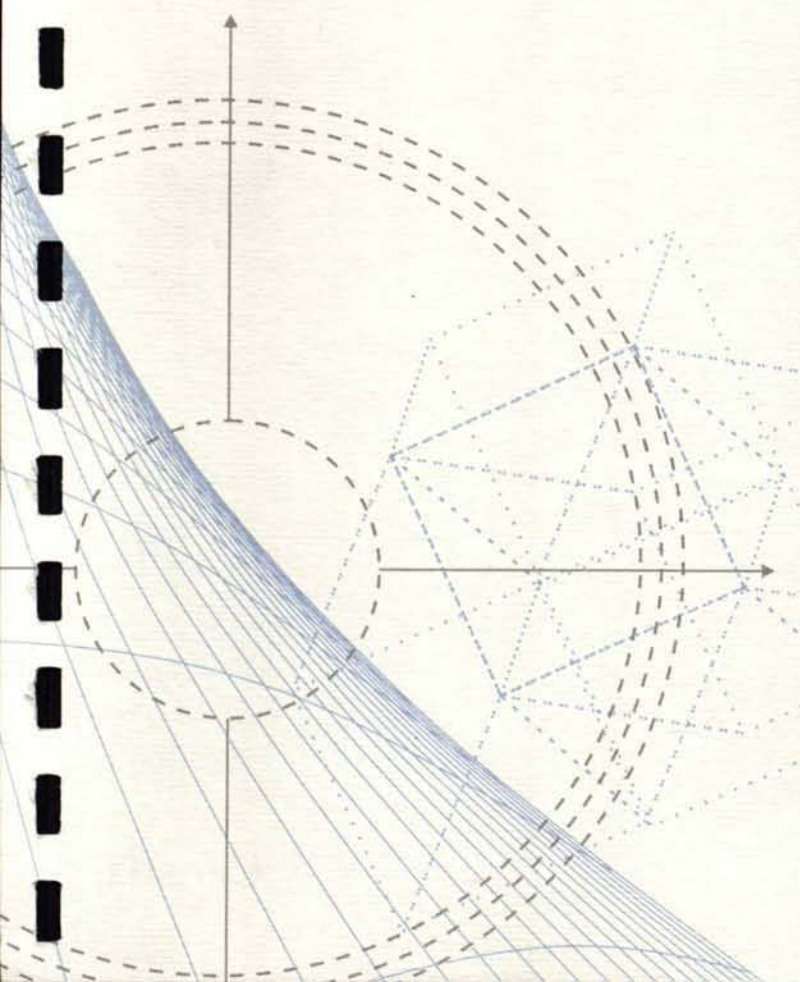
The MERCI Project

Final Report

John Robinson

Network Systems Research



CRC-RP-98-004
Ottawa, September 1998

Communications Research Centre
Centre de recherches sur les communications

THE MERCI PROJECT

ABSTRACT

During 1996 and 1997 CRC participated with a consortium of European research and industrial organisations in a European Union sponsored Project called MERCI (Multimedia European Research Conferencing Integration). The objective of MERCI was to investigate the technical and human factors issues and to develop technology components for multimedia collaboration on the Internet.

This report introduces briefly the MERCI Project and the method of work adopted by the partners. The report describes the contributions that CRC made to the project and presents our observations about the state of multicasting and videoconferencing on the Internet. CRC results from MERCI included the development of a general framework for the analysis of videoconferencing to support network monitoring and human factors studies, measurement of the performance of several trans-Atlantic IP multicast connections and experimental integration of these into the European MBone infrastructure, and the development and deployment of several new multicast network monitoring and polling tools.

The MERCI Team at CRC

The CRC team members who contributed to the MERCI Project included the author, Dr. Andrew Patrick and Dr. Dan Pilon who was at CRC on a post-doctoral fellowship. John Stewart, under contract to CRC, was an essential member of the CRC team. Michel Savoie provided support from the BADLab. Dr. Gerard Nourry and Erle Jones provided encouragement throughout the Project.

ACKNOWLEDGMENTS

The assistance of the following individuals is gratefully acknowledged.

Vincent Taylor from DND/CRAD with technical support from Joe Spagnolo of NRNS Inc. provided the DRENet connection. Yves Poppe of Teleglobe Canada Ltd. , Bill St.Arnaud of CANARIE Inc. and Volker Reible and Peter Feil from DeTeBerkom in Berlin, Germany contributed to the provision of the connection via the CANTAT-3 trans-Atlantic link. Bill Coderre provided project management assistance from the Canadian Embassy in Brussels.

TABLE OF CONTENTS

1.0 INTRODUCTION

During 1996 and 1997 research staff from the Network Systems Research Group at CRC participated with a consortium of European research and industrial organisations in a project to investigate the technology components and tools for multimedia collaboration on the MBone, i.e. the portion of the global Internet that is multicast enabled. The purpose of this report is to wrap up the project by describing the contributions that CRC made to that project and providing some concluding reflections about the state of multicasting and MBone videoconferencing on the Internet.

The structure of this report is as follows. The following sub-sections give some background to the Project and describe the method of work that was adopted by the MERCI partners. The next Section presents the results from CRC's participation in the project. That is followed by a Section describing the IP multicast networking infrastructure that was used for the interconnection of the MERCI partners. The final Section provides a brief concluding review.

