MICE

National Support Centres

An Introduction to
Multimedia Conferencing over the Internet

This is an introduction to the technology and the suite of tools* which are available to users to support multimedia conferencing. It attempts to explain the background, general principles and some of the most important technical terms. It gives information on how to obtain the tools, the documentation and advice about installing and using them. Finally, it presents some examples of current and potential applications of the technology and suggestions for further reading.

Despite the title, this guide is not just about conferences. The technology and tools have already been used to support remote collaboration in areas such as distance education, healthcare and the arts, where members of a group need to interact but are geographically separated. It is likely that new users will suggest further new applications.

The intention is that a computer user with only limited understanding of the underlying technology, should be able to understand this guide. Readers with more extensive technological knowledge may therefore wish to skip some sections.

*Since 1993 the MICE project has been piloting and developing a number of public domain software tools for multicast-based multimedia conferencing. The software tools have been used regularly since Spring 1993 by MICE partners (UCL is the leading partner in a consortium of 9 research and development institutions in Belgium, France, Germany, Norway, Sweden and the UK) and other European projects for holding remote project meetings.

BACKGROUND

Videoconferencing has been possible for some time. Telephone companies offer videophone and videoconferencing services but most of these require the purchase of special equipment (videophones and videoconferencing suites) and set up multi-way conferences as a series of point-to-point connections. This is an expensive and often cumbersome way of holding remote meetings, and does not scale to supporting large user groups who want to have interactive meetings. The Internet provides an alternative that can be scaled more economically.

The last two years have seen a huge growth in media interest in the Internet. Much of this attention has focused on services which support asynchronous communication - such as electronic mail, bulletin boards and the World-Wide Web (WWW). It is less well known that computer networks such as SuperJANET can be used to transmit voice and video in real time, making multimedia conferencing on the Internet possible. Conferencing over the Internet is different because it uses *multicast* transmission instead of the point-to-point communication used by the telephone companies. It is this multicast technology (explained more fully in the next section), that gives the Internet community an economic way of supporting multi-way multimedia conferences between large numbers of participants.

INTRODUCTION TO THE TECHNOLOGY

A computer-supported conference involves the transmission of audio, video and data - hence ‘multimedia’. In this section we review the process of capturing, sending and receiving these multimedia streams. This is followed by a brief introduction to multicasting over the Internet.

This is a technical area where a glossary is appropriate so the main terms are defined in the panel at the end of this document. It might also be useful to refer to the accompanying list of acronyms.

Transmission processes

Analogue video and audio must be captured and digitized before it can be transmitted. After the digitized data has been captured it is compressed to reduce the quantity of information which needs to be transmitted. There are different ways of capturing, digitizing and compressing the analogue streams produced by the camera and microphone. These variations are also reflected on the receiving end of the interaction where the process must be reversed to provide analogue video and sound again.

Digitizing may be achieved in several different ways. The generic term for a hardware device for conversion of an analogue stream to digital and back is a CODEC. A CODEC may handle video or audio or both together. It may be implemented as either hardware or software. Many workstations use a frame grabber to supply the video, frame by frame, to a software CODEC program. Audio may be digitized by a software chip in workstation hardware.

Video compression may involve several stages. Basic compression is applied to each frame. Further compression is achieved by calculating differences between successive frames and sending only those differences. Yet more savings in bandwidth can be made by predicting such changes and sending only the information which modifies the predictions. This technique uses motion vectors to predict changes due to motion in the picture. In both these cases there is the need to periodically send full reference frames (INTRA frames). These frames provide a new point of reference for the succeeding *difference* frames (INTER frames). The compression process may also be performed in hardware or in software.

After compression, the data is segmented into small fragments - *packetized* - before transmission over the network.

At the receiver the data is stripped out of the packets, uncompressed and converted back into the analogue domain. In some cases the uncompressed video is passed directly to the window management software for display (for example in Sun workstations). In other cases it may be converted to a TV standard format such as PAL and redirected to a standard TV monitor.

Hardware and software may vary at each location and all variants will interwork where there is a common network. This allows machines with different CODECs to interwork. However, for ISDN devices such as videophones to be integrated with conferencing over IP networks there has to be conversion in a facility such as a CMMC conference multiplexing and management Centre - CMMC -[CLAYMAN et al.]

The Multicast backbone (Mbone)

Multicast [DEERING] provides one-to-many and many-to-many network transmission services for applications such as video-conferencing which need to communicate with several hosts simultaneously. It has existed for several years on local area networks. On the Internet it is implemented through the Multicast backbone, or Mbone.

When a conference begins, a tree-like structure of connections is established between the participants. This is done dynamically; you do not have to set up all the links in advance and when a new participant joins the conference another branch is just added to the tree. The tree can also be 'pruned' dynamically, so that inactive branches are detached. This is more economical than point-to-point conferencing since, for example, only one connection would be needed between the UK and the USA, even if there were six US participants.

On the Internet, networks and hosts (eg workstations) are located by means of addresses. IP (Internet Protocol) addresses consist of four numbers which, between them, identify the network and host. If you want to know more about Internet addressing see [IP Addresses]. Transmission between sites is enabled by routers which communicate with one another and hold tables of routes between addresses. There may be several possible routes between two hosts.

The Mbone is a virtual network. It uses the same physical media as the Internet but at present, many Internet routers are not able to deal with multicast addresses. Special multicast routers, mrouters, are therefore needed. An mrouter is simply a workstation, located on a LAN, which is aware of and can interpret multicast addresses. Multicast messages are wrapped up as 'normal' Internet traffic - unicast IP packets - and passed between the mrouters. Thus the multicast backbone consists of connections between these multicast-aware mrouters, along which the encapsulated multicast traffic can flow. These connections are known as tunnels. It is important to remember that the traffic in the tunnels uses the real bandwidth of the Internet. For this reason, moderation is always necessary in using the Mbone tools.

A user-level introduction to multicast and the way it is used for multimedia conferencing is given in [BRUTZMAN & MACEDONIA] and [ERIKSSON].

WORKING OUT YOUR REQUIREMENTS

There are a number of issues which will help to determine whether an application will work over the Internet, and, if so, what equipment is needed. These include quality, types of interaction required, the type of shared application needed (if any) and the grouping of participants. In this section these factors are considered, together with the configuration and cost of a typical workstation hardware platform. Although the technology described in this document requires multicast capable UNIX workstations to operate, some tools will interwork with PCs or MACs. We tell you where to find out more about this.

