ESM Live Broadcast System

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http://esm.cs.cmu.edu/
Agenda

- Overview of End System Multicast (ESM)
- Deployment Experience
- ESM Setup
- Questions and Answers
Support Ubiquitous Broadcast over the Internet

- **Anyone** can broadcast
- **Can reach any** broadband host on the Internet, regardless
  - connectivity constraints (NAT/firewall)
  - bandwidth capacity (DSL, 10+Mbps, …)
  - OS (Windows, Linux, Mac)

19th ACM SOSP, Oct. 2003
Project Members

Faculty
- Hui Zhang

Ph.D. students
- Yang-hua Chu
- Aditya Ganjam
- Eugene Ng
- Sanjay Rao
- Kay Sriganidkulchai
- Justin Weisz

Research staffs
- Jibin Zhan

Master students
- Shawn Wang
- Annie Cheng
- Frank Chan

Undergraduates
- Brian Goodman
- Philip Yam
- James Grugnale
- Chris Palow
- Tian Lin
- Vishal Soni

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Broadcast by Naive Unicast

Source

Internet

300 Kbps

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End System Multicast

Overlay Tree

CMU
Gatech
Stanford
Stan-LAN
Stan-Modem
Berk1
Berk2
Berkeley
Gatech
CMU
Stan-LAN
Stan-Modem
Berk1
Berk2

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End System Multicast: Benefits

- **Scalability**
  - Routers do not maintain per-group state

- **Easy to deploy**
  - Works over the existing IP infrastructure

- **Can simplify support for higher level functionality**

![Diagram showing network connections between CMU, Stan-LAN, Stan-Modem, Gatech, Berk1, and Berk2, with labels for Transcoding, Priority, Unicast congestion control, and Retransmission.](http://esm.cs.cmu.edu)
Supporting Receiver Heterogeneity

- Source sends multiple bitrates video streams
- Prioritized forwarding at every link
- Hosts dynamically choose best viewable bitrates
- Can seamlessly leverage layered codec

Encoders

HQ Video (300Kbps)  LQ Video (100kbps)  Audio (20Kbps)

Source

420Kbps

120Kbps

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Concerns with End System Multicast

- Higher latency
- Packet duplication
- Group dynamics
- Network dynamics
- Scalability concerns

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Overview of CMU End System Multicast (ESM) Project

- **ESM architecture and initial protocol Narada:** (1998-2000)
  - Motivation: IP Multicast is the wrong abstraction and mechanism to support multi-party applications over the Internet
  - Early papers published in ACM SIGMETRICS'00, ACM SIGCOMM'01
- **System development/protocol improvement:** (2000-2002)
- **Deployment:** (2002-2003)
Components for two types of Users: Publisher/Event Organizer, Viewer.

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First broadcast in Aug ’02: Sigcomm02

The latest is the DARPA Grand Challenge unmanned vehicle race on March 13, 2004.

Total ~25 events, ~200 operational hours
- ~6600+ participants: across 5 continents, in home, academic and commercial environments, behind various technologies (DSL/cable modem, wireless, etc) and NAT/Firewall.

Ease of Use:
- Viewer: 2 or 3 Clicks, Download & install software: a few minutes
- Publisher: Audio/video/computer equipments: ~ 0.5 -- 3 hours. (depending on the environment and quality requirement)
## Major Event Highlight

<table>
<thead>
<tr>
<th>Event</th>
<th>Duration (hours)</th>
<th>Unique Hosts</th>
<th>Peak Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>SIGCOMM ’02</td>
<td>25</td>
<td>338</td>
<td>83</td>
</tr>
<tr>
<td>SIGCOMM ’03</td>
<td>72</td>
<td>705</td>
<td>101</td>
</tr>
<tr>
<td>SOSP’03</td>
<td>24</td>
<td>401</td>
<td>56</td>
</tr>
<tr>
<td>DISC’03</td>
<td>16</td>
<td>30</td>
<td>20</td>
</tr>
<tr>
<td>Distinguished Lectures</td>
<td>11</td>
<td>400</td>
<td>80</td>
</tr>
<tr>
<td>AID Meeting</td>
<td>14</td>
<td>43</td>
<td>14</td>
</tr>
<tr>
<td>Buggy Race</td>
<td>24</td>
<td>85</td>
<td>44</td>
</tr>
<tr>
<td>Slashdot</td>
<td>24</td>
<td>1609</td>
<td>160</td>
</tr>
<tr>
<td>Grand Challenge</td>
<td>6</td>
<td>900</td>
<td>280</td>
</tr>
</tbody>
</table>

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Performance

- User feedbacks: very positive
- Measured performance metrics
  - over 80% viewers do not see any loss of Audio or Video. 90% of viewers saw loss less than 5%.
Group Dynamics

conference start

lunch

conference end

folks not actively watching?