1.1 Project Background and Objectives

MERCI (Multimedia European Research Conferencing Integration) [1, 2, 3, 4] was a European Union Framework Four Telematics R&D Project . CRC was eligible to participate as an official partner in this European research project because of the Science and Technology Agreement signed by Canada and the European Union (EU) in 1995. A Work Plan [5] describing CRC's intended contributions to MERCI (R&D activities, deliverables and resource commitments) was provided to the MERCI Project Manager and incorporated in the official revised MERCI Project Plan [6] that was published for the EU in November 1996. The MERCI Project began officially on 1 December 1995 and terminated two years later on 1 December 1997.

The overall objective of MERCI was to provide the technology components to allow proper deployment of the tools for multimedia collaboration. The R&D activities were organised under three themes:

1. Technical issues
   -the multimedia tools must operate over a wide range of network technologies and computer platforms.
   -the components must adhere to new Standards to ensure that they interoperate with technologies emerging from worldwide research sites and industry.

2. Human factors issues
   - the multimedia tools must be made easy to use for the uninitiated.
   - tools are needed for conference booking, setup and control, and diagnosis of problems as they occur.
   - problems that arise in the use of large lecture rooms for multimedia conferencing must be resolved.

3. Development of components
   - flexible hierarchical multimedia storage mechanisms.
   - better quality multimedia video and audio components and stream synchronisation mechanisms.
   - security that will restrict access to and authorise users of conferences and document stores.

Additionally, to verify the MERCI technology and its utility in different applications and network environments a number of validation activities were planned - project coordination conferences, distance learning seminars, surgical workshops and commercial testbeds.

MERCI was a large undertaking involving eight academic and research organisations and four industrial partners from six countries. Given the scope of the MERCI Project it is no surprise that CRC was not active in all the work. The results of all the Project activities, however, are available to CRC under the MERCI Project agreement.

The partners in the Consortium included the University College London (UCL), the French National Institute for Research in Computer Science and Control (INRIA), the Swedish Royal Institute of Technology (KTH), Oslo University in Norway, the German National Research Centre for Computer Science (GMD), the Stuttgart University Supercomputer Center (RUS) and the Communications Research Centre (Figure 1). Under a preceding EU Project (MICE) [7] some members of this group of researchers made important contributions to the development of the MBone protocols and applications and they played a central role in the deployment of the MBone in Europe. That initiative was continued in MERCI.

Figure 1: The MERCI Partners

1.2 Method of Work

1.2.1 The Work Packages

The activities in MERCI were organised into a number of Work Packages (WPs) (Table 1) each responsible for a particular area drawn from the overall Project objectives. Each WP had a Lead organisation and participants from a subset of the MERCI partners. Some of the WPs addressed technical matters, e.g. development of audio and video tools, while other WPs concerned a series of demonstrations, distance-learning and surgical workshop validation activities.

Work Package	Name	Description/Objective
WP 1	Management	
WP 2 *	Activity with External Groups	includes concertation activities with other EU Projects and interface for the Project with Standardisation bodies.
WP 3	Multimedia Conference Components and Cross-platform Support	to develop multimedia components, principally better quality video and audio and stream synchronisation, to increase the range of platforms the tools run on and to ensure interoperability between Internet and ISDN technologies.
WP 4 *	Usability and User Interfaces	to ensure that the tools provided in the rest of the project are really usable by the uninitiated and in other CEC and National projects.
WP 6 *	Network Support	to ensure that the MERCI multi-media tools operate over a wide range of technologies: LANs, ISDN, ATM, etc.
WP 7	Multimedia Server Support	to provide a database repository of conferences; to optimise multimedia storage; to define flexible hierarchical multimedia storage mechanisms
WP 8	Conference Control and Management	to develop tools for booking conferences, controlling bandwidth usage, setup and control of mulitplexors and transcoders and diagnosis of problems.
WP 9	Conference Room Support	to resolve problems that arise in the use of large lecture rooms for multimedia conferencing.
WP 10	Security Support	to provide security that will restrict access to and authorise users of conferences and document stores.
WP11 *	MERCI Seminars	a validation package to apply the tools in distributed seminars
WP 12 *	Surgical Workshop	a validation package to apply the highest-quality tools in a surgical workshop series held at Middlesex College.
WP 13	Commercial Trials	a validation package to apply the tools in commercial context with industrial partners

[* WPs to which CRC contributed]

Table 1: The MERCI Work Packages

CRC participation in MERCI included contributions to several of the research Work Packages (WP4 & WP6) and to several of the validation Work Packages (WP11 & WP12).

CRC also contributed to WP2 (Activity with External Groups) by maintaining an exchange of information and collaboration where appropriate with complementary Canadian activities. There was regular contact between DRX staff and CANARIE to exchange information about respective research activities, especially the CANARIE Multicast Project [8] and the NTN MBone trials. Interaction with the Canadian contributions to the NICE-Global, G-7 GIBN and MAY Projects was facilitated because the CRC BADLab was a participant in those projects.