Your final configuration will depend on a number of variables, including cost and individual subjective assessments of the quality factors.

Quality:

The number of separate video images which need to be received simultaneously will partly determine the hardware needed to receive and display them. This is closely linked to the quality of image needed since the two factors trade off against each other.

There are three video encoding formats under the H.261 standard, CIF, QCIF and SCIF. The use of QCIF is common where only a simple head and shoulders view is required. The larger formats require more processing power in the hardware.

Another factor influencing the quality is the relative stillness of the image. Since most of the data transmitted for a given video stream consists of changes to an image, the fewer the changes, the lower the required bandwidth to transmit the video and the lower the processing power needed at each transmitter/receiver. For this reason it is important to select a camera which does not have auto-focus set permanently, since auto-focus tends to see all small movements as major changes to the image.

Factors relating to transmission are crucial but it is important to realise that significant variations in the quality of both audio and video may result from changes in conference environment. Background noise or lighting, for example, different levels of expertise in handling tools such as microphones, or differences in peripherals all affect the quality of the output. If you wish to make use of the conferencing tools see [SASSE et al] for advice on these aspects.

Type of shared application:

In many audio visual interactions there will be the need for a shared application on which all may work or comment. Typically this will include a whiteboard application on which all may write and which is simultaneously updated for all participants. Several such applications are available and they make minimal demands on the workstations and the network. Other applications may require many more resources. Remote retrieval of large images or stored audio/video material, for simultaneous review at many separate sites, will, however, affect both the cost and the practicality of such an application on a network with limited bandwidth.

Interaction type:

The cost of setting up a video network is dependent also on the type of interaction needed between the participants. If they need to participate actively, as in a conference, then each must be provided with the means to both send and receive. If a simple one-way transmission, analogous to TV broadcast, is all that is required, the receivers' equipment will be simpler and can be cheaper. Decode only can be provided in software and receive-only locations will not require a camera or frame-grabbing hardware.

Grouping of participants:

Whatever the interaction type, the grouping of the participants must also be a factor. Each location may have a single person at a workstation, several sharing a workstation or a larger group in a room equipped with a single set of suitable equipment. In the latter cases, there are obvious equipment savings to be made.

Workstation configuration & cost

To transmit and receive in a conference, the workstation must be of sufficient power to handle high speed streams from video frame grabbers or CODECs and lower speed streams from the network. Typically, the network speed is the limiting factor at present, but in future, with the increasing deployment of high speed networks, the workstation may become the bottleneck.

The software runs on all the main UNIX workstation platforms - Sun, HP, SGI and DEC. For these platforms there are a number of possible hardware combinations each with characteristics and costs which must be considered in detail when a project is proposed. A zoomable camera is not mandatory but is sometimes useful to scan documents. A different camera can be used to show documents when the first camera is fixed on the workstation. Currently, only one camera can be used at a time, so the video must be switched; there are several possible ways of doing this.

Typical configuration:

As an indication of the cost, a good quality configuration would typically include:

Workstation

Video Input Device

Camera.

The approximate total cost of this equipment would be seven thousand pounds. This is a guideline only. For up-to-date information on hardware suited to your particular needs, contact your local MICE National Support Centre [MICE NSC].

PCs and Macs:

Internet videoconferencing in the world of PCs and Macs is mainly provided by the application CU-SeeMe [COGGER et al.]. This application is not based on multicast and therefore does not optimise the use of the network. Multicast software will be available for both platforms in the near future, but in the meantime it is possible, using NetVideo (nv) [FREDERICK]] and Visual Audio Tool (vat) [JACOBSON3], to interwork with CU-SeeMe via a reflector.

THE CONFERENCING TOOLS

The Mbone tools are just that - separate tools for each of the elements of a typical multimedia conference. There is no integrated user interface to control these tools so the user needs to handle each tool separately. The tools may be classified into the following groups:

- video
- audio
- shared workspace
- conference management

Video

There are currently three main video tools in use on the Mbone, INRIA Videoconferencing System (IVS), Net Video (nv) and vic. IVS offers integrated audio with the video whilst the others are video only. IVS uses the ISO standard H.261 video encoding, nv uses its own encoding, cellb, or the Sun format. VIC offers a range of encodings for the transmitter and selects the correct decoding option for the receiver.

vic, from LBL, Berkeley [JACOBSON2], provides a main window showing the active participants in the conference with details of their address, video encoding, transmission rate and loss rate. Vic will transparently decode video from a range of encodings. An example of the main window is shown as Figure 1. Each image can be