10am west coast
Example Overlay Tree (SIGCOMM '02)

- U.S. East Coast
- U.S. Central
- U.S. West Coast
- Europe
- Asia
- Unknown

Source (CMU)
Agenda

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Viewer UI: Join the Broadcast

End System Multicast

View SIGCOMM 03's Broadcast Schedule

This event is currently being broadcast.

**Step 1**
Download and install the following if you have not done so:

<table>
<thead>
<tr>
<th>Windows</th>
<th>Macintosh</th>
<th>Linux</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Quicktime 5 or above</td>
<td>1. Quicktime 5 or above</td>
<td>1. CodeWeavers Crossover Plugin + Quicktime 5 or above</td>
</tr>
<tr>
<td>2. ESMsetup.exe (3.3 MB)</td>
<td>2. esm.Darwin.tar.gz (5.0 MB)</td>
<td>2. esm/Linux.tar.gz (5.0 MB)</td>
</tr>
</tbody>
</table>

**Step 2**
Choose your link nature:

- T1 / DSL / Cable Modern users, click on **Below 10 BaseT**
- Ethernet (with T1 and above) users, click on **Above 10 BaseT**
A Very Simple System Setup

Speaker/Slides → Audio Video Capture → Encoding Machines → Hub (or wireless) → Internet

Audio/Video Capture Encoding machines Net Connectivity

Conference floor

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More Professional Setup

Audio/Video Capture  Encoding machines  Net Connectivity

Conference floor

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Example Professional Setup

- Speaker’s Laptop Containing slides
- Video Mixer
- VGA-TV Converter
- Camcorder
- Video Mixer
- Video Capture Card
- Audio Cable to Encoder1
- Encoder1
- Encoder2
- Video of slides to mixer
- Mixed Video to encoders
- Video of speaker to mixer
- Video Capture Card
Cost

❖ One Time Cost

<table>
<thead>
<tr>
<th>Equipment/Software</th>
<th>Brand and website</th>
<th>Price Estimation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Video Selector &amp; Mixer (O)</td>
<td>SFX-9 <a href="http://www.simacorp.com/">www.simacorp.com/</a></td>
<td>$500.00</td>
</tr>
<tr>
<td>VGA-&gt;TV converter (O)</td>
<td>AVerKey300 Gold: <a href="http://www.aver.com/products/">www.aver.com/products/</a></td>
<td>$250.00</td>
</tr>
<tr>
<td>Video capture card (O)</td>
<td>Viewcast osprey-50: <a href="http://www.viewcast.com/products/">www.viewcast.com/products/</a></td>
<td>$100.00</td>
</tr>
<tr>
<td>Encoding software: Mpegable broadcaster (M)</td>
<td><a href="http://www.mpegable.com">www.mpegable.com</a> Free Evaluation</td>
<td>$300.00</td>
</tr>
<tr>
<td>Camcorder (1 or 2) (O)</td>
<td>Any reasonable camcorder should be fine</td>
<td>$400.00 -</td>
</tr>
<tr>
<td>Encoding Machine I/II (O)</td>
<td>Window 2000/XP, Pentium IV</td>
<td></td>
</tr>
</tbody>
</table>

❖ Next release: open source encoder, free
People Involvement

- **Preparation Before the Event: 1-2 volunteers**
  - Network connectivity and conference Audio/Video set up.
  - Using ESM publishing toolkit website to create the events and schedule. (very min. work involved)
  - Let your potential audiences know the broadcast and the web links (created by ESM toolkit) to tune in.

- **During the broadcast: 1-2 volunteers**
  - Set up all the components mentioned above.
  - One or two operators (one for Camcorder, one for the video mixer) should be enough.
  - Monitoring the broadcast using the ESM web GUI is recommended.
ESM makes live web cast easy and affordable.

- Anyone with a camcorder, a computer, and an Internet connection can do it.

Technology developed and deployed first by ACM SIGCOMM community

Technology mature for wider adoption