1.2.2 Project Coordination

Internet Electronic Mail was used throughout the project for planning and coordination and mailing lists were set up for each Work Package. Several participating organisations maintained a Web site to advertise their involvement in MERCI and a master site was maintained at UCL. These Web sites acted as a repository of Project software and documentation. CRC set up a Canadian Web site and a software repository [9] for the CRC prototypes that were developed under the Project.

To assist in Project management and coordination and to test the MERCI products, bi-weekly Project meetings were held using the MBone. Regular face-to-face management meetings were found to be essential as well, to review the status and progress of the Work Packages and to plan collaboration. These were held quarterly and a CRC representative attended most of these meetings. Additionally, there were occasional face-to-face meetings for specific Work Packages that were called by the WP Leader when it was deemed necessary.

1.2.3 Project Deliverables

Under the MERCI contract, the Project Manager was obliged to provide to the EU a package of peer-reviewed software with documentation and annual Project Reports, as well as to present several official Demonstrations for the EU in Brussels. In support of these obligations, the partners delivered to the Project Manger research reports, experimental and test results, prototype software, and the partners supported the series of demonstrations and validation activities.

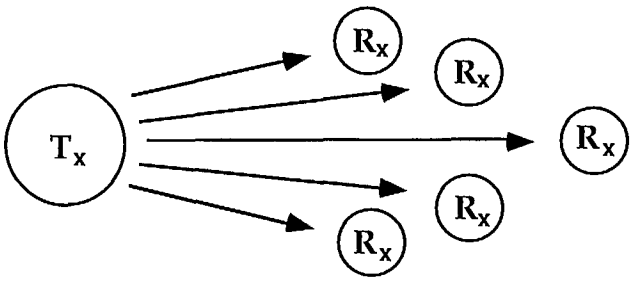
Software prototypes for three new MBone tools were delivered by CRC to the MERCI Project. CRC contributions also included results from performance measurement and usability experiments and participation in a number of the demonstrations and validation events. The CRC contributions and deliverables provided to the MERCI Project are described in Section 2.

2.0 Results

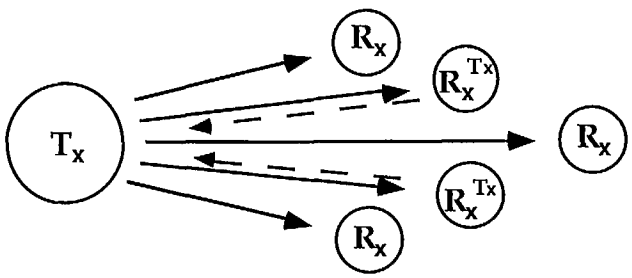
2.1 Framework for the Analysis of Video-Conferencing

While technologies have existed for several decades, at least in prototype form, it is only with the emergence of the Internet and the new multimedia computer innovations that videoconferencing has become an attractive possibility as an affordable mass communications service. In the last few years experiments on the Internet have demonstrated several possible types of video conference services that have attracted the attention of a number of different potential user communities. This is currently a nascent technology and communications service, and the development of a framework for videoconferencing was undertaken to provide a general analysis tool. This was found to be particularly useful for our multicast network management and human factors studies.

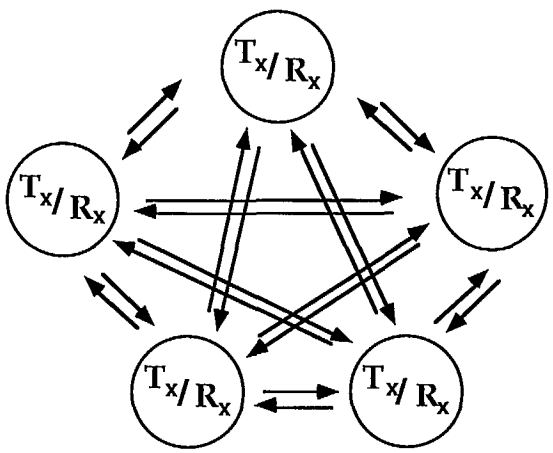
Our general framework for the analysis of video-teleconferencing is based, at the first level of resolution, on the organisation of sessions into categories by type. A typical conference session involves multiple participants exchanging multimedia information interactively in real-time. Every participant will receive and possibly transmit at least audio and video. Based on factors such as the size of the audience and the style of participation (passive reception, occasional transmission, etc.) three types of conference sessions are distinguished: broadcast, seminar and meetings (Figure 2). For each type the information flow and traffic patterns are significantly different. This categorisation assists in deriving an understanding of the needs and requirements for network monitoring and control [10].



BROADCAST



SEMINAR



MEETING

Figure 2: Conference Session Types

The categorisation of conference sessions by type provides a useful starting point however a detailed assessment of human factors issues requires a more rigorous taxonomy. For this purpose three parameters of concern have been defined: the task of the session (meeting, education, entertainment), the media used during the session (video, audio, shared workspace), and the communication modes involved (interactive vs. non-interactive and formal vs. informal) (Figure 3). Placing videoconference sessions and software in this parameter space provides valuable information about the technical and human requirements [11].

