Getting on the MBone

Videoconferencing Over the Internet

Stephen Casner
University of Southern California
Information Sciences Institute

April 13, 1995
NLUUG Spring Conference

Videoconferencing Over the Internet

Q: Possible to send live audio/video over the Internet?

A: Yes, we do it every day! Started on ARPAnet in 1974.

Q: Will it work anywhere?

A: Point-to-point anywhere with enough bandwidth.
Multipoint conferences and seminars on the MBone.

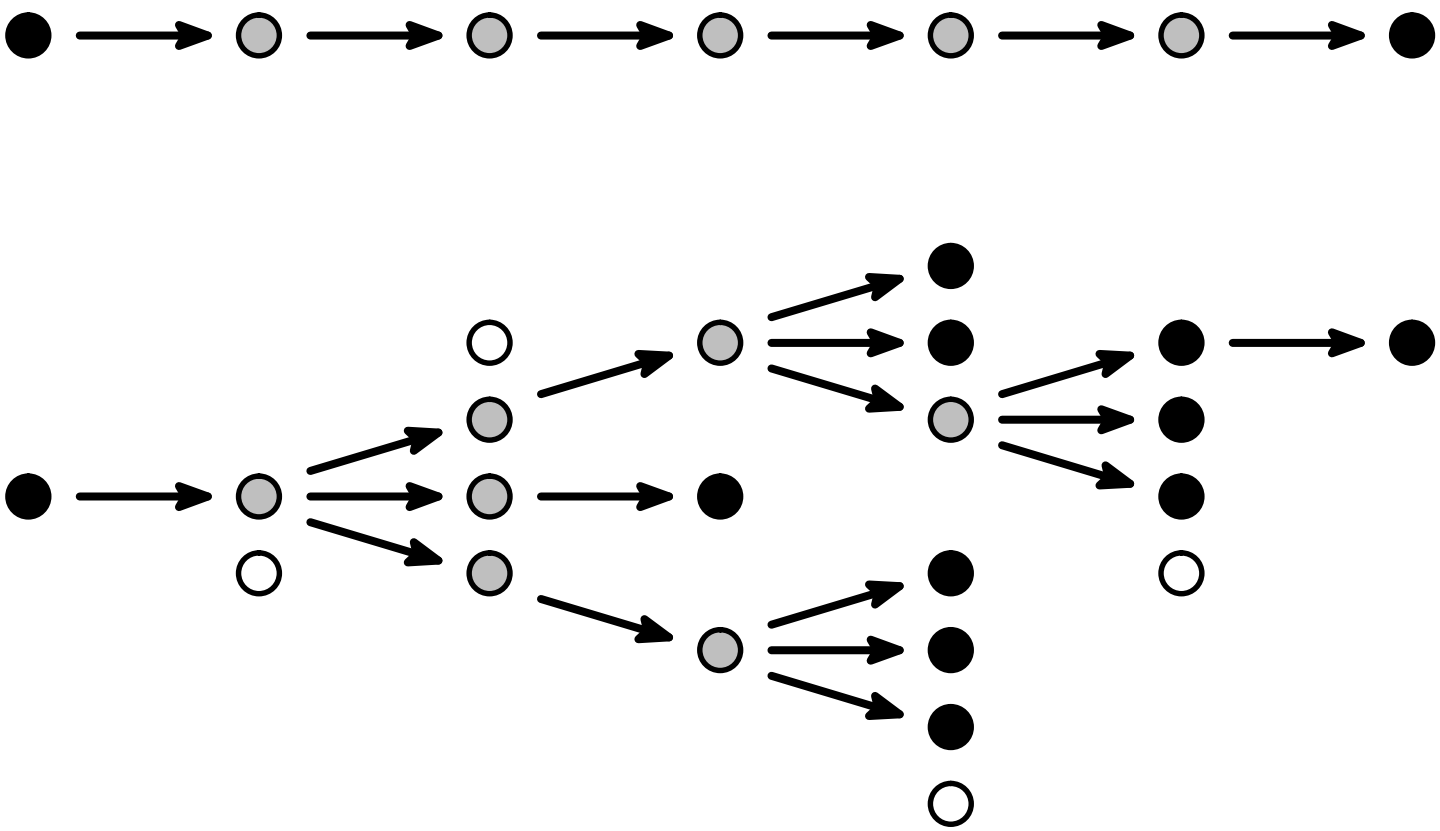
Q: Will the Internet replace the telephone network?

A: Maybe some day, but not right away.

MBone = Multicast Backbone

- A few thousand people are connected.
- More than 200 events have been “multicast”
- Some events have 100’s of participants
- Can be received by modern UNIX workstations with no special hardware using software available by FTP
- Your site can participate in this experimental system
- Standards in development for production Internet support
- Commercial products are emerging

Multicasting — Transmitting Packets to a Group



IP Multicasting

- Extends Ethernet multicast idea to whole Internet
- Each group identified by a Class D IP address (224.0.0.0 – 239.255.255.255), permanent or transient
- Group members may join and leave at will, any number
- Senders need not be members
- Senders don’t need to know who the members are

