# ESM Live Broadcast System

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

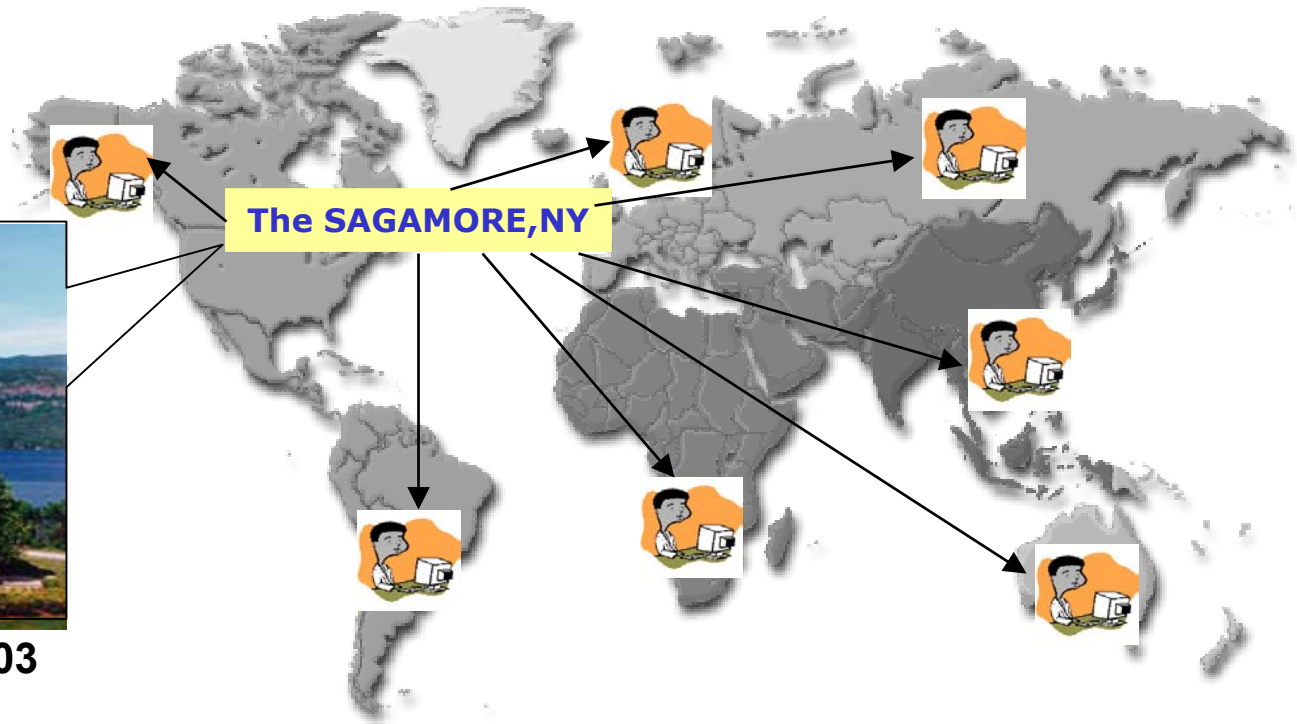
# Agenda

- 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 Sripanidkulchai