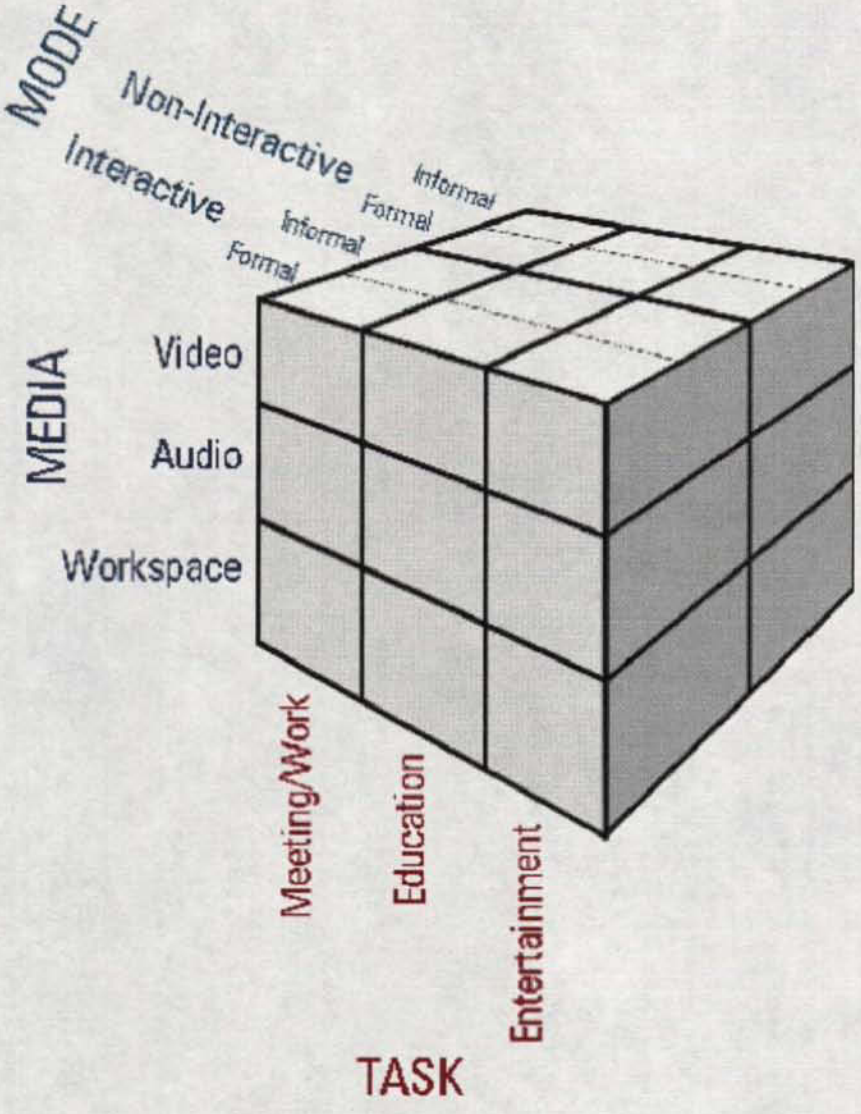


Figure 3: Schematic Representation of Videoconference Taxonomies

2.2 Network Performance

To support the development of multicast network technology and applications a part of the Internet, called the MBone, is configured to handle IP multicast traffic. The MERCI partners each was responsible for their access to the MBone and together ran trials and experimented with the MBone network in Europe. At CRC, obtaining and maintaining a stable trans-Atlantic connection and integrating this into the experimental MBone infrastructure of our partners was a continuing challenge throughout the MERCI Project. We explored various Internet routes to Europe. The various networks and connections that we used are described in the next Section.

A MERCI project objective was to conduct a program of quality of service (QoS) performance measurements that would characterise the experimental MBone and its multicast routes as well as support the installation and maintenance of the network infrastructure. Throughout the project the varying condition of the European networks was a constant impediment to systematic performance measurements. While our performance measurement activities provided essential support to the success of the various conferences that were held throughout the project it was not possible to conduct a long term program of measurements as had been initially hoped

The problem was not particularly with the underlying communications links although reliable high bandwidth connections are a scarce and expensive commodity. The problem was with the network level management of the MBone. The limited extent to which native IP multicast routing is supported on the Internet has encouraged the proliferation of numerous tunnels[1] that currently constitute the largest part of the backbone of the MBone. These tunnels are managed by a loose federation of volunteers yet to be reliable they require constant attention and frequent reconfiguration. The situation is aggravated by the lack of adequate tools for performance measurement, diagnosis and network management. This latter problem motivated us to develop several new tools [12] for multicast monitoring and QoS measurement. These are described below.

Despite these problems the MBone service was good enough for us to carry out a considerable number of trans-Atlantic video conferences during the project and to allow experiments and trials of prototypes. This has made an important contribution to the development of the technology that is needed to promise a well managed Internet multicast video conferencing service in the near future.

[1] To support a tunnel a computer must run the MRouteD software. Two such computers, connected across the Internet, can then be configured to exchange IP multicast packets encapsulated in IP unicast packets. That is an MBone "tunnel".

2.3 Deliverables

2.3.1 Software Prototypes

During the project, CRC produced and delivered three new MBone tools to MERCI. They are introduced briefly in this Section. More detailed information about these tools can be found in the research reports and software documentation [10, 11,12,13,14, 15].

Software prototypes of these tools were provided to the MERCI partners, evaluated by peer review and released to the international Internet/MBone community for testing and evaluation. They are now available for public release and can be found in the MERCI software repository. The software carries a CRC copyright notice. These technologies are available for commercial development, under the CRC technology transfer program.

