MPEG1 IP Multicast Video, UO and Internet2...

Society of Motion Picture and Television Engineers (SMPTE)

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Introduction

An outline of today's talk

- An explanation of what we're trying to do
- Our choice of delivery technology (IP multicast)
- Our choice of video format (MPEG1)
- Our choice of delivery tool (Cisco's IP/TV)
- What we've got available as content
- Future opportunities

What we're trying to do...

We want to be able to deliver long-ish programs of 'TV quality' video, to a 'large audience,' over the network.

- 'Long-ish' programs at 'TV quality' means (for us) 1 to 2 hour chunks of "NTSC-like" video, NOT the short clips of blurred herky-jerky postage stamp-size streaming video found on some web sites, nor is it the H.323 interactive (and bi-directional) video conferencing we're using for today's talk.

And let's "operationalize" what we mean by a "large audience"

- Let's call a "large" audience anything over half a million viewers...
- For context, something like the Victoria's Secret 1999 lingerie show webcast reportedly drew ~1.4 million viewers (see: http://zdnet.com.com/2100-11-501609.html?legacy=zdnn) and "regular" cable reaches 88.7 million homes according to www.cabletvadbureau.com

And while we're "defining this" and "defining that"...

- "Over the network" means over the wide area network, e.g., not just to "on-campus" audiences over a local area network, but coast-to-coast and border-to-border, as well as overseas, via networks such as Internet2 (and/or the commodity "regular" Internet).
- Now you have an idea of what it is that we're trying to do.
- "So what's the big deal?" you ask...

“It’s all about the bandwidth…”
(actually, it’s all about the $$$)

Let's do a back of the napkin calculation….

- Let's assume we have half a million simultaneous viewers, each of which might need a 56Kbps video stream… how much bandwidth would we require?

  500,000*56,000 bits per second =28,000,000,000 bps or ~12 OC48 (2.4Gbps) circuits…That would be, um, rather expensive (Qwest says an OC48 is $1,207,000/month [www.boardwatch.com/isp/bb/Qwest.htm])

And of course, 640x480@30 fps won't shoehorn into 56Kbps...

- Delivery of 640x480@30 fps video typically implies 1-1.5 Mbps/stream (e.g., "T1 speed" traffic), NOT teeny tiny little 56Kbps dialup-like streams.

  At that speed, we'd need over 312 OC48's to deliver half a million separate concurrent streams -- no one has that sort of capacity!

And then there's software licensing costs...

- For example, RealNetworks quotes Realsystem Server Professional at the rate of $21,313.00 for just four hundred (400) simultaneous users. Want to guess what a 500,000 viewer license for Real costs?

And hardware delivery costs...

- And let's not forget, even if we had that super jumbo Real server license we still need a farm of PCs to deliver all that streaming traffic…

- Bottom line:
  streaming video **DOES NOT SCALE**

How about just having people download video files from a web server?

- Having people download stored video files from a web server would have no software licensing costs, but users aren't willing to "wait to watch" -- they want to be able to watch a video while it is downloading. There's also the issue of how to cleanly handle real-time delivery of ongoing video (e.g., gatewaying of a local video source)

Why not use H.323, like you're using for this talk now?

- The problem with H.323 is that it fans out to multiple recipients via something called an MCU (a multipoint conferencing unit), and they tend to be rather expensive. Just to give you an idea just how expensive MCU's can be, a fifteen port RadVision MCU lists for $18,500 at http://picturephone.com/products/radvision_mcu.htm ...15 ports down; 499,985 ports/$616,642,000 to go...

An H.323 Datapoint

- The largest H.323 event ever, the Megaconference III, held on October 3rd, 2001, consisted of some 200+ sites and involved 25 cascaded MCU's (see: http://www.mega-net.net/megaconference/finalreport.htm) -- that was a herculean effort, but still well short of our target…

H.323 conference scheduling, gatekeepers, mike muting, etc.

- H.323 video conferencing is also notorious for having heinous scheduling issues, a plethora of different formats and speeds to try to accommodate, a fondness for "gatekeepers" (think of gatekeepers as video conferencing "firewalls"), problems with people not muting their microphones (sometimes being bidrectional is <u>not</u> a good thing), etc. H.323 video, like traditional web streaming video, **<u>DOES NOT SCALE</u>**

Thought experiment: why does broadcast/cable TV scale?

- Broadcast/cable TV scales well to large audiences because:
  -- programs are broadcast on a scheduled basis, with viewers "joining in progress" (TV does not try to do "video on demand")
  -- a single common transmission gets shared across all viewers; e.g., an increased number of viewers does not translate to an increased demand for bandwidth

So let's not reinvent the wheel--let's just do the same thing on the network...