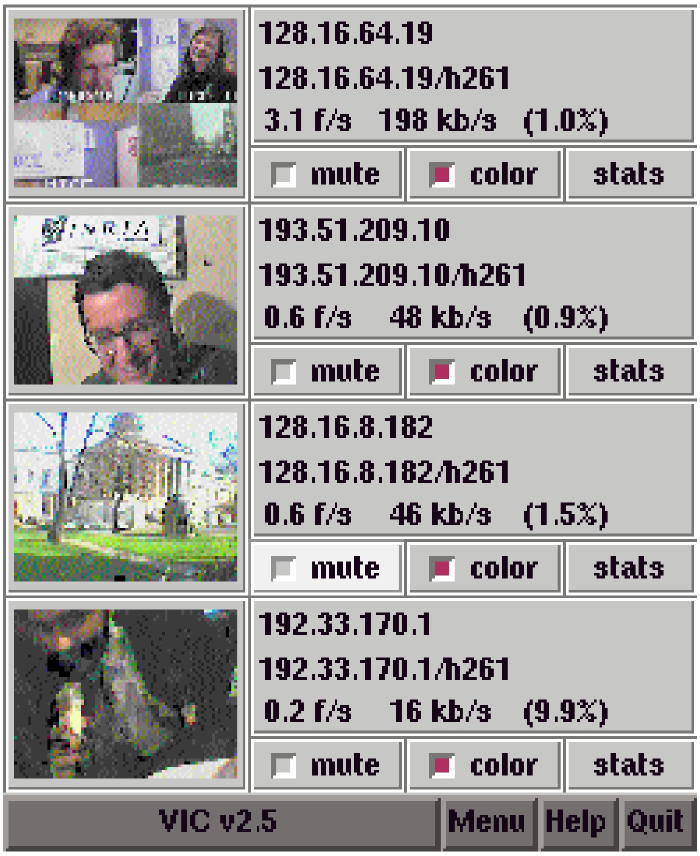


Figure 1 - vic main window

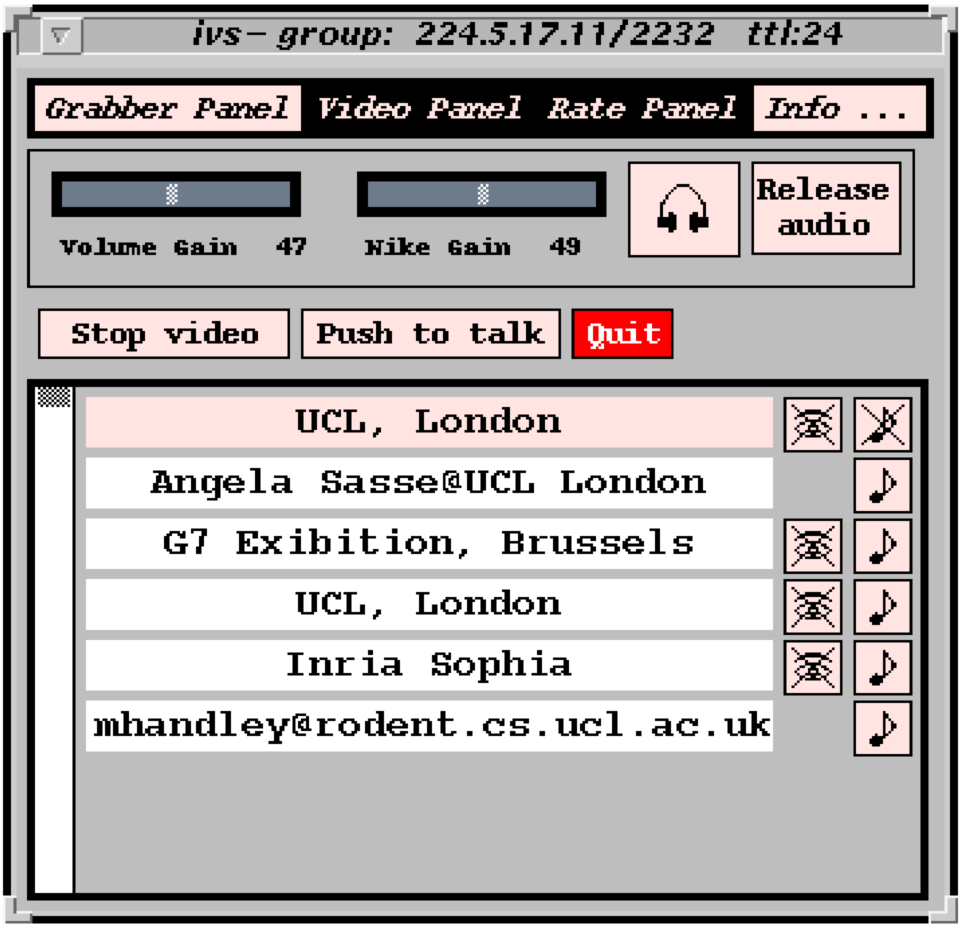
Figure 2 - vic menu

selected from the list shown and displayed at sizes up to SCIF and NTSC. If several participants are using the vat audio tool, vat can automatically determine and display the image of the current speaker. The buttons at the base of the window offer *Help* and a *Menu*. The menu (Figure 2) provides the means to initiate video transmission by selecting the encoding method, the size of image and the maximum rate of transmission. It also offers options for the presentation of the main window elements and a list of all members of the conference which includes those participating as receivers only.

IVS, from INRIA, Sophia Antipolis [TURLETTI] provides an integrated audio and video interface. It also allows point-to-point as well as multicast conferencing. The main window, shown as Figure 3, displays the list of participants and