2.3.1.1 MPoll

A real-time opinion polling and rating collection tool called MPoll [11] was developed by Andrew Patrick. MPoll was produced with the following uses in mind:

- to collect quality ratings during multicast sessions,
- to collect opinions and votes during multicast collaborative work sessions,
- to collect opinions on general topics or current events.

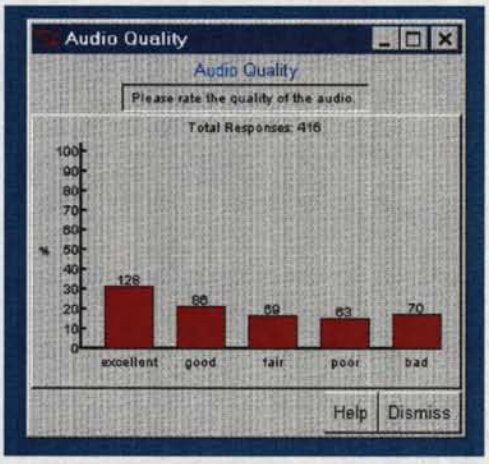


Figure 4: MPoll Results Displayed

In the main MPoll window questions are presented to the users. Users can create a new question and this will become available to all the users who have joined that multicast session. As users answer the question the responses are distributed to all the participants,

where they are tallied and can be displayed as shown in Figure 4. More information including technical details are provided on the Web site [13] and in several reports [11, 14].

2.3.1.2 MERCInari

During the first year of MERCI an MBone quality-of-service (QoS) monitoring platform (MERCInari - MERCI network active recording interface) was developed by John Stewart and John Robinson to monitor and record traffic during multicast events for QoS management and to collect and record QoS performance statistics for later analysis and diagnostics. The concept is based on the use of RTP/RTCP and the QoS flow performance parameters that can be obtained from that protocol. Figure 5 shows a typical MERCInari output giving packet count, packet loss and throughput on an MBone video channel between CRC and UCL in London England. More information about MERCInari can be found in reports [14,15]

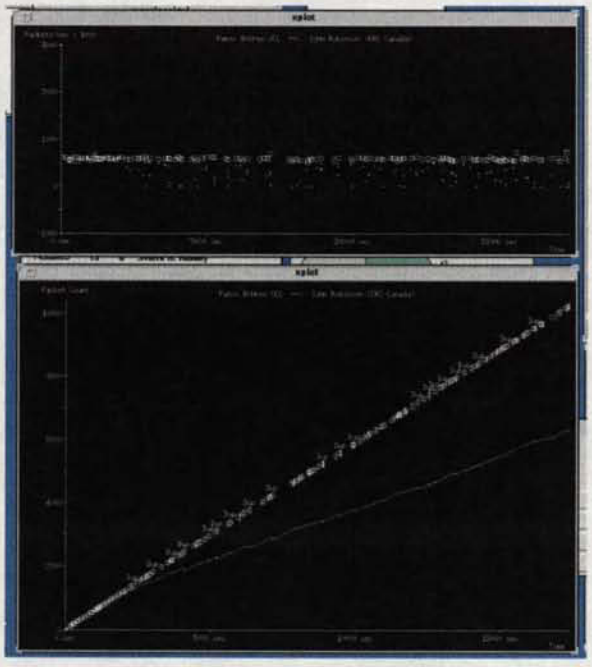


Figure 5: Time Series showing Packet Count, Packet Loss and Throughput

2.3.1.3 MultiMON

An IP multicast monitoring tool called MultiMON was developed by John Stewart and John Robinson. MultiMON is a protocol monitor that collects, organises and displays the IP multicast traffic at the location of the MultiMON Server. MultiMON can be used as a very general purpose monitoring tool, however it was designed with particular consideration for monitoring local area infrastructure such as might be under the management of a corporate network administrator. Figure 6 shows the main Client monitoring window. The total bandwidth occupied by the multicast traffic detected at the server site is given and a graphical (pie chart) breakdown of the traffic by application type is displayed. Technical details are provided on the Web site [15] and in a research report [12].

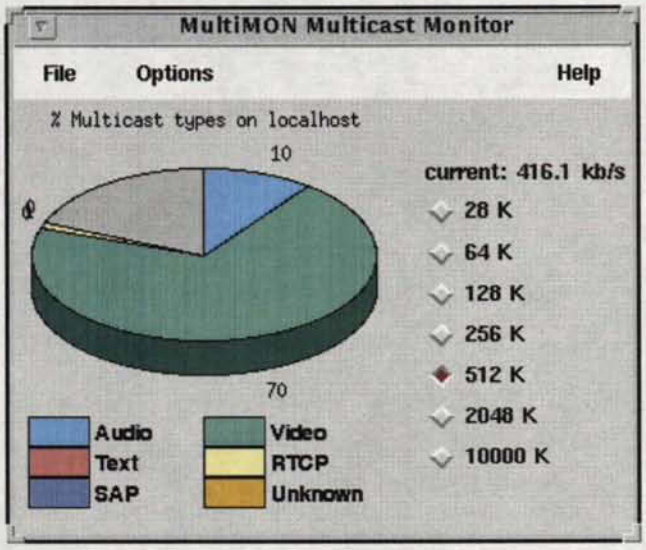


Figure 6: The MultiMON Client Main Window

2.3.2 Reports, Presentations & Publications

The following is a list of the reports, presentations and publications, concerning the MERCI Project, that have been produced by CRC staff.