- 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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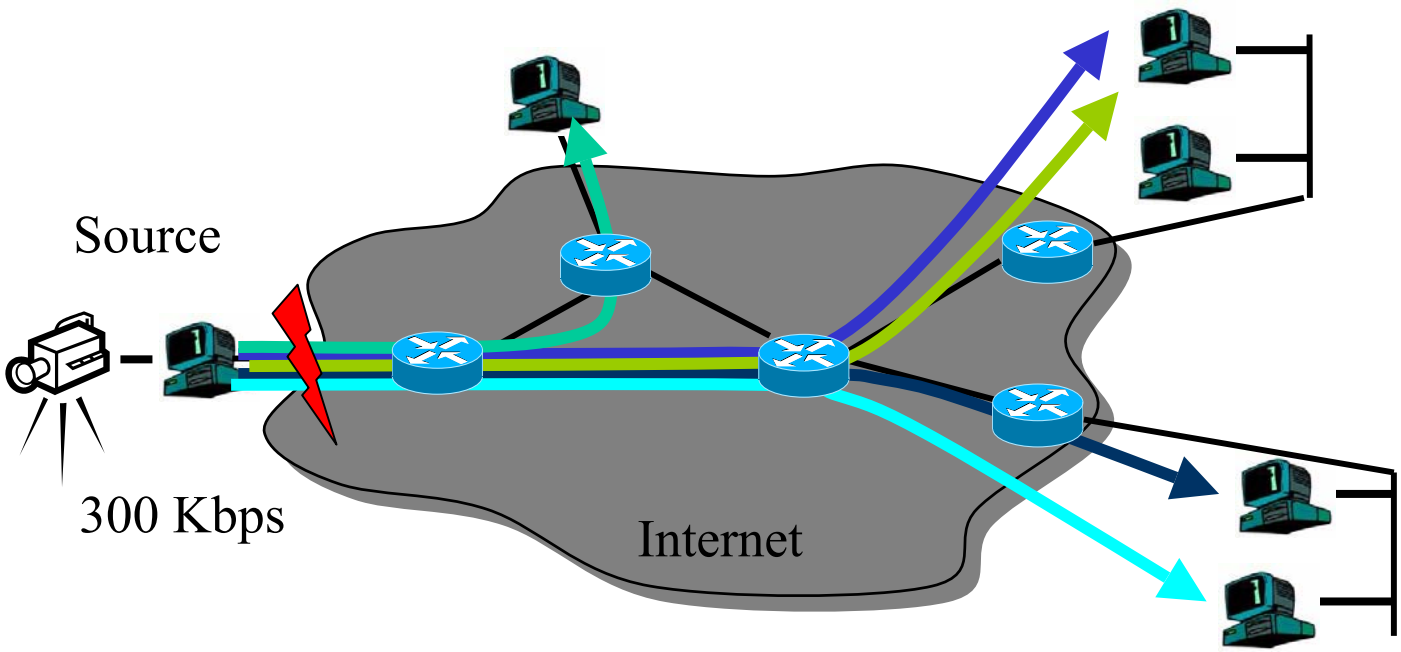
# Broadcast by Naive Unicast