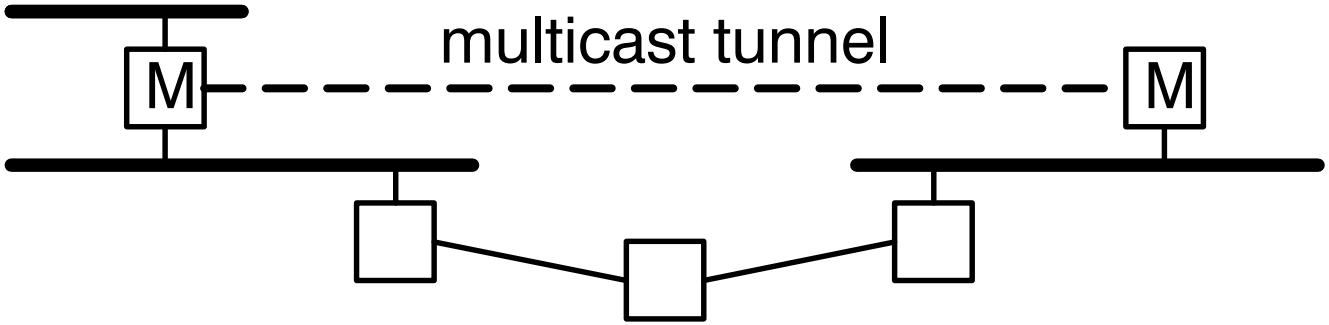
IP Multicast Routing

- Internet Group Management Protocol (IGMP), RFC 1112, used by multicast routers to learn what groups are present on attached subnets

- Variety of routing protocols may be used among multicast routers to construct tree from source to group members
  - Distance Vector Multicast Routing Protocol (DVMRP)
  - Multicast Open Shortest Path First (MOSPF)
  - Protocol Independent Multicast (PIM)

Problem: None were implemented in production routers!

Workaround: Multicast Tunneling



IP encapsulation

tunnel source	tunnel dest.

normal multicast packet

original source	multicast dest.	

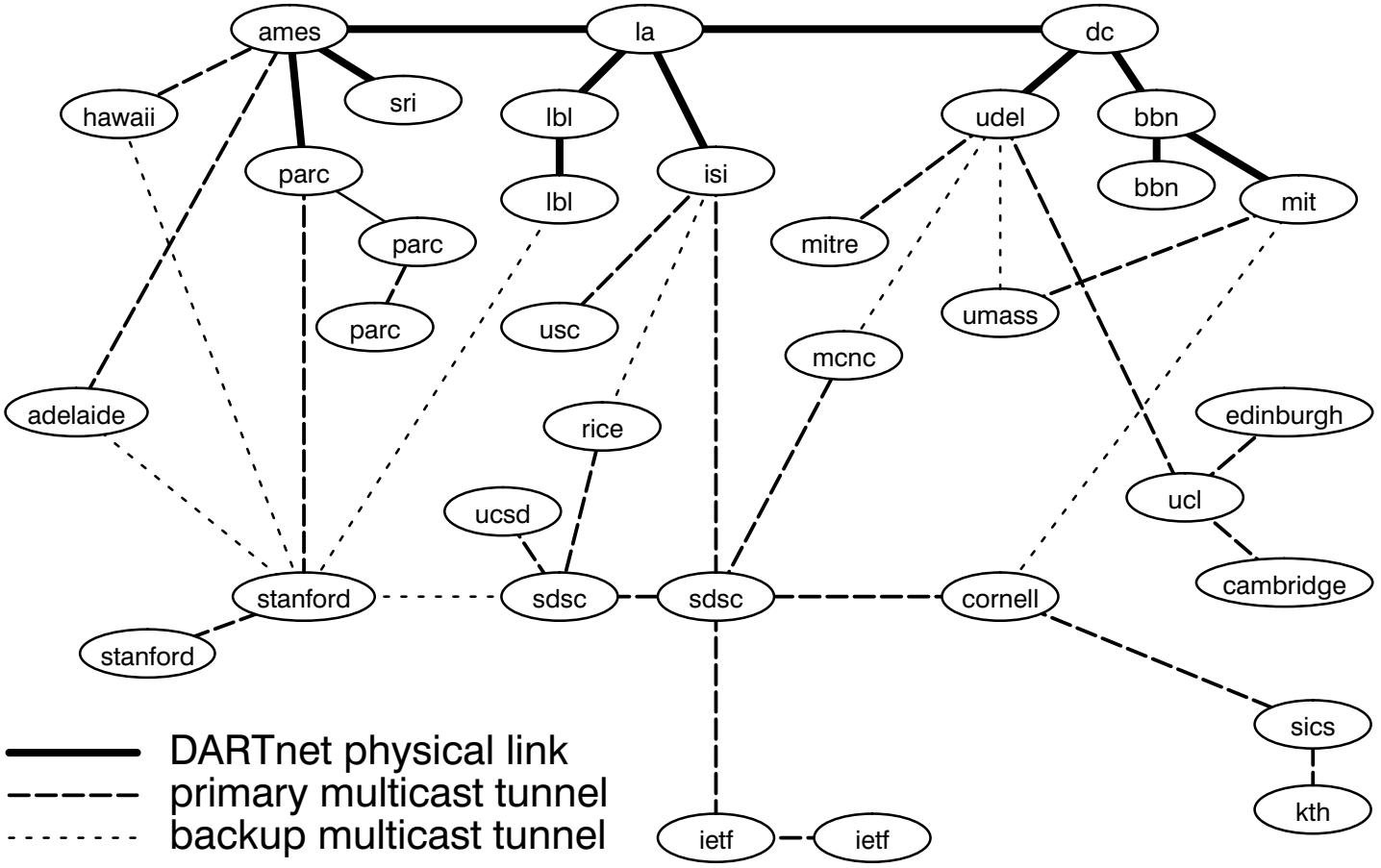
Giving multicast a kick-start!