Figure 3 -

ivs main window



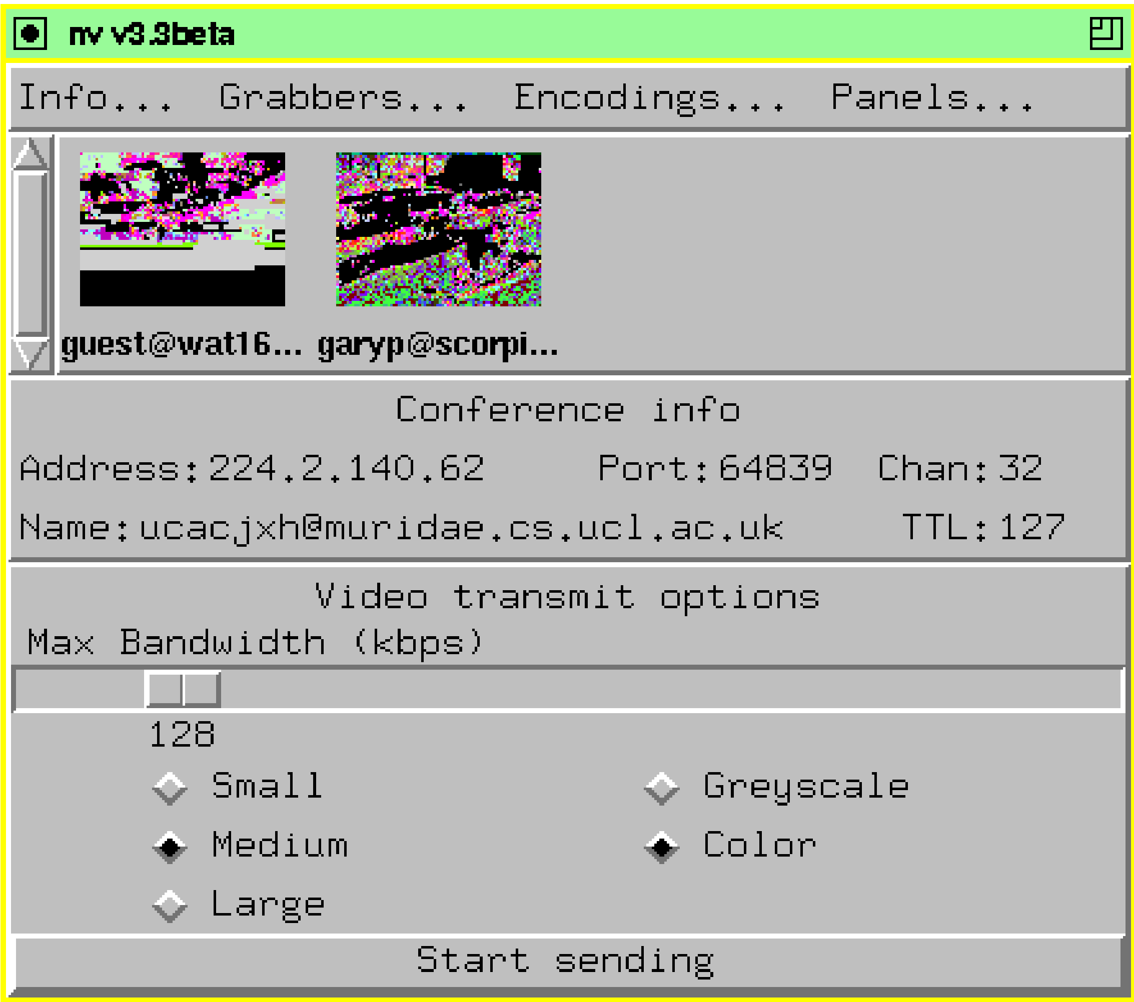


Figure 4 -
nv window

indicates their participation status with icons for video and audio. These allow users to accept or suppress video and audio from each participant independently. Panels at the top of the window are used to control the display of images, through the *Video Panel* and the transmission of images, through the *Grabber and Rate* panels. Having set the parameters, the user selects *Encode video* to transmit. The audio side of the interface is similarly simple to use and is controlled from the second line of buttons. The output type (loudspeaker or earphones) is controlled by an icon and to start the audio the user selects *Get audio*.

Net Video (nv), from Xerox PARC [FREDERICK], provides video-only conferencing as point-to-point or multicast. It has a main window with all the video streams displayed from which any individual stream may be selected. The window has four buttons at the top to allow the user to select *Grabbers, Encodings* and, using *Panels*, the format of the window itself. The default window, shown as Figure 4, includes Conference details and the transmit options. Grabber controls and receive defaults may also be displayed or hidden. The original Mbone video tool, **nv** is widely used and valued for its simplicity. It has the additional advantage of interworking with CU-SeeMe [COGGER], the unicast videoconferencing software for PC and Mac.

Audio

The primary tool for audio conferencing over the Mbone is vat, although use of audio from within IVS is increasing. With vic now able to interwork with vat to display the video image of the person currently speaking in a conference, the stage is set for an increase of such interworking. There is, of course, an increasing number of commercial products which are being promoted as telephone conferencing substitutes and which are outside the scope of this discussion.

Visual Audio Tool (vat), from LBL, Berkeley[JACOBSON3] is another straightforward tool with a simple user interface. The main window is shown as Figure 5. It has a title, a list of participants and, to their right, some controls. If a participant is speaking, a dot is shown in a box to the left of the name. Clicking on this box will suppress the audio from that person. Clicking on the name