2.3.2.1 Reports

"Work Plan for CRC Contributions to the MERCI Project",
Dr. J. L. Robinson, 13 September 1996

"CRC Contributions to the MERCI Project (December 1995 - February 1997): Status Report",
Dr. J.L.Robinson, April 1997

"MERCI Usability Assessment",
Dr. D.Pilon, unpublished CRC Report, 20 June 1997

2.3.2.2 Presentations

"The MERCI/MECCANO Project - MBone Research in the EU F4 Programme",
Dr. J. L.Robinson, CRC VPRB Seminar, May 1997

"QoS Monitoring for MBone Diagnostics",
Dr. J. L. Robinson & J. Stewart,
Net'97: The 11th Annual Canadian Internet Conference, Dalhousie University, Halifax, Canada, June 1997.

"MBone Studies at CRC",
Dr. J. L. Robinson,
invited presentation to CANARIE WorkShop on Future Directions for the CA*Net II, Montreal, November 1997

"The Human Factors of MBone Videoconferences",
Dr. Andrew Patrick,
invited presentation to WurcNet MBone WorkShop, UCalgary, 5-7 May 1998

"User-Centred Design of an MBone Videoconference Polling Tool",
Dr. Andrew Patrick
Net'98: The 12th Annual Canadian Internet Conference, Whistler, BC, May 1998.

2.3.2.3 Publications

"QoS Monitoring for MBone Diagnostics",
Dr. J. L. Robinson & J. Stewart,
Proceedings of Net'97, Halifax, NS, June 1997.

"User-Centred Design of an MBone Videoconference Polling Tool",
Dr. Andrew Patrick
Proceedings of Net'98, Whistler, BC, May 1998.

"The Human Factors of MBone Videoconferences:
Recommendations for Improving Sessions and Software",
Dr. Andrew Patrick,
submitted to Journal of Computer-Mediated Communications

"Monitoring Tools for IP Multicast and MBone QoS Management",
J.L.Robinson & J.A.Stewart, in preparation

2.4 Validation Activities

CRC participated, over the course of the Project, in a series of multimedia conferencing events, including Scientific Seminars (WP11), Distance Learning Initiatives and a Surgical Workshop (WP12). As well, private videoconferences were held regularly by the partners for project co-ordination and these occasions were used to test and assess the technology. All but the most official of these events served additionally as validation activities: occasions to trouble shoot the network connections, to test and evaluate prototypes and new releases of the tools, and for usability assessment of the video conferencing technology.

On 14 October 1997, as part of an official Project Review to the European Commission in Brussels, the MERCI consortium presented the products and progress of their work to EU officials. This EuroDemo is described here because it provides a good illustration of a typical MERCI MBone event. Several of the partners, who could not be in Brussels for that event, joined in by MBone videoconference from the facilities at their home organisations. CRC software prototypes were presented at this Project Review and CRC staff participated remotely in the meeting.

A snap-shot of the computer screen taken during that event is shown in Figure 7. Partners from CRC, Germany (Darmstadt), Norway (Oslo) and the United Kingdom (London) are visible in the video window. For this event the video tool VIC v2.8 was used and a recently released version of the audio tool RAT (a UCL contribution to MERCI) was presented. The multicast traffic was monitored with MultiMON and QoS performance was measured with MERCInari.