Several elements came together:

- Multicast developed in 1988 but not widely deployed
- Workstations have built-in audio, software video display
- DARTnet enabled testing multicast audio and video

Wild idea: Send live audio from March 1992 meeting of Internet Engineering Task Force (IETF)

San Diego IETF multicast router topology, March 1992



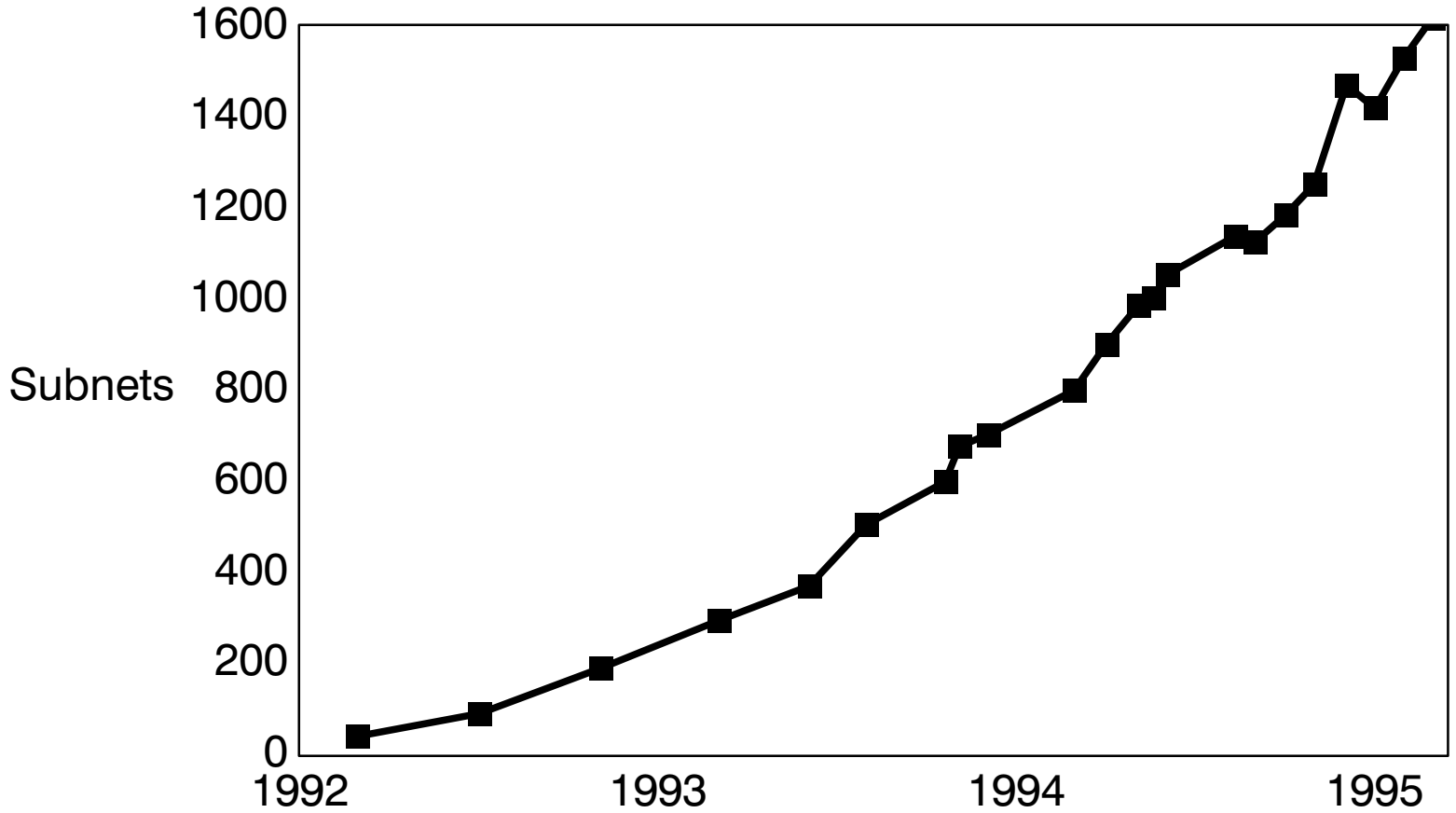
Looks like it was a good idea!

- Remote participants in March 1992 IETF meeting:
  - 32 hosts
  - 4 countries
- Repeated the experiment for July 1992 IETF meeting, decided to make this permanent and call it MBone.
- Growth in seven IETF meetings since then:
  - 700 hosts cumulative
    (comparable to number of local attendees)
  - 25 countries
  - video in addition to audio, two channels