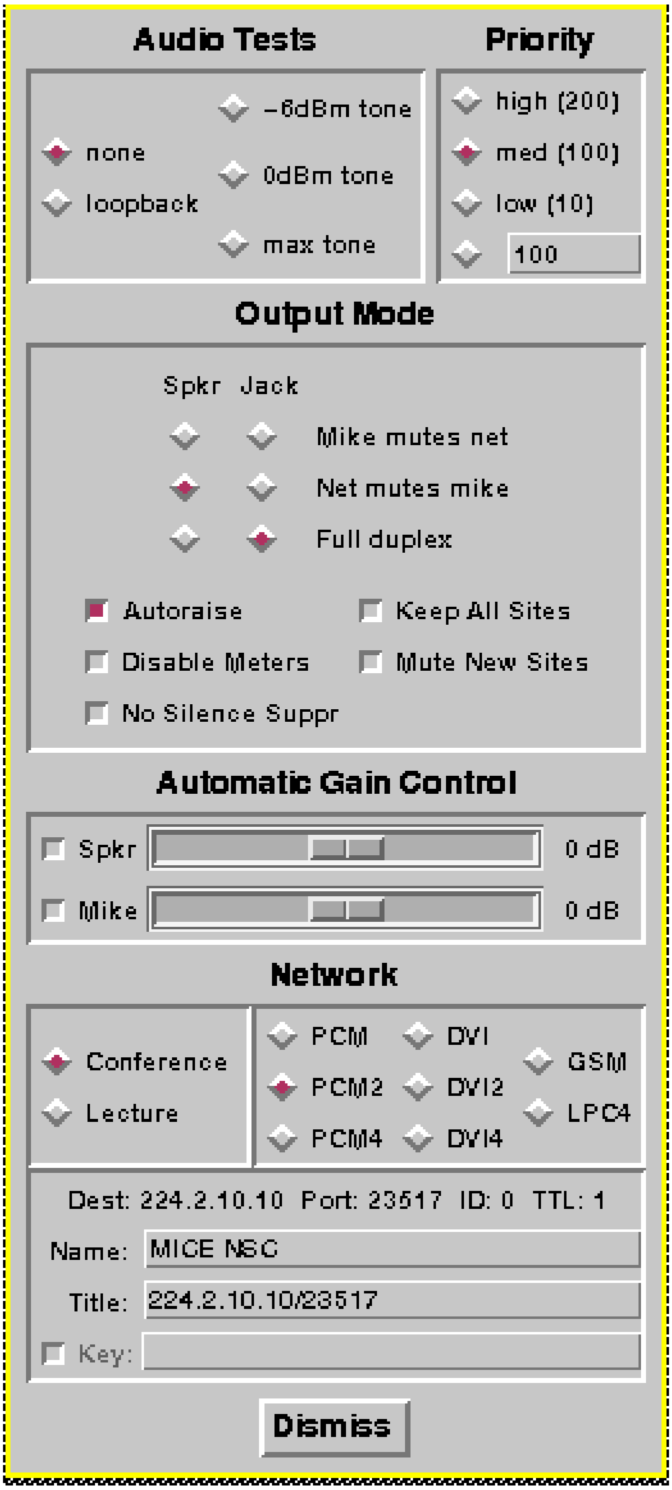


Figure 5 - vat controls

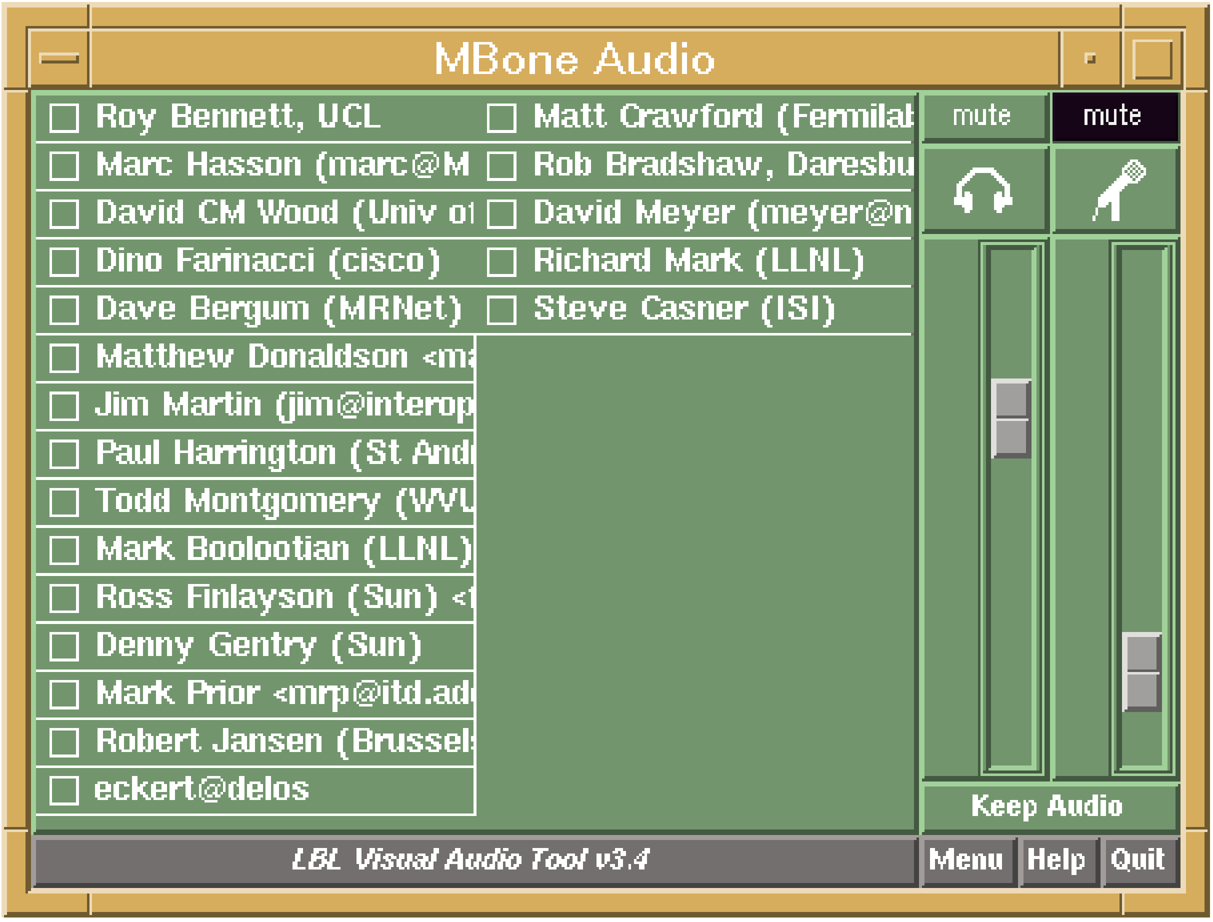


Figure 6 - vat main window

will pop-up a window of statistics relating to reception from the person. The main controls are two vertical columns to the right of the participants - one for receiving, the other for transmitting. Both allow you to mute the channel and provide a volume control slider. On the input side either loudspeaker, headphones or line-out may be selected by sequentially clicking on the button shown as headphones in Figure 6. The *Release* and *Keep* buttons allow the user to switch the audio device between several concurrent vat sessions, in cases where, for example, more than one conference is being monitored.

At the foot of these columns are the *Menu* and *Help* buttons. The menu window, shown as Figure 6, contains the controls and switches needed to run the tool. These include testing, transmission and network controls. They allow the user to set the encoding and to select between *Conference* and *Lecture* mode. This is an important distinction. Since the Mbone is implemented over a datagram network, there is a chance that packets will be missing or misordered at the receiver. It is pointless resending lost packets since the need is for smooth and timely playout of audio. However, sometimes misordered packets can be retrieved if the receiver delays playout for a short time. Increasing playout delay may improve quality and is practicable in the case of a lecture where the flow is in one direction, but not where there is a need for interactive dialogue as in a conference. Hence the two settings. The final panel of the window contains the details of the user. An encryption key may be used to maintain confidentiality.

3. Shared workspace

There are several tools for using shared applications in a multicast environment. Some are based on shared text management and others are for sharing images. Only the most widely used of these, wb, will be discussed here.

Whiteboard (wb), from LBL, Berkeley [JACOBSON4] is a full-colour, shared display function for teleconferencing over the Mbone. For meetings, it provides a normal shared whiteboard on which participants may write, draw and type with all contributions visible to all participants. In a seminar it can be used to display a sequence of slides by using its capacity to import PostScript pages. This provides the functionality of an OHP. In this mode there is a support tool from the same authors called wbimport from the same source. Wbimport allows for more control over the display of the images. An example of a postscript image with annotations is shown as Figure 8. The controls of the whiteboard are intuitive, most of them being set on the right side of the main window. At the top are the drawing tools, then two pop-up menus for *font* and *brush size*. Below is the colour palette, an *undo* button, the orientation controls and a *print* button. At the foot of the window are controls for managing the pages and importing either text or postscript files.

In addition to the whiteboard window itself there is a separate control window (Figure 7). The upper section, *Activity*, shows those who have contributed with current contributors highlighted. All *Participants* are shown below this with details of a highlighted participant shown in the *Participant Info* section. Checking the box to the left of each participant prevents the display of that persons contribution - a useful feature in an open environment where the whiteboard is vulnerable occasionally to anonymous graffiti. Under *Network* are the details of the user and finally some more controls. Of these, the significant one is *Mute New Sites* which allows you to prevent the contributions of any new people joining the conference from appearing on the whiteboard. The feature complements that provided for individuals in the *Participants* section.