- For our network video delivery, we'll use…
  -- Join-in-progress, NOT video-on-demand
  -- And we'll share a single copy of each program (we won't replicate program content on a per-user basis)
  -- But is there a technology that will let us do this over the network? Yes.
  It is called **IP multicast.**

“So tell me about IP multicast…”

What is IP multicast?

- IP multicast is a way for multiple viewers to jointly share network-delivered video

  IP multicast video automatically gets sent by the network only to those parts of the (IP multicast enabled) network where someone actually wants to watch that particular content. Visualize a tree with its root at the video source. That tree grows or builds out in real time as viewers request video content

The key IP multicast property: it scales

- Whether you've got one viewer or five hundred thousand of 'em, when you use IP multicast, you only need to send one stream to service all of them.
- Of course, if you do offer two different programs, you need to offer two streams (one for each of the two programs), but that seems fairly reasonable to me. :-)

Do all networks “know how to do” IP multicast?

- Unfortunately, no. MOST commercial networks are **not** IP multicast enabled.
- Why?
- Some legacy network hardware may not support IP multicast well (if at all).
  -- Cisco and Juniper routers are usually fine
  -- Most layer two ethernet switches are okay, although those that do IGMP snooping do a better job of limiting IP multicast traffic than those that don’t.

Moreover...

- Some ISP upstream backbones may not be IP multicast enabled (but many leading Internet backbones are multicast capable these days)
- In the bad old days, IP multicast had a reputation for being hard for network engineers to configure/debug.
- Many commercial networks were (and are) dialup oriented, but most video IP multicast content requires more than 56kbps

Well, what about commercial broadband providers?

- Broadband has the bandwidth IP multicast apps want, but most broadband providers are NOT IP multicast enabled. Why?
- Cable modem services are offered by cable TV companies, and they think they know how you should be getting TV quality video: "Would you like just HBO and ShowTime, sir, or our deluxe $89.95/month package with all our premium channels?"

How about DSL ISPs?

- The lack of IP multicast availability on DSL service providers is harder to explain, unless you once again “follow the money.”
  DSL providers typically sell 640Kbps worth of bandwidth to a home customer for $30/month. If a customer actually routinely USED all that bandwidth, the DSL ISP may find himself having to buy Internet transit bandwidth (to service that demand) from a national backbone at $100’s/Mbps/month... this is not a recipe for DSL provider profit!

Okay, then who <u>can</u> get IP multicast traffic?

- Users at many large research universities (particularly those connected via Internet2)
- Users at some government science and technology-related agencies connected to a federal mission network (such as the Department of Energy's ESNet or NASA's NISN network)
- Some foreign R&E network users
- Users at some large/technical corporations

“That doesn’t sound like ‘half a million’ viewers...”

- Well, that’s true… We know from http://www.nanog.org/mtg-0110/ppt/eubanks/slide011.htm that there are some 4,642 network prefixes which are multicast enabled (and each prefix may represent a handful to tens of thousands of viewers). Multicast broadcasts during the 9/11 tragedy drew over 800 viewers… and the key point is that we COULD do millions if the viewership was out there...

How can I tell if my network is IP multicast enabled?

- You can try asking your network support folks, but they may not know, or what they think they know may be wrong in your case
- Or you can empirically test your connection using: http://www.multicasttech.com/mt/
- "Okay, I tested it, and in fact it isn't multicast enabled… how do I get it fixed?" You need to talk with the network engineer(s) who run your network -- you can't enable multicast, they need to do it.

“My network engineer needs a multicast tutorial…”

- The best tutorial materials available are those at: ftp://ftpeng.cisco.com/ipmulticast/training/index.html
- If you are connecting via Internet2/Abilene, see: http://www.abilene.iu.edu/mccook.html
- If all else fails, have your engineer talk to engineers at your upstream ISP (remember, they’ll need to be multicast enabled, too, so they should have someone who can help)

So what's all this About "DVMRP" and the MBONE?

- DVMRP was a way of overlaying multicast tunnels on top of the regular Internet. The MBONE was one such collection of such tunnels. Do NOT do DVMRP anymore.
- Deploy native IP multicast, instead, and deploy it THROUGHOUT your organization, not just in one little multicast-enabled subnet… [UO, for example, enables IP multicast throughout UONet, our campus network]

What internet service providers offer IP multicast today?

- See: http://www.broadcast.com/mcisp/ and http://www.multicasttech.com/status/ [plus maybe YOURS, if you ask them!]
- Many service providers have never thought about offering IP multicast services because they didn't think there'd be any interest; customers never ask for multicast because they "know" it wouldn't be available… a classic chicken and egg situation...

“Why MPEG1?”

