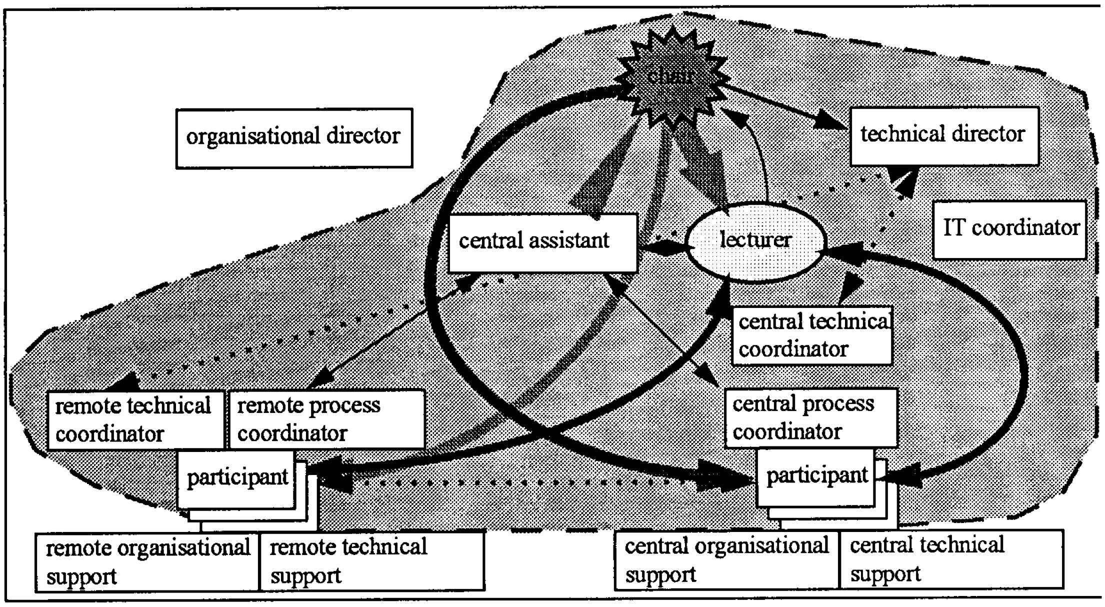

Figure 3 : functional model for teleclassing

4.2. *architectural model*

4.2.1. audio, video and data interconnections

N-ISDN and a LAN-WAN network are choosen to run the virtual classroom sessions. Video and audio are dealt with according to the standards family. H.261-H.320, while an Ethernet-LAN connects the PC's. A maximum of 13 Belgacom and 1 external site are interconnected through the Multipoint Control Unit (MCU) with a star-like network architecture (see Figure 4) and bi-directional bandwidths of 128 or 384 kbit/s for the audio-visual signal.

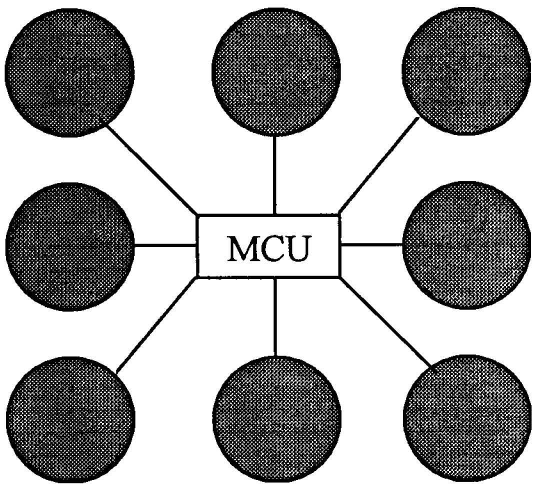

Figure 4 : network architecture for the audio-visual signals

State of the art V-Tel TC2000 videoconferencing roll-abouts with dual display and an ETHERNET-LAN card are used. As the T120 functionality is not included in the MCU, the LAN-WAN network is used to visualise the presentation on PC in the remote centres.

A chat or mail application informs the lecturer about remote questions. The lecturer invites the site to intervene. Image switching is voice controlled. Strongly directed interactivity minimizes chaos.