Conference management

There are no tools to actively manage conferences on the Mbone. Resource management, quality of service guarantees and a conference booking system are for the future. There are two programs, however, which, in some sense help to manage conferences. They allow an event to be publicised and provide a simple way to join. There is no conference protocol for participants mandated by these programs. Floor control is not automated and each event must decide on a plan of action to suit its particular needs. The approach is very flexible, but requires more sophistication from users than would a more controlled environment.

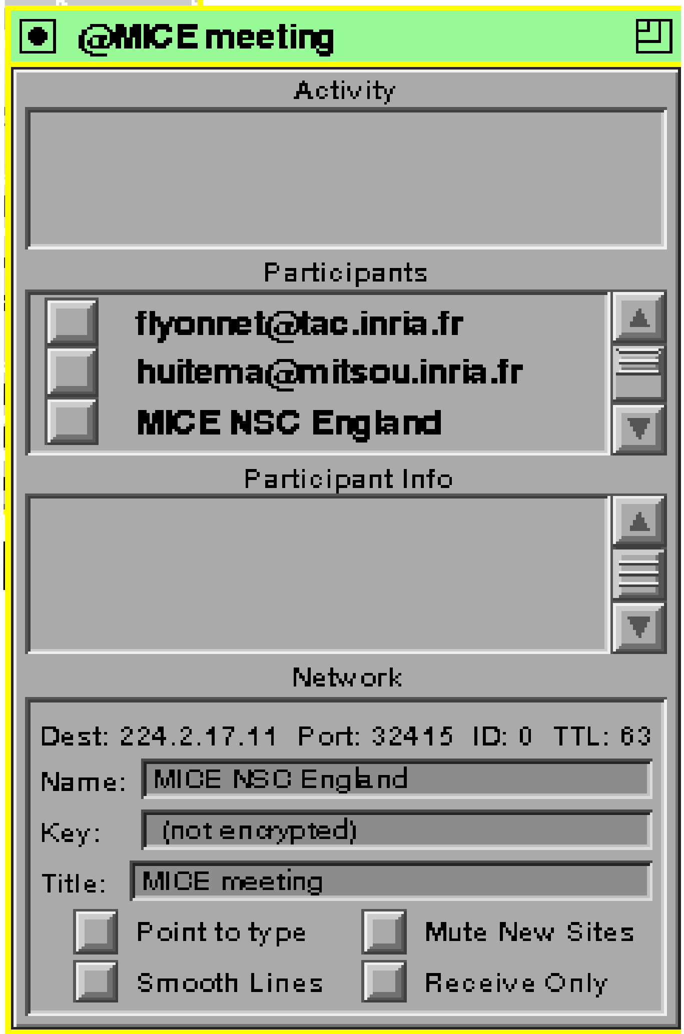


Figure 7 -wb control window

The **Session Directory (sd)** tool, from LBL, Berkeley [JACOBSON1], provides the basic advertising and invocation only. It is widely used by the Mbone user community

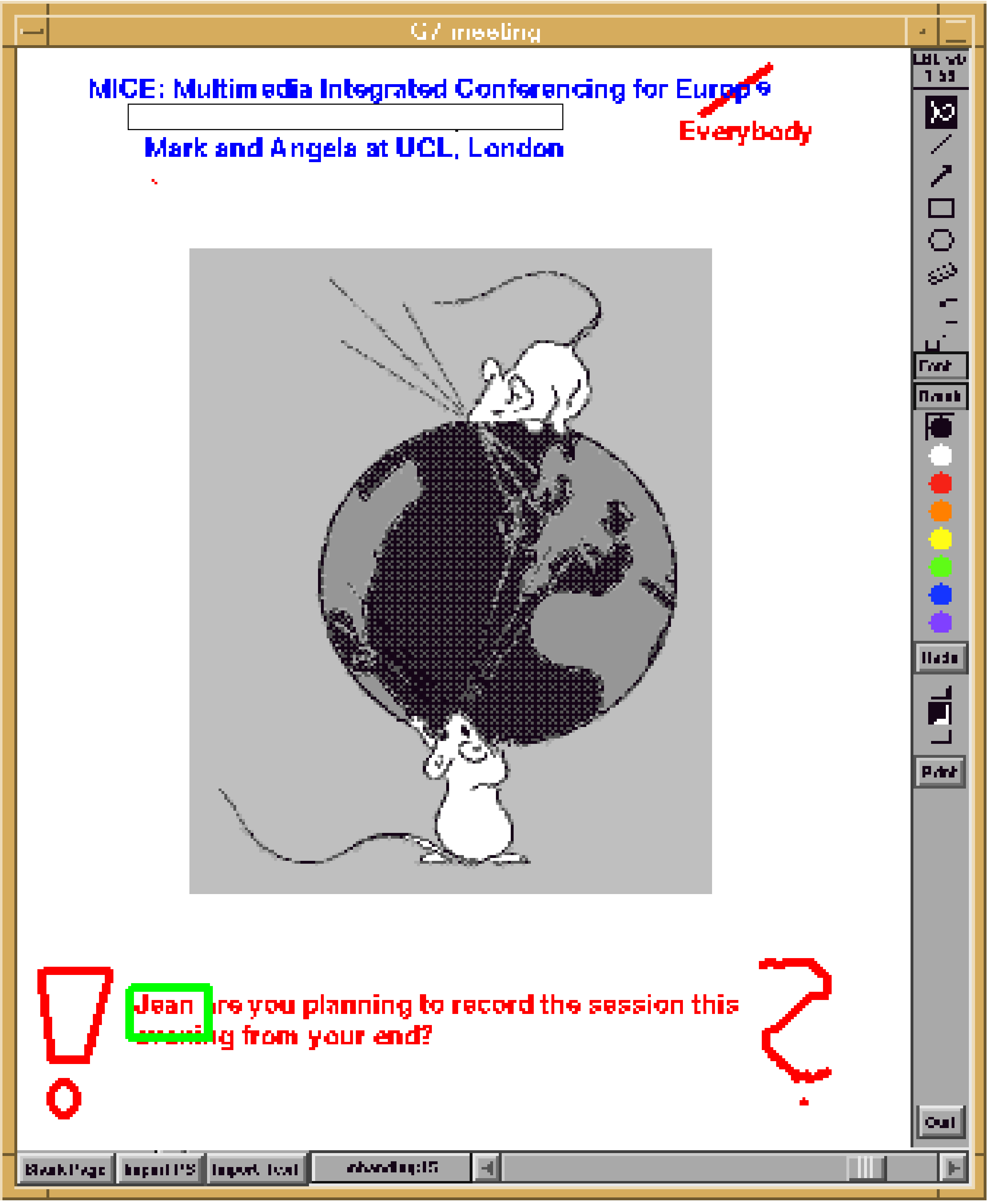


Figure 8 - annotated whiteboard

and is the default standard tool. It has a simple format - the main window is shown in Figure 9. The list of available sessions is in the upper half of the window; details of the highlighted session are shown in the lower half. The buttons at the base of the window allow you to open a session (i.e. to join in), to set up a new session, to edit sessions which you created and to delete them.