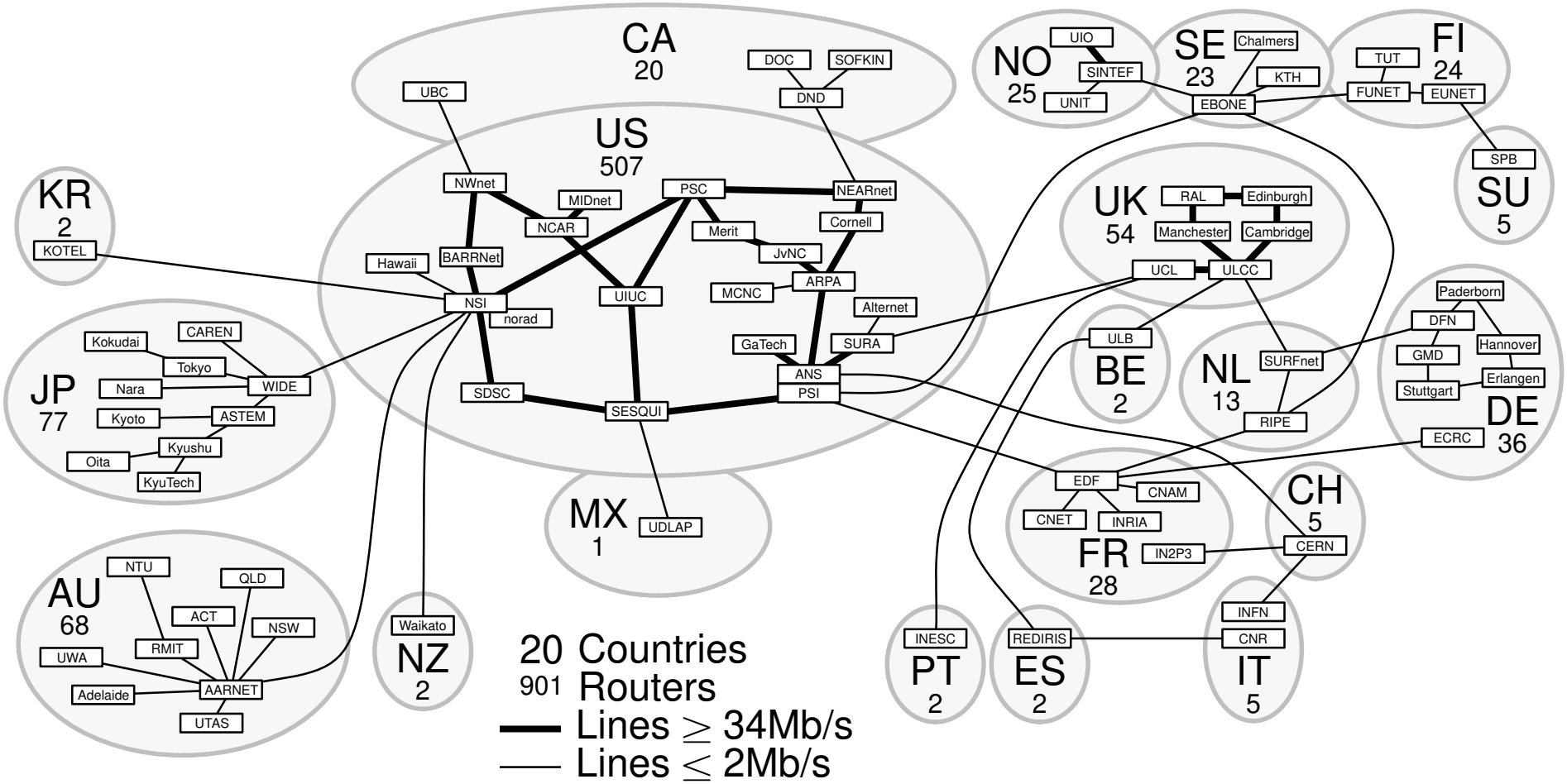
What is the MBone?

- Virtual network for multicast, overlaid on physical Internet *(but will become less virtual over time until it disappears)*
- Multicast-capable islands interconnected by tunnels
- Voluntary participation by IP service providers and end users who install multicast routers (mostly workstations)
- Experimental, not production *(but expectations growing, and commercial multicast routers are now available)*
- Many people have contributed: BBN, INRIA, ISI, LBL, PARC, IETF hosts, network providers, end users

MBone Growth



Major MBone Routers and Links, May 1994



Wide Variety of Multicast Events

- Many events are seminars / conferences like IETF:

  Australia and UK Networkshops, RIPE in Prague, JENC in Trondheim, INET'93, Pancreatic Islet Symposium, Top Quark briefing, Interop

- Smaller, more interactive groups:

  IETF Working Group meetings, private 3-5 person collaborations

- Broadcasts hint at potential for very large scale services:

  Rebroadcasts of NPR and NASA Select, Radio Free Vat

- Also transmissions other than audio and video:

  JASON Project (oceanographic visualization), UH weather satellite images. multicast distribution of Netnews

Some Applications on MBone

Audio tools:

Visual Audio Tool (vat) from LBL

Network Voice Terminal (NeVoT) from UMass

Video tools:

Network Video tool (nv) from PARC, vic from LBL,

INRIA Videoconferencing System (IVS)

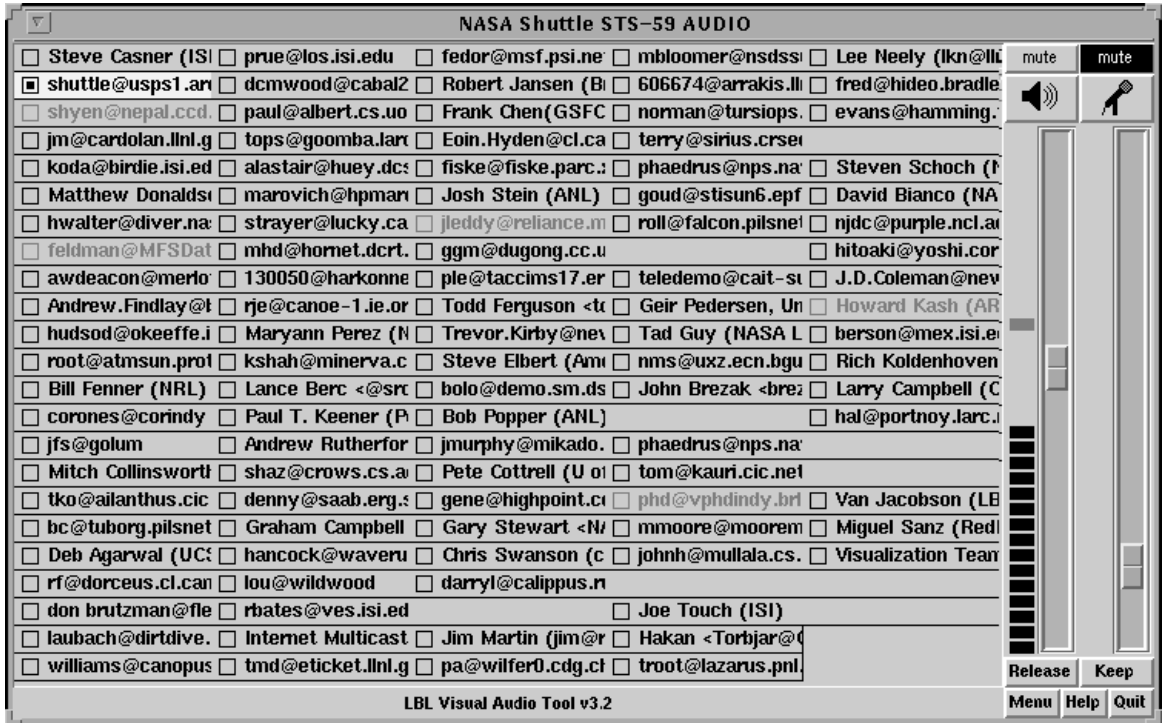
Session Managers:

Session Directory (sd) from LBL

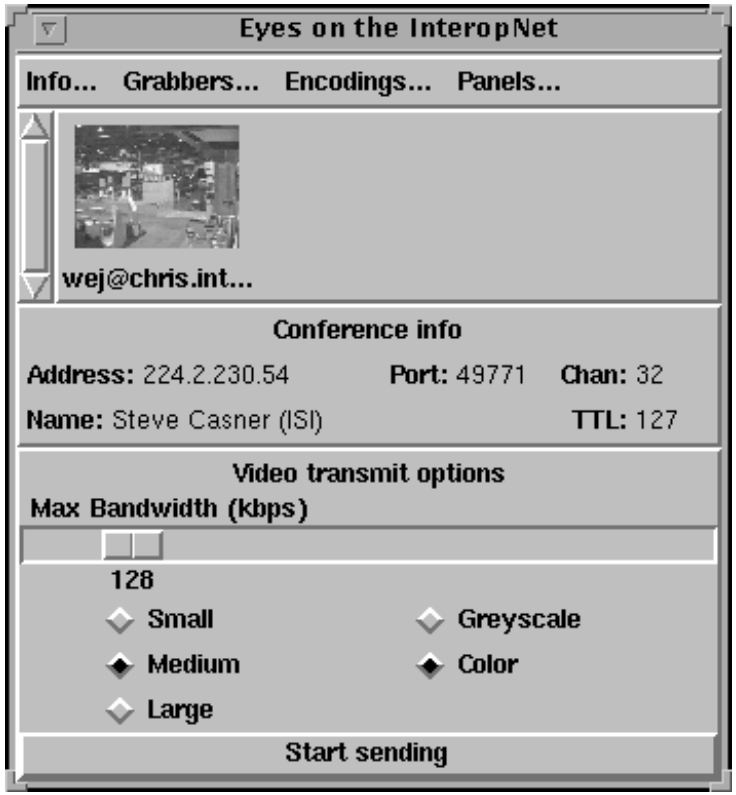
Multimedia Conference Control (mmcc) from ISI

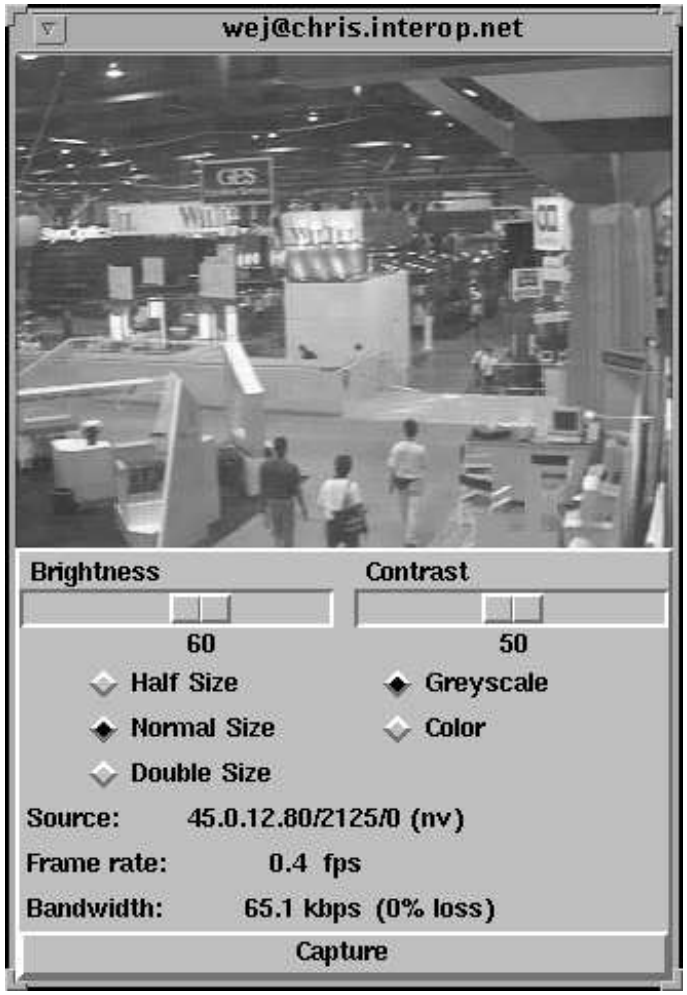
Others: whiteboard (wb) from LBL, image (imm) from UH