Choice of codec (video format) is as critical as choice of content delivery technology

- Choice of video codec determines the balance between three cofactors:
  -- video quality
  -- bandwidth required
  -- encoding/decoding cost (in $$$ or time)
- Our choice has generally been MPEG1 (640x480@30 fps at around 1-1.5Mbps)

MPEG1 isn’t perfect

- MPEG1 shows artifacts when displaying visually complex, fast moving content (worse case scenario: basketball on a parquet basketball floor)
- At 1-1.5Mbps, MPEG1 is really a little more bandwidth intensive than we might like for DSL connected users
- MPEG1 does typically require a hardware encoder board (but it can usually be decoded in software)

MPEG1 vs. MPEG2...

- Given the efficiency of IP multicast, some may wonder why we decided to use good old MPEG1 at 1-1.5Mbps?
- E.G., why not use MPEG2 at 4-12Mbps, for example? Now that would unquestionably be TV quality video, right? And we're only talking about sending one shared stream with multicast, right? So why not make it the best quality we can?

MPEG1 hits a unique network "sweet spot"

- Remember that many IP multicast users are University folks, connected by campus ethernet networks (sometimes fast ethernet, often just "regular" 10Mbps ethernet).
- 1-1.5Mbps worth of IP multicast traffic doesn't disrupt routine campus network traffic much, even if it is injected into a shared/half-duplex regular ethernet environment. (4 Mbps worth of MPEG2 is a lot of traffic for that sort of scenario…)

Plus… multiple multicast streams can start to add up...

- What happens when you get three or four different 1-1.5Mbps multicast streams being viewed at the same time on a given 10Mbps switched LAN segment? That starts to feel sort of hot (although it still does okay).
- Three or four 4Mbps MPEG2 streams, on the other hand, all directed at a 10Mbps ethernet segment, means that you're toast! (multicast is not meant to be a network denial of service tool!)

The Hardware Factor(s)

- Another crucial factor favoring MPEG1 over MPEG2 is that it is easy to decode MPEG1 in software on virtually any current generation PC or Mac. MPEG2 often requires hardware assisted decoding (or non-free software) -- if viewers have to buy something, you've just lost your audience.
- MPEG2 format encoded video also takes more disk space to store than MPEG1…
- MPEG2 also requires use of more sophisticated video capture/encoding cards.

So why not do H.261 or some low bandwidth video protocol?

- The quality of low bandwidth H.261 video is noticeably worse than that of MPEG1. Pixelation and other display artifacts routinely occur. Low bandwidth H.261 video quality is just not sufficiently good for folks to routinely watch...

What about MPEG4 format?

- Like MPEG2, MPEG4 certainly has potential, but it will all turn on licensing issues; for more info, see: www.m4if.org, www.mpegla.com, and isma.tv
- Or see: http://www.internetnews.com/infra/article/0,,10693_983771_1,00.html (“Oh, for Streaming Out Loud!”)
- For now, we don’t view MPEG4 as a viable alternative to MPEG1 for what we’re doing

“What Actual Program Are You Using?”

Cisco's IP/TV

- We use Cisco's (formerly Precept's) IP/TV product (see http://www.cisco.com/iptv/) for both encoding and receiving IP multicast MPEG1 format content…
- In particular, note that the Windows PC IP/TV client may be freely distributed when used in conjunction with an IP/TV 3400 Series Server; see: http://videolab.uoregon.edu/iptv_readme.txt
- Copies of the IP/TV client are available online from http://videolab.uoregon.edu/

A polished commercial solution for most flavors of Windows...

- The IP/TV client provides an excellent polished commercial solution for users running a Windows 98/ME/NT/2000 system.
- What about Windows XP? XP users can also run the current version of IP/TV, but the current version of IP/TV has some problems with H.261 sessions. (MPEG1 sessions will be fine, however, and future releases should fix this bug).

The "Adobe Acrobat Reader" model of software licensing

- Cisco's willingness to try the "Adobe Acrobat Reader" model of licensing, whereby people using their IP/TV server can freely provide copies of the IP/TV client, is absolutely crucial to the successful diffusion of IP multicast technology. We all owe Cisco a big "Thank You!" for making the IP/TV client available this way!

What About Mac and Unix folks?

- We believe that to be a success, any solution has to handle Mac and Unix folks as well as PCs… and this one does...
- Mac users should try MacTV, available online from http://www.iwitnesstv.com/
- MIM, an open source application written at UO for Unix platforms, is available as source (or Linux binaries); see: http://videolab.uoregon.edu/mim/

“So what web page do I click on to see what’s on?”

- IP/TV, as it is usually used, is not designed to run within your web browser -- it is actually a standalone application in its own right. IP/TV learns about available programming from a “content manager” such as iptvhost.uoregon.edu
- After users install IP/TV (just as they would any other Windows application), they just launch IP/TV to see a list of programs.