The **Multimedia conference control program (mmcc)** from USC/ISI, Marina del Rey [SCHOOLER], provides point-to-point or multipoint teleconferencing. In contrast to sd it allows a caller to explicitly invite others to participate in a conference, and alerts them to accept or decline. Like sd it automatically sets up the underlying audio, video and shared workspace programs among members of a conference and releases them at the end. It complements the open approach of advertising public sessions used by sd with a more private session style for smaller conferences. Thus, session advertisement is internal to the group of participants.

Figure 9 - sd window

HOW TO GET STARTED

What you need to have

The prerequisites may be categorised under the headings of justification, connectivity and equipment.

Justification: For many users the most important benefits may be hard to measure (an enhanced experience for students in distance education, or better co-ordination and co-operation in a working group, for example). These days, however, a financial justification is usually needed. This can be made in terms of saved travel expense where there is a need for regular meetings with colleagues at remote locations. Multimedia conferencing cannot yet replace the need for *real* meetings, but it can reduce that need. In the MICE project [HANDLEY et al.] which links partners all over Europe, the regular weekly meetings over the network have reduced the need for full-scale face-to-face meetings at a common location.

Connectivity: You and your prospective partners in conferencing will need a good connection to the Internet. The minimum recommended by MICE Support Centres is 256 Kbps, but success has been achieved with 128. In the UK the SuperJANET network is providing excellent connectivity to universities and other academic and research institutions. The panel on page 16 shows the list of institutions currently connected to the SuperJANET Mbone pilot network which provides them with at least 8 Mbps between one another. Shortly Mbone connection will be available to all universities.

Equipment: You will need a workstation similar to that described earlier. If you need to have a number of people in a conference room, you will need some means of displaying the workstation screen image onto a larger screen and possibly a radio microphone to allow easy change of speaker. For basic conferencing the costs are not excessive.

What you need to do

If you have sufficient access to the Internet, you need to have your network provider connect you to the Mbone. This is done by establishing an mrouter on your site and creating a new tunnel to an adjacent mrouter already on the Mbone. For UK JANET users, full guidance can be obtained from [JIPS MBONE GUIDE].

Help available

Building on the experience of the MICE project and with the support of UKERNA,a number of MICE National Support Centres have been established throughout Europe. The UK centres are at University College London, Edinburgh and Glasgow universities and the University of Wales at Aberystwyth. Each of these centres can provide advice, contacts with network providers and access to the free software. Help is provided through World-Wide Web pages [MICE NSC], through electronic mail (email) and over the telephone. Demonstrations can be arranged to give prospective users an indication of the quality and scope of the technology first-hand.

APPLICATIONS

The use of the technology for international research cooperation between European researchers, and with colleagues in the US and Australia, has been demonstrated successfully in public events at a number of conferences.

Since seminars are a major example of collaboration between researchers, the technology was piloted by setting up a distributed International Research Seminar Series on Communications, Multimedia, Distributed Systems and CSCW, and inviting researchers and graduate students from all over the world to participate.

In addition to these public demonstrations, MICE partners and other European projects use the technology for weekly project meetings.

Minimal Invasive Surgery Workshop

A two-day workshop on novel minimal invasive surgery techniques, attended by surgeons specialising in this area, was held at the Middlesex Hospital in London on November 10 and 11, 1994. The workshop consisted of talks and a number of live operations to demonstrate surgical techniques and sessions were transmitted to Sahlgrenska Hospital in Gothenburg (Sweden). On the second day, surgeons in Gothenburg and at the University Hospital in San Francisco demonstrated novel surgery techniques in live operations which were watched by the workshop participants in London. A question-and-answer session between members of the London audience and the surgeons in Gothenburg and San Francisco followed the operation.

ArtAIDS Launch

The Artaids project [ArtAIDS] involves a number of renowned artists, who agreed to donate a piece of electronic art to Crusaid, a UK Aids charity. These art pieces were to be used in a long-term project on cooperative art: they were made available on a World-Wide Web server for anyone to view and retrieve. Artists and other people were encouraged to create new pieces of art from this starter collection, and return them to the Artaids server as a further donation for Crusaid.

Stormy Waters

Digital artists from five continents sent images via the Internet to the event site on the River Clyde at Glasgow, where they were incorporated into a live arts show which included music and dance (even the shipyard cranes danced). The performance was watched by 3000 people on site and the live performance was multicast around the world on the Mbone.

ReLaTe Project

The ReLaTe project, funded by British Telecom as part of the BT/JISC initiative, aims to investigate the feasibility of sharing language teaching resources using multimedia conferencing technology. Following a study of the requirements for supporting tutors and learners in a range of language learning scenarios (lectures, small-group tutorials, one-to-one sessions), a demonstrator system was developed including an integrated user interface, enhanced audio and lip synchronisation. This has been used to deliver language teaching with tutors and learners from the language centres at UCL and Exeter University. Initial feedback has been extremely favourable and development work is continuing.