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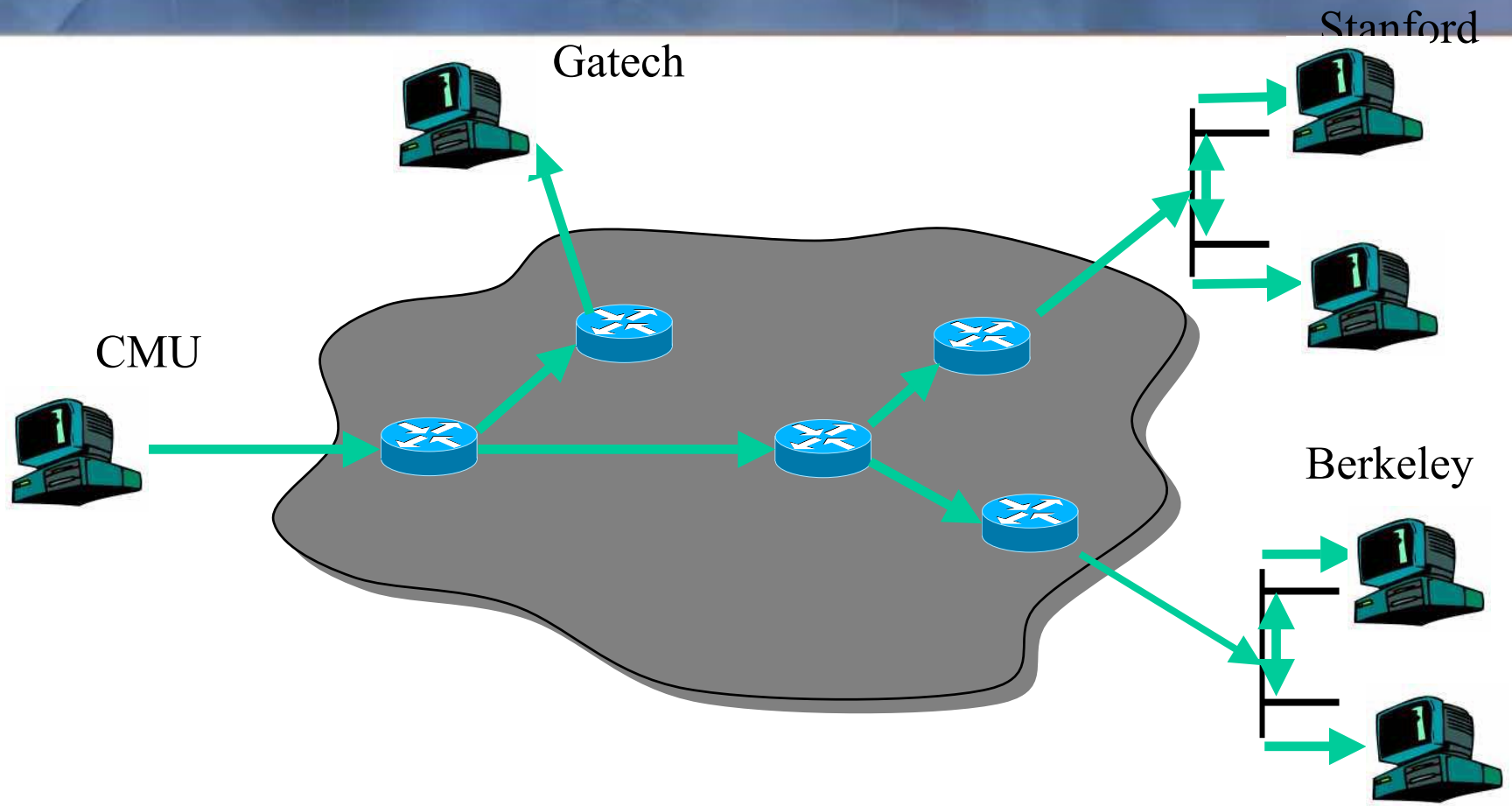
# IP Multicast