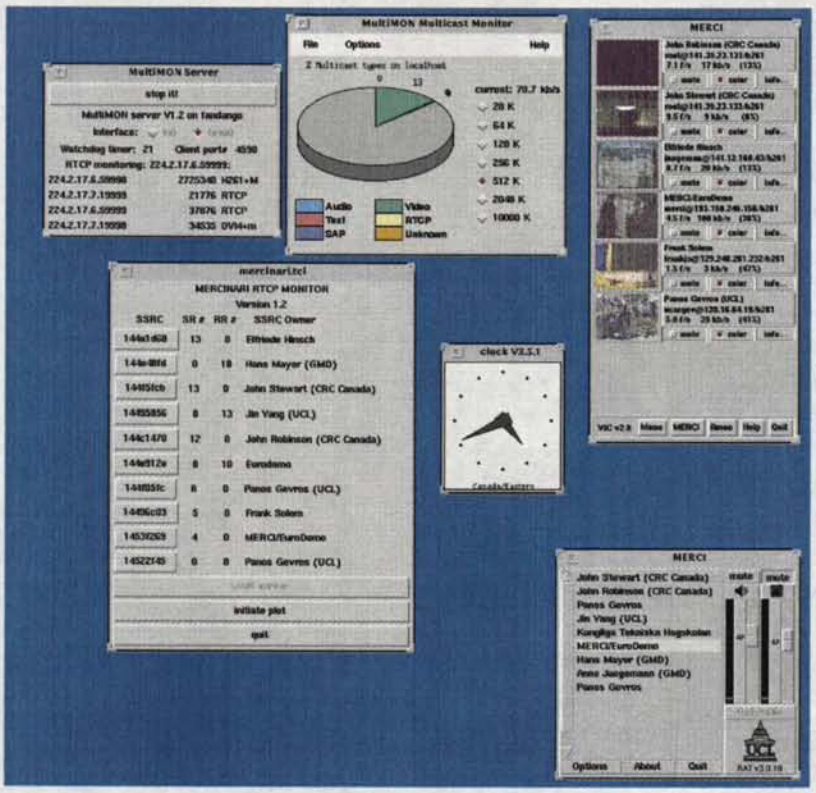


Figure 7: The October 1997 EuroDemo

3.0 The Network Infrastructure

3.1 Multicast Internet Connections to Europe

It was essential for CRC participation in the MERCI Project to establish and maintain an Internet connection to Europe that was capable of supporting IP multicast traffic. Three different Internet connections were available from CRC: via the O'Net/CA*Net to the USA; via the DRENet to the USA; via the CANARIE National ATM Test Network and the Teleglobe CANTAT-3 directly to Europe (Figure 8).

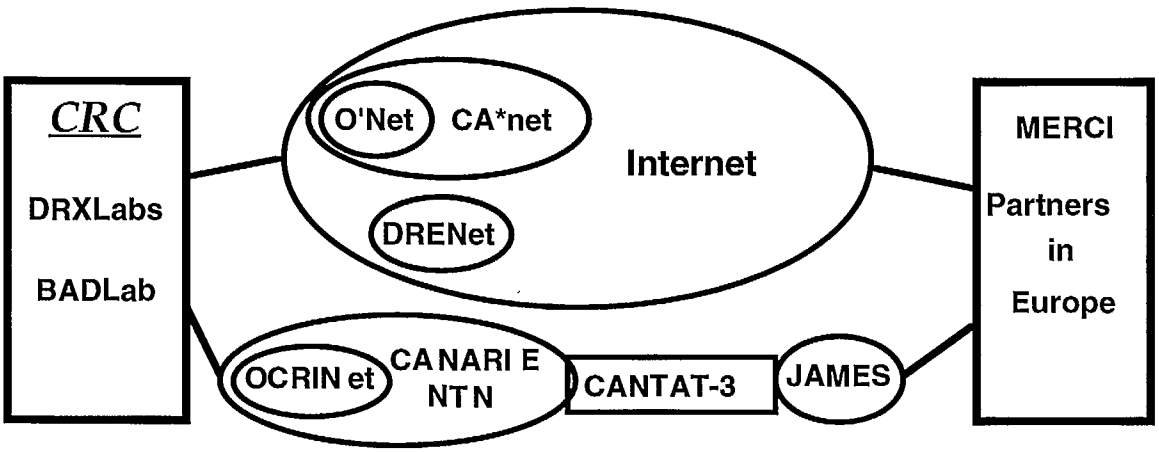


Figure 8: Network Routes between CRC and the MERCI Partners in Europe

3.2 O'Net/CA*Net

The Internet connection provided to CRC by O'Net/CA*Net for everyday Internet services did not support IP multicast traffic. During 1996/1997 there were a few trials in Canada, from example individuals at Dalhousie University and at the University of Montreal set up tunnels. CANARIE sponsored a multicast initiative [6] but this produced very little real activity. An MBone tunnel was set up from CRC to Toronto but the stability and the bandwidth of this connection was not compatible with the efforts of our European partners to set up and use a high-speed IPmc infrastructure for the Project. This was the least favored of our three multicast connections to Europe.

3.3 DRENet

The O'Net/CA*Net Internet connection at CRC could not support multicast traffic at the quality of service wanted for MERCI. This motivated us to request the use of DND's DRENet. The DRENet is a research network of the Canadian Department of National Defence that had a direct connection to a major Internet/MBone access point in the USA. A

DRENet connection was made available at CRC for R&D purposes through our contacts in the defense research program This was the most frequently used MBone access network throughout the duration of the MERCI Project.

At the beginning of the MERCI Project DND had a leased a circuit directly from the DRENet Network Operations Centre at DREO to an Internet Site in the USA. Unfortunately, the MBone connection to Europe via the DRENet did not provide the high bandwidth wanted for the MERCI experiments and, problematically, it did not support the management protocols that were essential for the development of monitoring and diagnostic tools. During the second year of MERCI the leased line was replaced with a tariffed Internet connection from an Internet Service provider (iSTAR). There were some indications that this might in provide a better quality of service, however there was not sufficient time remaining to explore this further under MERCI.

3.4 CANTAT-3 & JAMES

The shortcomings of the DRENet connection motivated us to vigorously pursue the use of the CANARIE National Test Network and a trans-Atlantic link via the Teleglobe CANTAT-3 to get a direct, high-speed connection to Europe. These used leading edge fibre-optic and ATM technologies.

In Europe there has been a tight linkage between the MBone, the European ATM Test Networks and the European components of the global Internet. The MICE Project was a prime user of the ATM Test Network that was available at that time and this was embedded in the European Internet (for experimental MBone use only). The MERCI partners continued this arrangement using the EU JAMES Project [16] to experiment with an expanded and improved international MBone that integrated the emerging high speed networking facilities provided by ATM with their local Internet infrastructure.