Figure 5 gives an overview of the equipment installed in a classroom and needed for a lecturer. Not all remote sites can be visualised simultaneously. This will hamper the interaction between different classrooms. This can however be overcome partially by the use of groupware tools

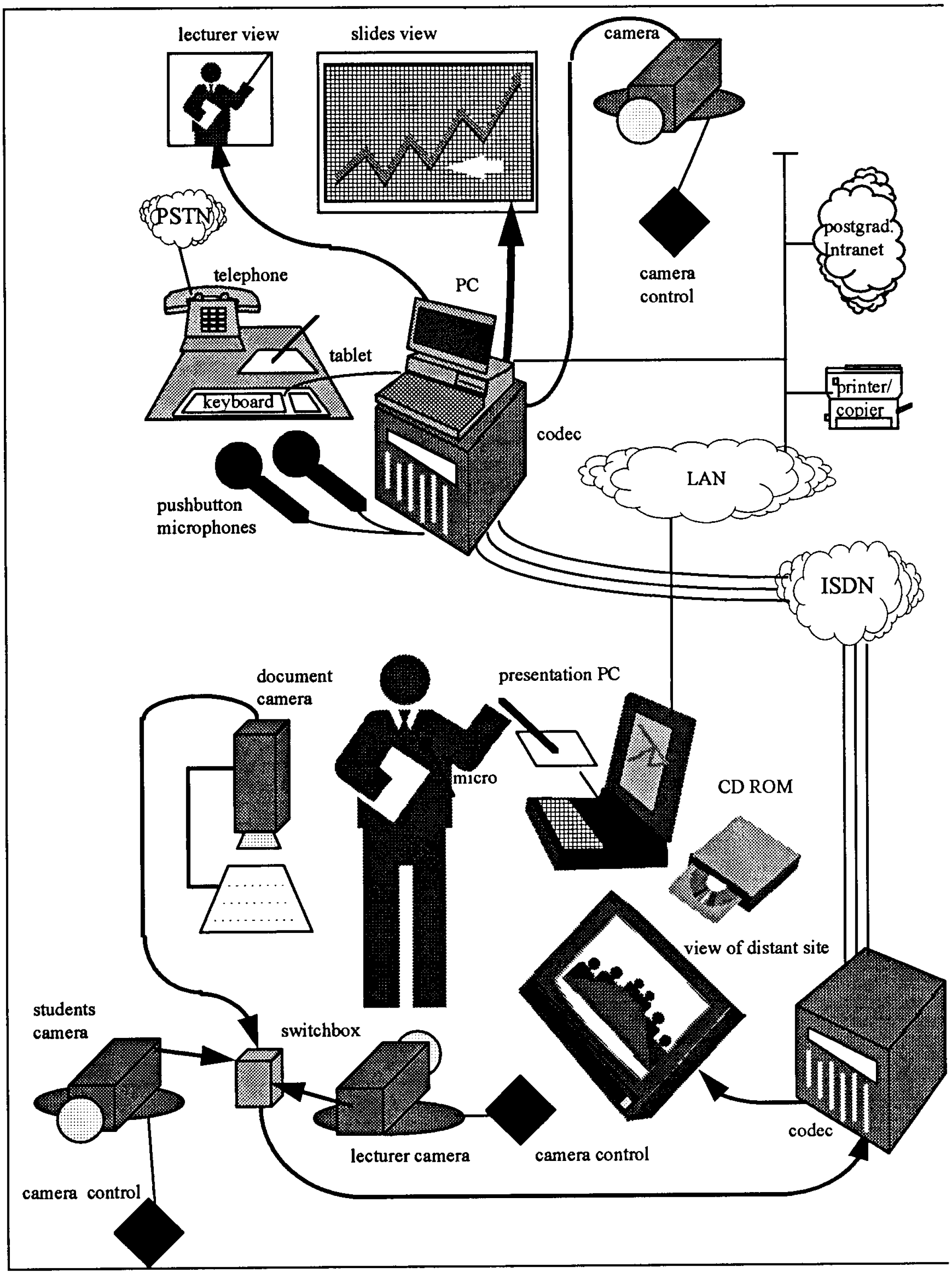

Figure 5 : set up of the virtual classrooms

4.2.2. Additional information

Between the different lectures, the students can collaborate on practical exercises, or study some topics more in depth by themselves.

Complementary information about the lectures is made available on servers connected to an intranet using the World-Wide-Web technology, with a gateway to the Internet. Web technology offers more scope for data interchange and interactivity. Students have the opportunity to retrieve exercises written in the Java language and to execute them locally, or they can send e-mails.

The physical infrastructure is shown in Figure 6. All employees have a direct connection to the intranet in their office but, in order to provide an access to the Intranet where no LAN connection is available (home, demonstration areas, ...), a gateway to the ISDN network has been set up. In this case, at the user side, the configuration is made of a computer, an ISDN terminal adapter (TA) and adequate software. In the context of telelearning and in terms of performance, this solution is satisfactory : compared with typical Internet speeds, the information is provided fast enough to the student.