Visual Audio Tool (vat)

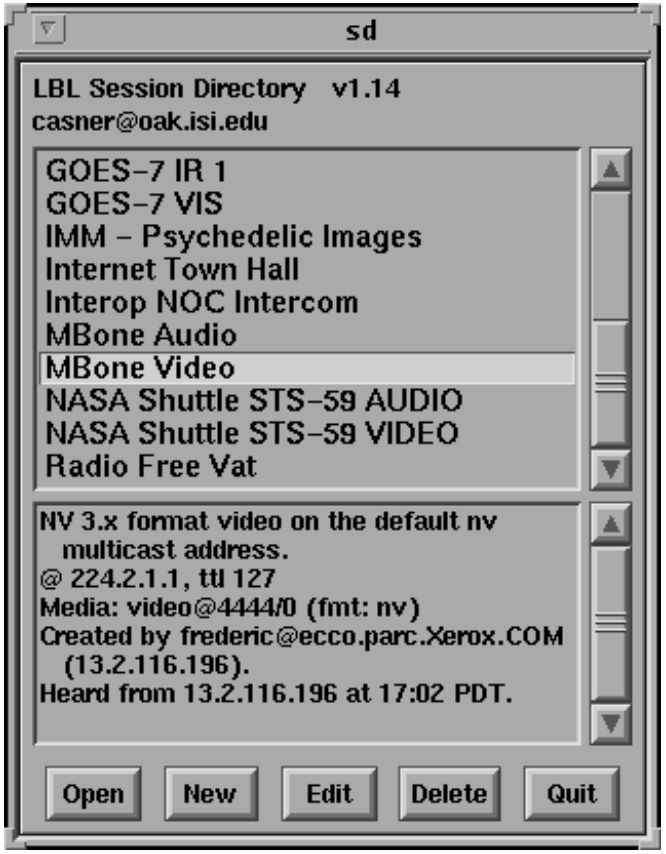


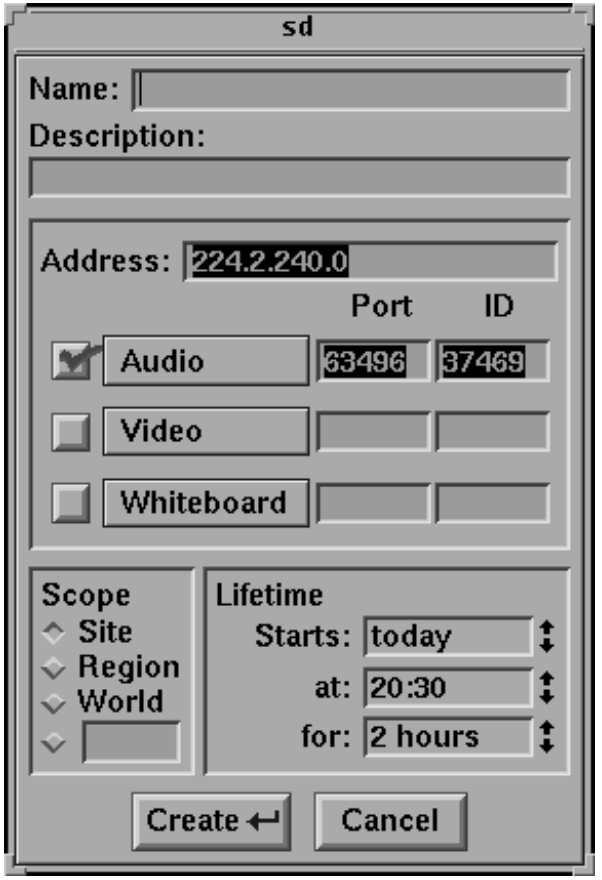
Network Video tool (nv)