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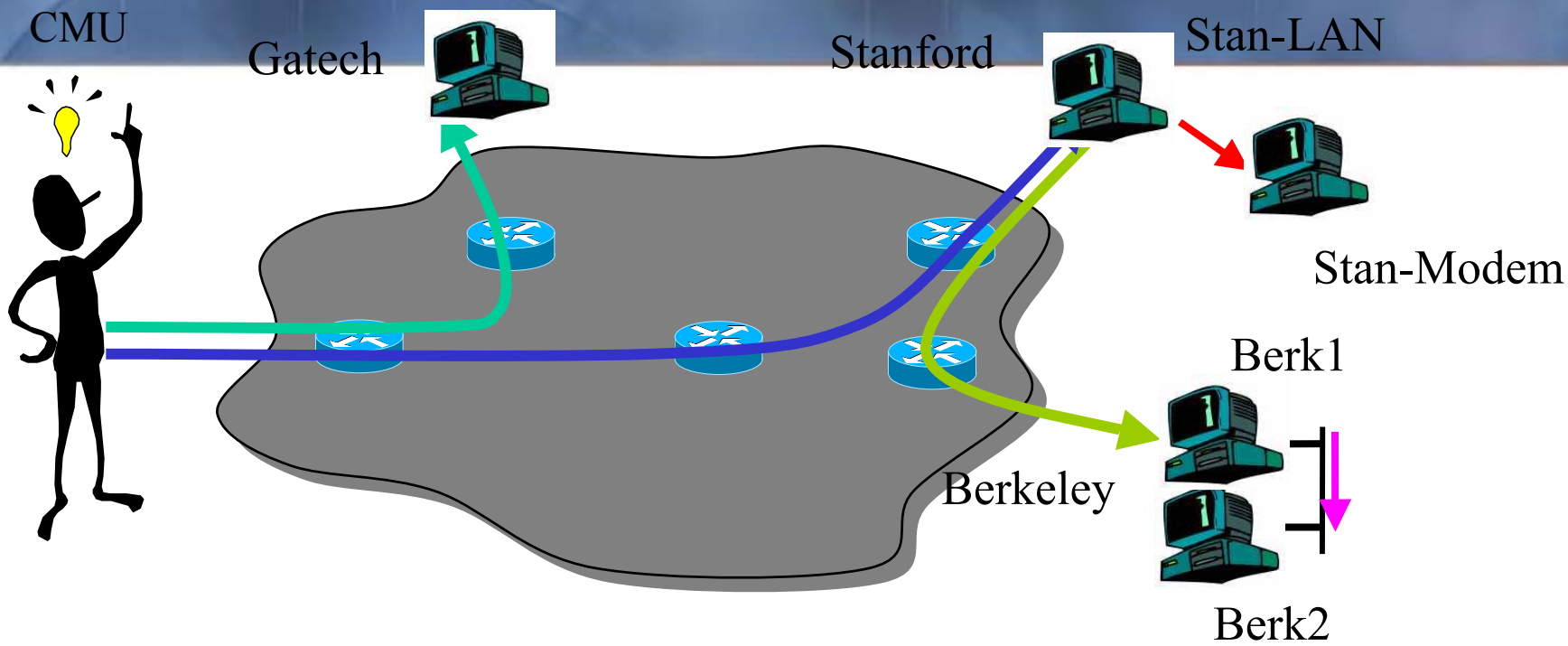
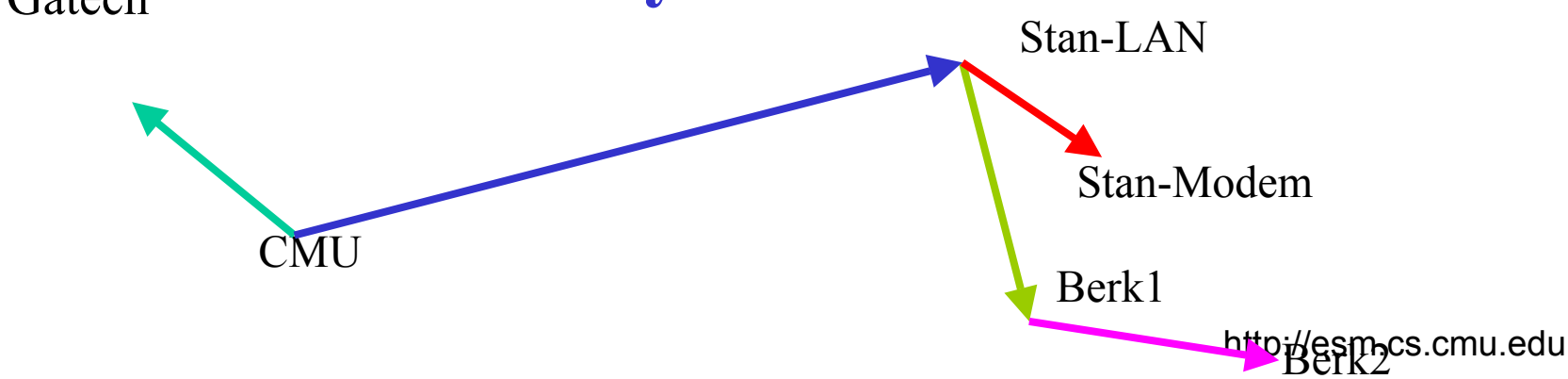
# End System Multicast