REFERENCES

[ArtAIDS] ArtAIDS - a collaborative project for CRUSAID, a leading UK AIDS fund-raising charity.
URL *http://artaids.dcs.qmw.ac.uk:8001/*
[BUCKETT et al.] Buckett, J.; Campbell, I.; Sasse, M. A.; Hardman, V.; Watson, A. : ReLaTe: Remote Language Teaching over SuperJANET, to be presented at UKERNA Networkshop, March 28-30, 1995
[CLAYMAN et al.] Clayman, S.; Hestnes, B.; Kirstein, P. :The Interworking of Internet and ISDN Networks for Multimedia Conferencing, to be published in Information Services and Use, IOS Press, 1995.
[COGGER et al.] Cogger, : CU-SeeMe
URL ftp://gated.cornell.edu/pub/video/CU-SeeMe.FAQ.7-6.txt
[DEERING] Deering, S. : Host extensions for IP multicasting. Network Working Group Request for Comments 1112, August 1989.
[ERIKSSON]Eriksson H. (1994): Mbone: The Multicast Backbone. Communications of the ACM, Vol. 37 (8), 54-60.
[FREDERICK] Frederick R. nv - Manual page, XEROX PARC.
[HANDLEY et al.] Handley, M.J.; Kirstein, P.; Sasse, M.A. : Multimedia integrated conferencing for European researchers (MICE): piloting activities and the conference management and multiplexing centre. Computer Networks and ISDN Systems 1993, 26, 275-290.
[IP ADDRESSES] http://www.wrq.com/techweb/tutorials/tcpip/ipadd1/htm
[JACOBSON1] SD README file, Lawrence Berkeley Laboratory (LBL), March 30th 93
[JACOBSON2] Jacobson, V. VIC manual pages, Lawrence Berkeley Laboratory (LBL), 2 November 1994.
[JACOBSON3] Jacobson, V. VAT manual pages, Lawrence Berkeley Laboratory (LBL), February 17th 93.
[JACOBSON4] Jacobson, V.WB README file, Lawrence Berkeley Laboratory (LBL), August 12th 93.
[JAMESON et al.] Jameson D.G., Hobsley, M.; O'Hanlon, P.; Buckton, S. : Surgical Teaching Project in Surgery, ED-MEDIA 94, World Conference on Educational Multimedia and Hypermedia, Vancouver, Canada, June 25-29, 1994.
[JIPS MBONE GUIDE] URL: http://www-mice-nsc.cs.ucl.ac.uk/mice-nsc/tg,html
[KLINE] Kline, C.: Maven URL http://pipkin.lut.ac.uk/WWWdocs/LUTCHI/misc/maven.html
[MACEDONIA & BRUTZMAN] Macedonia, Michael R.; Brutzman, Donald P. : MBone Provides Audio and Video Across the Internet. IEEE COMPUTER, April 1994, pp. 30-36.
[MICE NSC] The MICE National Support Centres, supported by UKERNA:
England - URL: http://www-mice-nsc.cs.ucl.ac.uk/mice-nsc/
Scotland - URL http://mice.ed.ac.uk/mice/
Wales - URL http://www.dcs.aber.ac.uk/mice/
SASSE et al.] Sasse, M. A.; Bilting, U.; Schulz, C-D.; Turletti, T. : Remote Seminars through Multimedia Conferencing: Experiences from the MICE project, Proc. of INET'94/JENC'5, June 1994.
[SCHOOLER] Schooler, E.:MMCC Manual page. USC/ISI.
[TURLETTI] Turletti, T. : The INRIA Videoconferencing System (IVS), ConneXions - The Interoperability Report, Vol. 8, No 10, October 1994, pp. 20-24.

FURTHER READING:

Installation and User manuals for software supported by the MICE NSCs:
URL http://www.cs.ucl.ac.uk/mice/mice-nsc/tools/

GLOSSARY

Analogue representation uses an indicator that can vary continuously (eg a speedometer needle) to represent changing values. An analogue signal changes smoothly.
Bandwidth a frequency measurement, used to show the amount of information that can flow through a communications channel. Expressed in terms of thousands of bits per second.(*Kbps*) or cycles per second (*hertz).*
CIF Common Image Format with dimensions of 352x288 pixels.
CODEC (COder/DECoder) converts analogue to digital and digital to analogue.
Digital representation uses distinct objects or digits (eg 0 and 1) to represent something. A digital signal changes abruptly from one value to the next.
Ethernet a set of standards covering hardware, software and communications for local area networks; a high bandwidth communications channel.
Framegrabber a device which captures video a frame at a time from an analogue video source.
H.261 a video encoding standard.
Host: a computer accessed via a network.
Mbone the Multicast-capable backbone of the Internet. It consists of a network of tunnels linking the islands of multicast-capable sub-networks around the world.
Motion vectors provide the information to a video decoder on where in the current frame to place the individual blocks which have moved since the previous frame.
Mrouter the workstation running the mrouted program which routes multicast traffic between multicast-capable subnetworks.
Pixel a picture element on a video screen. It is the smallest component of a screen image.
Protocol a set of standards that govern the transfer of information between computers over a network or via telecommunications systems. To reduce errors, the computers at both ends of a communications link must follow the same protocol.
QCIF Quarter Common Image Format with dimensions of 176x144 pixels.
Router a device for routing packets through a packet-switched network.
SCIF Super Common Image Format with dimensions of 704x576 pixels.
Tunnel a connection between two Mrouters to carry encapsulated multicast packets between multicast-capable subnetworks.

ACRONYMS

ATM	Asynchronous Transfer Mode
CIF	Common Image Format
CMMC	Conference Multiplexing and Man-agement Centre
CODEC	COder/DECoder
CSCW	Computer-Supported Collabora-tive Work
EMMA	Enhanced Multicast for Multimedia Applications
HEFCE	Higher Education Funding Council for England
ISDN	Integrated Services Digital network
ISO	International Standards Organisation
IP	Internet Protocol
IVS	INRIA Videoconferencing System
JANET	Joint Academic Network
JIPS	JANET IP service
JISC	Joint Information Systems Committee
LAN	Local Area network
LBL	Lawrence Berkeley Labs
Mbone	Multicast backbone
MICE	Multimedia Integrated Conferencing for Europe
mmcc	Multimedia conference con trol
NTSC	National Television Standard Code
nv	NetVideo
PAL	Phase Alternate Line
QCIF	Quarter Common Image Format
SCIF	Super Common Image Format
sd	Session Directory
SuperJANET	National Broadband Net work for the UK academic community
TLTP	Teaching and Learning Technology Programme
UCL	University College London
UKERNA	United Kingdom Education and Research Networking Association
vat	Visual Audio Tool
wb	Whiteboard
WWW	World Wide Web

SuperJANET Mbone Pilot sites, November 1995

Aberdeen
Aberystwyth
Aston
Bath
BBSRC
Bristol
Brunel
Cambridge
Daresbury
De Monfort
East Anglia
Edinburgh
Essex
Exeter
Glasgow
Hertfordshire
ICRF
Imperial College
Lancaster
Leeds
Loughborough
Manchester
Manchester Metropolitan
MRC Hinxton Hall
Newcastle
Nottingham
Oxford
QMW
RAL
Sheffield
Sheffield Hallam
St Andrews
Strathclyde
Sussex
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