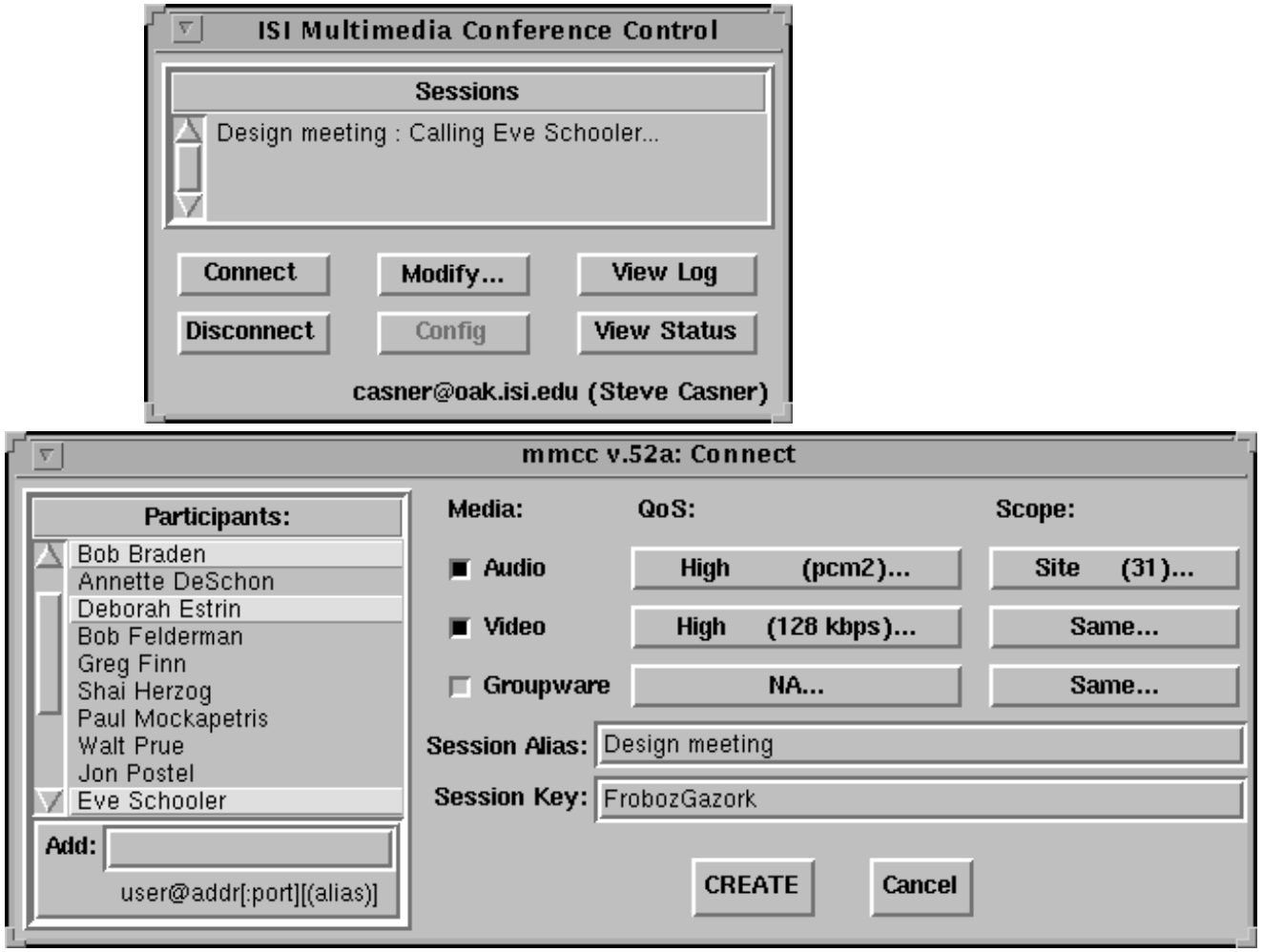


Session Directory tool (sd)





Multimedia Conference Control tool (mmcc)



Protocol Details

Internet:

Multicast IP

Transport:

Don't use TCP (don't want reliability, flow control)

Do use UDP plus RTP

Real-time Transport Protocol (RTP):

Provides sequencing, timestamping, reception reports

No explicit retransmission or flow control mechanisms

Standardization effort by IETF Audio/Video Transport WG

Application is adaptive to accommodate varying delays

Encoding Details

Audio encodings

- Uncompressed stream is 8Khz 8-bit μ-law (64Kb/s)
- Compressed data rates of 32Kb/s, 13Kb/s, 4Kb/s

Video encodings

- Typical resolution is 320x240 pixels, 8 or 24 bits
- Frame rate varies with image, bandwidth, system load (typical BW limit of 128Kb/s $=>$ frame rate $2-10$ f/s)
- Frame differencing and transform coding
- Typical compression ratio about 20:1

How much bandwidth is it?

- One source fits easily:
  - 200 Kb/s audio+video < 1.5 Mb/s << 45 Mb/s
- Very large compared to a 1 megabyte file transfer:
  - File transfer typically takes tens of seconds.
  - 1 MB = 40 seconds @ 200 Kb/s, but teleconferences may last minutes to hours
- Not very many calls compared to telephone company:
  45 Mb/s / 200 Kb/s = 225 simultaneous calls

  => *Need more capacity: "Information Superhighway"*

How well does MBone work?

- MBone works well on lightly loaded links
- Requires careful engineering to avoid duplicate tunnels over same physical path
- TCP is very polite — when real-time traffic induces losses, TCP slows down, effectively giving real-time priority
- Results are certainly useful, but not always as good as desired

What's the Problem?

Problem 1: *Powerful tools in the hands of naive users... Excessive audio and video traffic may cause an Internet meltdown.*

Problem 2: *Internet was designed for "best effort" delivery; Real-time traffic requires low delay and low packet loss rate.*

New Mechanisms for Real-Time Service

Research is underway and IETF working groups formed to develop standard protocols for real-time service in Internet:

- Flow specification and resource setup
- Packet classification and queueing to schedule each packet for forwarding in the appropriate order by priority
- Admission control (saying “No” if insufficient resources)
- May need accounting and usage feedback to the individual level

How to Join the MBone

1. Read the available information
2. Join the mbone mailing list, find the archives
3. Import software and test among local machines
   (may involve adding multicast extensions to kernel)
4. Make sure your network provider can support an MBone feed, or at least is willing to carry the traffic
5. Set up a tunnel to network provider's mrouter, or if none, coordinate via mbone list to identify a nearby node

(multicast should be part of normal service in the future)

1. Top-level Pointers to MBone Information

- Anonymous FTP from **ftp.isi.edu** directory **mbone**
  - **nluug-slides.ps.Z** or **nluug-slides-nopix.ps.Z** — these slides
  - **faq.txt** — Frequently Asked Questions
  - **mbone.mail*** — mbone list archive
- Via WWW from the "MBONE Information Web"
  - **http://www.eit.com/techinfo/mbone/mbone.html**
  - Start there and explore; learn where to get software
  - ▶ *Also **http://www.cwi.nl/mice/mice.html***

Recently Published Articles

- **IEEE Computer, April 1994**
  M. Macedonia, D. Brutzman, “MBone Provides Audio and Video Across the Internet”

- **IEEE Multimedia, Summer 1994**
  S. Casner, “Are you on the MBone?”