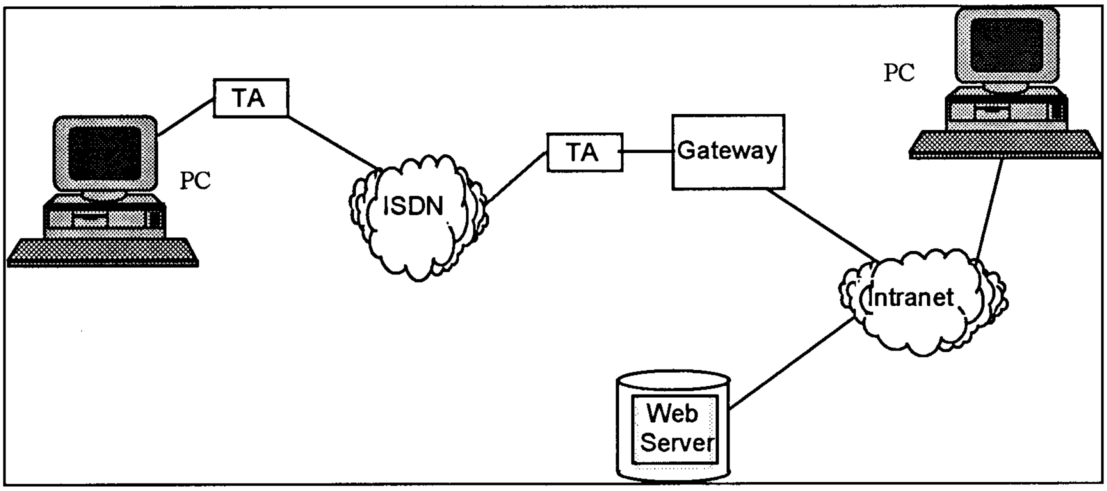

Figure 6 : Physical infrastructure for accessing additional information

5. Results of Narrowband experiments

Preliminary trials at Belgacom have validated the concept. Interesting conclusions could be drawn :

- 3BA's provide a relatively good image quality; with only 1 BA, small text on video documents is illegible
- transcoding the signal from 3BA's to 1BA with acceptable image quality is possible
- simultaneous view of lecturer and presentation is preferred to image switching
- the sound quality is more important than image quality
- the lecturers dress has to be choosen carefully for obtaining a nice and clear image
- the body language is not easily transmitted and perceived; hence creating efficient interaction between lecturer and remote classrooms is not obvious
- ....

  Conclusion: obtaining a good knowlegde transfer requires also a good preparation of the audiences and lecturer. Technology alone is not sufficient.

6. The NICE summerschool : a broadband teleconference

6.1. Introduction

The ACTS project NICE, under the leadership of BELGACOM "Research Development and Engineering", organised the distributed summerschool on Advanced Broadband Communications.

6.2. CSCW over ATM

Figure 7 shows the implemented network architecture. A single virtual conference room was created, using ISABEL*, a multimedia CSCW tele-education application.
The pan-European ATM network interconnected the sites. Both unicast and multicast IP traffic were handled by ISABEL. Both networks shared an underlying tree topology consisting of point to point bi-directional symmetric ATM Virtual Paths (AVP). Each site was connected by one AVP to the nearest node of the tree in the direction of the root. A bandwidth of 6 Mb/s (15.6 Kcell/s) was requested for each main node. In total 100 Kb/s for the unicast VPI and 5 Mb/s for the multicast VPIs were assigned.