CRC had an agreement with Teleglobe Canada under which some of the capacity of the CANTAT-3 trans-Atlantic submarine cable could be made available to CRC researchers for R&D projects. Recognising that a direct broadband connection would greatly enhance our MBone connectivity, CRC obtained permission from Teleglobe Canada to use the CANTAT-3 to connect to Europe. Access to the CANTAT-3 via the CANARIE National Test Network was supported by the CRC BADLab.

A CANTAT-3 link at 2 Mbps, between CRC and DeTeBerkom in Berlin, was established in Jan/Feb '97. A circuit from there to the Technical University of Berlin provided us with European MBone access. This was shared at CRC for MERCI and NICE activities. For several special MERCI events the ATM connection was redirected to the University of Stuttgart (RUS) and via their connections to the JAMES/MERCI MBone (Figure 9). Except for several routine maintenance shutdowns the CANTAT-3 was constantly available and provided a reliable 2Mbps trans-Atlantic service to the Project.

Figure 9: the CANTAT-3 link to the European MERCI/JAMES MBone

4.0 Concluding Review

In general CRC participation in MERCI was very successful. Andrew Patrick and Dan Pilon made research contributions to the Work Package on Usability and Assessment. John Robinson and John Stewart contributed research results and provided infrastructure support to the Work Package on Network Services. The tools developed at CRC attracted interest in the international Internet community well beyond the Project partners. Within the Network Research Group at CRC there was a useful interchange of research results between the civilian and military network research programs. CRC is recognised nationally as a Canadian centre of Internet expertise. The existing CRC knowledge base in network performance characterisation, multicasting technologies and multimedia video conferencing was enriched by the experiences and lessons learned from sharing with international experts in the development of this leading edge technology.

During the MERCI Project we explored various Internet routes to the European MBone and measured the performance and investigated the multicast routing on those connections. Obtaining and maintaining a stable trans-Atlantic connection was a challenge throughout the MERCI Project because of the cost of reliable high bandwidth connections and the limited extent to which IP multicasting is supported on the Internet. Tools for performance measurement, diagnosis and network management are lacking and the multicast monitoring and QoS measurement tools developed at CRC are useful contributions to this field [12].

During the MERCI videoconference events the MERCI participants were both users and evaluators of the technology. CRC was a major contributor to the usability and human factors studies in MERCI. A general framework for the analysis of videoconferencing was developed and parameters of human factors concerns related to MBone videoconferencing were defined: the task of the session, the media used during the session, and the communication modes. Locating videoconference sessions and software in this parameter space provides valuable information about the technical and human requirements. Specific recommendations were made for MBone session organizers and software developers [11].

A follow on Project, named MECCANO (Multimedia Education & Conferencing Collaboration over ATM Networks & Others), will run for two years beginning in early 1998. CRC will continue, in the MECCANO Project, to carry on the research begun in MERCI on QoS management, network performance monitoring, human factors issues and interface design.

5.0 REFERENCES

[1] Programme Plan - MERCI -Multimedia European Research Conferencing Integration, Sector 3 1007 (RE), EU Telematics for Research, 1 December 1995

[2] Final Report RE 1007 - MERCI - Telematics Applications Programme Research, P.T.Kirstein & R.Bennett, v4 23 March 1998

[3] "Technical Innovations deployed by the MERCI Project", R.Bennett & P.T.Kirstein, Porceedings of Networkshop 25, Belfast, March 1997

[4] "Recent Activities in the MERCI Conferencing Project", P.T.Kirstein & R.Bennett, Porceedings of JENC8, Edinburgh, May 1997

[5] "Work Plan for CRC Contributions to the MERCI Project",
John Robinson, 13 September 1996

[6] "MERCI - Multimedia European Research Conferencing Integration - Programme Plan", EU Telematics Application Programme Contract, Sector 3 1007 (RE), November 1, 1996

[7] "Multimedia integrated conferencing for European researchers (MICE): piloting activities and the conference management and multiplexing centre",
M.J.Handley, P.T.Kirstein, M.A.Sasse,
Computer Networks and ISDN Systems 26 (1993)

[8] CANARIE MultiCast Test Project Web site,
http://www.wnet.ca/multicast/.

[9] CRC MERCI Web site,
http://www.merci.crc.ca

[10] "QoS Monitoring for MBone Diagnostics", Dr. J.L.Robinson & J.Stewart, Net'97 Conference Proceedings, June 1997, Dalhousie University, Halifax, Canada

[11] "The Human Factors of MBone Videoconferences: Recommendations for Improving Sessions and Software",
Dr. Andrew Patrick, submitted to the Journal of Computer-Mediated Communications

[12] "Monitoring Tools for IP Multicast and MBone QoS Management",
J.L.Robinson & J.Stewart, CRC Report - to appear

[13] MPoll Web Page,
http://www.merci.crc.ca/mbone/mpoll/

[14] "User-Centred Design of an MBone Videoconference Polling Tool",
Dr. Andrew Patrick, NET'98 Conference Proceedings, May 1998, Whistler, B.C.

[15] MultiMON Web page,
http://www.merci.crc.ca/mbone/MultiMON/

[16] Joint ATM Experiment on European Services (JAMES) Web site,
http://btlabs1.labs.bt.com:80/profsoc/james/