- **Communications of the ACM, August 1994**
  H. Eriksson, “MBone: The Multicast Backbone”

2. Joining the Mailing List

- **mbone** list is intended for those who are building multicast kernels and running MBone nodes (mrouters); hierarchy of regional and country lists is described in canned response from **mbone-request@isi.edu**

  Netherlands: ***mbone-nl-request@nic.surfnet.nl***

- **rem-conf** list is also appropriate for end users; mbone events are announced there, along with discussions of application software, cameras, etc. Send join request to **rem-conf-request@es.net**

3. UNIX Platforms for Multicast and MBone Tools

- **DEC Alpha** — OSF/1 v2.0 has multicast built in
- **DECstation 5000** (MIPS) — Ultrix extensions available
- **HP 9000/7xx** — HP/UX 9.01 extensions available
- **IBM RS/6000** — AIX 3.2.5 extensions; some aps ported
- **Intel 3/4/586** — BSD/386 1.1 has multicast built in; NetBSD 0.9 extensions available; FreeBSD; Linux
- **SGI Indigo, Indy** — IRIX 5.2 has multicast built in
- **Sun SPARCstation** — Solaris 2.x built in
  — SunOS 4.1.3 extensions are the reference

Personal Computers

- **DOS/Windows PC's** — multicast available in tcp/ip-32 for WFW, PC/TCP 3.2 & WATTCP (patches); others coming
  - CU-SeeMe non-multicast video application uses UNIX host as replicator
  - other applications in development
- **Macintosh** — no multicast, will be in Open Transport/TCP
  - CU-SeeMe non-multicast video application
  - Maven audio tool interoperates with vat (unicast)
- **NeXTSTEP** — multicast in 3.3, apps in development

4. Some Network Service Providers on MBone

Contact your network service provider —
if they are not on the MBone, suggest that they join.

- SURFnet, RIPE are top-level nodes in NL
- NLnet joined recently or will join soon

5. Setting Up a Multicast Router (mrouter)

- UNIX workstation running mrouted (DVMRP protocol)
  - ☞ Multicast release 3.3 for SunOS does pruning;

    Vendors are integrating it into their OS's
  - ☞ Soon release 3.5 with "default route"
- Alantec PowerHub (DVMRP)
- Proteon routers (MOSPF and DVMRP)
- cisco routers with 10.2 (PIM and DVMRP interoperation)

Configuring a Tunnel

- Need cooperation of some node already on the MBone
- Both ends add the tunnel to the “virtual interface” configuration of the node, specifying the addresses of the local and remote ends
- Analogous to installing a wire in a physical network

Metrics and TTL Thresholds for Tunnels

- **metric** represents “cost” or “length” of the link
  - ☞ Because the max path length allowed in DVMRP is 31 and MBone diameter approaches that, tunnel metric should almost always be set to 1 (minimum)
- **threshold** establishes minimum TTL needed for a packet to be forwarded across the tunnel; used as a (crude) administrative scope mechanism
  - ☞ In the Netherlands, TTL 48 reaches the whole country (sd’s “Region” scope)

Bandwidth Limit and Scoped Addresses for Tunnels

- Can specify a maximum bandwidth that will be sent over the tunnel to ensure multicast doesn't overload the net
- Priorities may be assigned to streams to control which get dropped
- Top of multicast address space is to be set aside for administratively scoped groups; tunnel can specify an address value and mask that will be blocked both ways

Good MBone Citizenship

- MBone is an experimental system, requires cooperation to achieve the “greatest good for the greatest number”
- MBone bandwidth is only about 500Kb/s due to:
  - Maximum packet rate of workstation mrouters
  - Ethernet saturation with multiple copies
  - Reasonable limit on fraction of a T1 line consumed
- Run whatever you like locally, but limit world-scope traffic
- Suggestion: allow only group execute protection on tools, add new users to group only after receiving instructions

Firewalls

Many sites operate with a firewall (filtering router or application relay host) that would not allow MBone traffic to pass (UDP packets with random port numbers).

- Some allow multicast tunnel traffic to flow through:
  - IP-in-IP (protocol 4) and IGMP (protocol 2)
  - Decapsulation routine discards any non-multicast
- RTP includes a source identifier to facilitate the use of application-level relays (Sun has experimental one)

A Caution About cisco Routers

It is important to avoid “process switching” in any cisco routing real-time traffic (multicast or not). The result is bad periodic breakup.

- Don’t configure “no ip route cache”
- Don’t take a full Internet routing table feed if you don’t need it, because route flaps cause cache invalidation
- It is best to have all interfaces carrying multicast traffic on the same controller if possible
- If you run PIM, be very careful with “ip dvmrp metric”

Watch Out for Dinosaurs!

It is a protocol violation to send **ICMP net unreachable** in response to multicast packets — causes audio/video breakup for all receivers! Some known offenders:

- Banyan VINES server — patches are available
- MacTCP 1.1.1 — upgrade to 2.0.4
- IBM RT AIX 2.2.1 — use as boat anchor
- EtherRoute (Compatible Sys. Corp.) — upgrade to 2.06
- Ascend Pipeline 50 ISDN brouter — upgrade to 4.2Bp2
- Others: UNISYS Net-6000, IBM running MVS/ESA, Netblazer 40 v2.3

Summary

- Internet MBone video is already useful and lots of fun
- You can join into this experimental system
- Real-time service is coming, then Internet will work well
- Not just for executives, but for designers, engineers, etc.
- Target is wide-scale use — seminars, collaboration, individuals becoming broadcasters