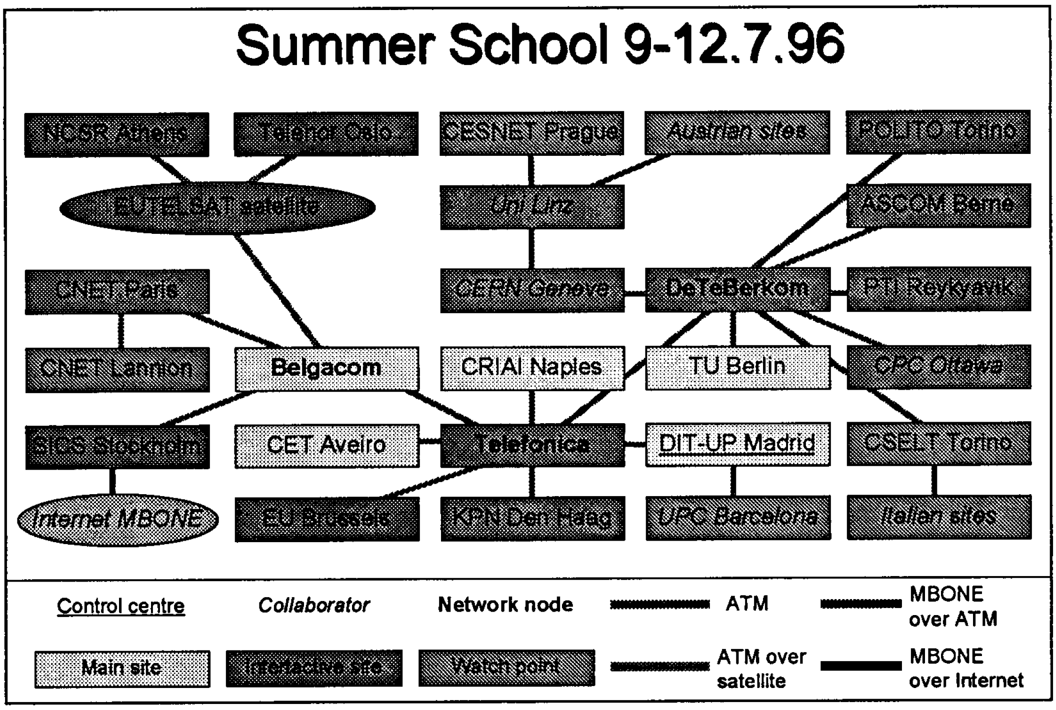

Figure 7 : network architecture for the Summer School

6.3. Results

ATM still does not realize its full potential.
Actually, the only available international ATM network service is CBR, point-to-point, (semi)permanent VPs. This is too limited for the CSCW application. Multicast must be implemented at higher layers, increasing complexity and reducing performance. The lack of signalling complicates network management and operation.
The major limitations for user equipment are

- high cost
- underdeveloped traffic control functions, causing high cell loss rates
- implementation restrictions in ATM boards for workstations (no PCs!).

As ATM is evolving very fast, these limitations will soon be overcome.

* Isabel has been developed in RACE project IBER

6.4. *Size thoughts*

Reference (2) arguments that the ISABEL application incorporates all the functionality needed for tele-education. Using all its features is however not yet obvious. A huge infrastructure and support base and a lot of moderation is required for obtaining a fully distributed interactive lesson. This "virtual classroom" consisted however of 19 interactive sites, with 500 "students"

6.5. *ABC satellite links to Greece and Norway*

Isolated ATM-islands can be connected to ATM-networks in Western Europe through satellite. Two sites were connected to the summerschool via a BELGACOM earth station.
The satellite connection yielded the same quality as terrestrial links. A system allowing the space link to be operated as an ATM switch, was used. It supported full cell-by-cell connectivity for user to user and network applications. The equipment was used as an interface between the satellite link (8 Mbps) and the terrestrial ATM-link (155 Mbps SDH or 34 Mbps PDH).

7. Comparison between narrowband and broadband experiments

Advantages of the broadband virtual classroom sessions based on the ISABEL software:

- easy combination of images and sound from different locations and/or applications[†]
- multicasting reduces the bandwidth requirements : a virtual classroom of N sites requires $N+\Sigma(M(t)*H)$ unidirectional connections, with M(t) : number of active sites at each moment (mostly only 1, sometimes 2) and H : number of links between the active site (leaf) and the director site (root). Narrowband ISDN requires 2N unidirectional connections however.
- total number of sites is practically illimited; showing them all simultaneously is mostly not usefull.
- much higher image resolution
- easy switching between lecturers in different locations[‡]

The distance learning model[2] was well followed. A process director assisted the lecturer with his presentations. A technical director controlled sound and images. Both functions were mirrored in all lecturing sites (and partially also in secondary sites). The resulting highly directed way of working avoided "chaos".

Apparent disadvantages compared to narrowband videoconferencing were mainly due to the still immature state of technology and network implementation.

- the technological environment is built upon expensive UNIX platforms; O&M requires specialized personnel
- very low refresh rate in composite view of the remote audiences' image
- desynchronisation between image and sound
- the bandwidth per link is high compared to the results obtained with narrowband videoconference.
- combination of the slide and the lecturers image on one screen is disturbing
- last minute changes to the presentation (and hence data conferencing) was still not possible

[†] Playing around with images in case of narrowband videoconferencing requires a clever setup of codecs and analog video mixers. The number of codecs required doubles (and hence the delay increases considerably). Purely digital, it is even harder to realise in real time.

[‡] This however, is also possible in narrowband multipoint videoconferencing. One needs to install in each of the locations however additional equipment (eg. lecturer video and camera)

8. Future improvements and conclusion

When image quality and flexibility is important and the number of sites is high and variable, broadband technology outperforms narrowband tele-education. Nevertheless further improvements at the ATM transport level are required for achieving optimum performance. This is partially due to the immature state of the technology.
One of the major potential advantages of tele-education using an ATM transport network is the multicasting functionality that can keep the communication bill in case of many (international) sites surprisingly low.
The most important advantage of narrowband tele-education is the existance of an operational ISDN infrastructure. The image quality however is poor, and image handling is inflexible.
Actually, both technologies still fail to give the lecturer and the students the feeling of personal involvement. All participants should be pedagogically well prepared to overcome the limitations of technology.

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[1] "Distance Learning : Technology and Applications"; D. Minoli, 1996, Artec House, Inc.
[2] "Modelling the Summerschool", Martin, Presented at the NICE Summerschool, Berlin 9-12.7.96