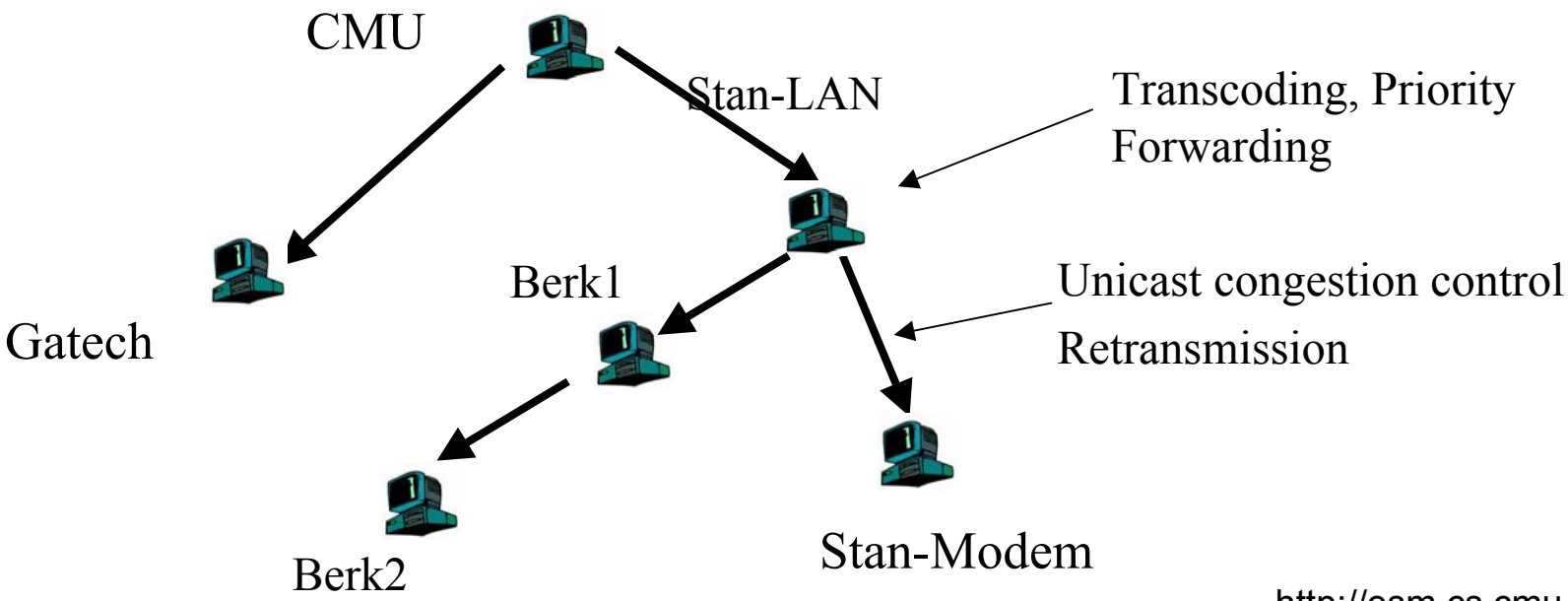



## Overlay Tree



# 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**

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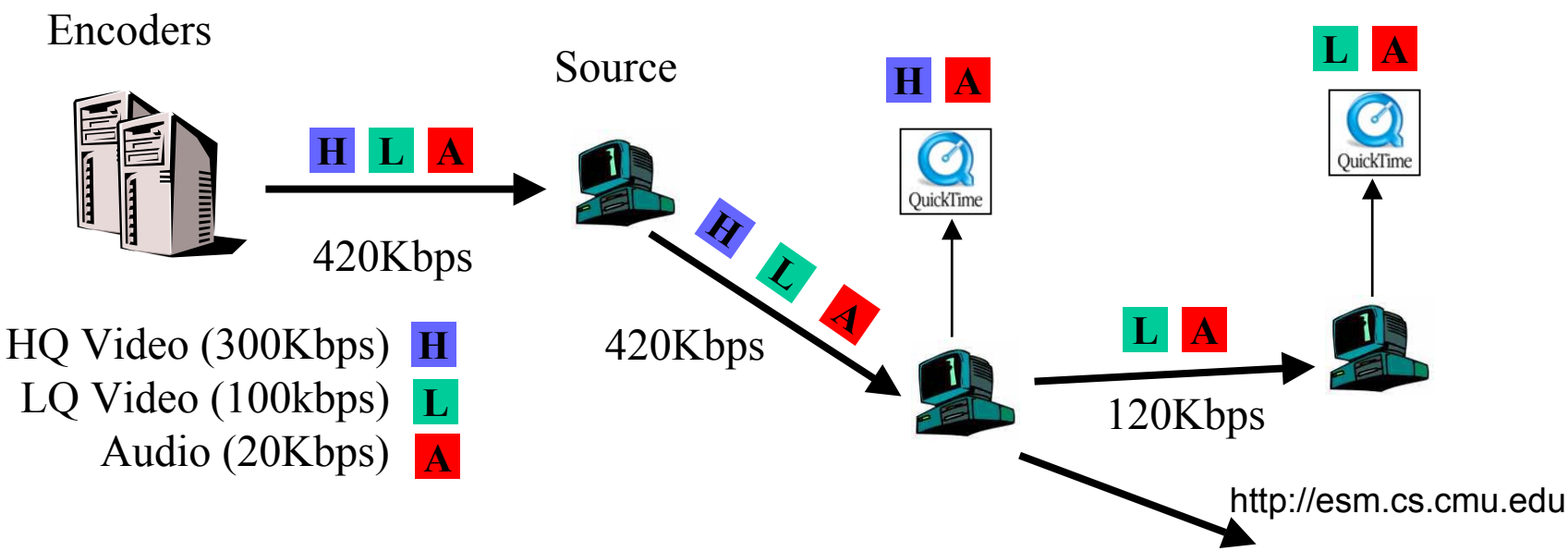