“Some of the things I click on never show me anything!”

- Did you give it a second? Multicast takes a few seconds to get content out to you...
- If none of the programming listed works for you, you may not be on an IP multicast enabled network; does the IP multicast tester mentioned on slide 26 work okay?
- If some programming (such as the stuff from UO) works fine, but some of the other stuff doesn’t, you may be running into a scoping issue.

“What’s ‘scoping?’ ”

- Scoping controls “how far” IP multicast goes [typically on the basis of the “number of hops” (or routed links) content traverses]
- Administrative scoping is intended to allow arbitrary regions (such as sites or consortia) to limit the diffusion of content to their arbitrary set of connected locations
- Program announcements may go places where the associated underlying multicast content doesn’t reach; this is irritating, but not really a big deal.

“So What Can I Watch?”

Some programs currently available from UO include...

- The Archaeology Channel
- NASA TV
- UO Broadcasts - NASA Videos (several)
- UO Broadcasts OPB's "Oregon Story"
- UO DOD News Clips
- UO Medical Mgmt of Biological Casualties
- UO Presents-Documentary-AFNOG 2001

We know this is sort of an odd assortment.

The Copyright problem

- What's currently available via IP multicast is largely a function of copyright issues…
  -- all video content is copyrighted "at birth"
  -- the cost to license copyrighted video content for "worldwide" distribution (even if the effective audience is in the hundreds or low 1000's) is astronomical
  -- it is unclear/unlikely that compulsory copyright licensing is applicable (see: www.loc.gov/copyright/fedreg/cable92.2 ...who'd be a multicast "subscriber"?)

“Well, what about local content, like college sports?”

- Major college sports (such as football or basketball) tends to be “all licensed up…”
- Minor sports can be hard to videotape (and recall that MPEG1 doesn’t do fast moving complex scenes very well, anyhow)
- Most musical performances have copyright issues, and/or potential incremental costs associated with broadcast performances and “union scale” rate issues for musicians.

And music industry groups sure aren't helping...

- For example, we had partnered with a local radio broadcaster to offer three of their stations via IP multicast (one adult contemporary station, one country western station, plus a third "oldies" station) -- only to eventually have to discontinue those multicasts due to changes in licensing/ royalty agreements (KWAX, UO's classical station, was and is still available via IP multicast)

“What about locally originated educational programming?”

- Maybe that sort of thing exists at some sites, but there isn’t much broadcast oriented original educational video programming coming out of the University of Oregon (and most local off-campus students couldn’t get IP multicast anyhow, sigh…)
- Most local video classes are oriented toward delivery via a closed two-way H.323 based environment, and isn’t produced for general broadcast distribution.

What's left...

- What's available via IP multicast is what's left, such as:
  -- some (but not all) government videos
  -- educational videos produced by local public broadcasting stations and made available with their permission (but even then, most of it is licensed to the hilt and thus off the table/unavailable)
  -- video we go out and capture ourselves, such as at networking conferences such as NANOG or IETF. Speaking of which...

Cisco's generous support...

- To facilitate the production of technical content from network meetings and related events, Cisco made a large (quarter million dollar) donation to UO, a donation which has made it possible for UO staff to travel to events such as IETF meetings and NANOG meetings. Once there, UO staff multicast those events live (and also capture the events for redistribution later)… These are precisely the sort of events that motivate network engineers to enable multicast! :-)

Yet clearly, none of that's a huge "popular draw"

- We understand that the programming currently available via IP multicast isn't exactly breathtaking; trust us, we'd love to be able to routinely broadcast one of the major broadcast channels (ABC/CBS/NBC/Fox/WB) or PBS or CNN worldwide via IP multicast… but we don't see much hope of that happening in the foreseeable future (but hey, if any one of you know someone, please feel free to send them our way :-)).

Another possibility...

- Rather than going for broad mass market audiences, another possibility is going for specialty audiences, such as retransmission of foreign language TV stations for expatriate audiences located here in the United States. Conventional cable systems often offer Univision or the equivalent in Spanish, but what about programming in French, German, Russian, Chinese, Japanese, and other languages? IP multicast could efficiently reach those viewers…

Future Opportunities

Content diversification aside, what else is ahead?

- Single source multicast (SSM) simplifies some aspects of IP multicast distribution, and makes IP multicast more resistant to certain types of attacks while facilitating integration of multicast with WWW (see http://videolab.uoregon.edu/projects.html)
- Scalable multicast-based video on demand solutions are also under development by companies such as Digital Fountain (see http://www.digitalfountain.com/)

Questions?

- Thanks for the chance to talk to you today!
- Are there any questions?