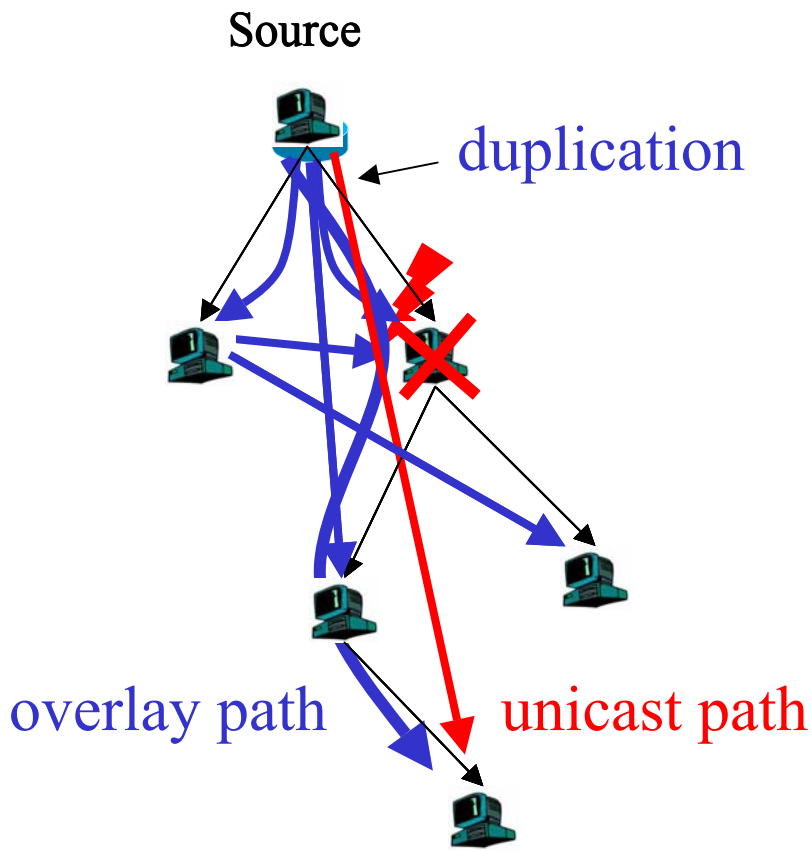
# Supporting Receiver Heterogeneity

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



# 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)**

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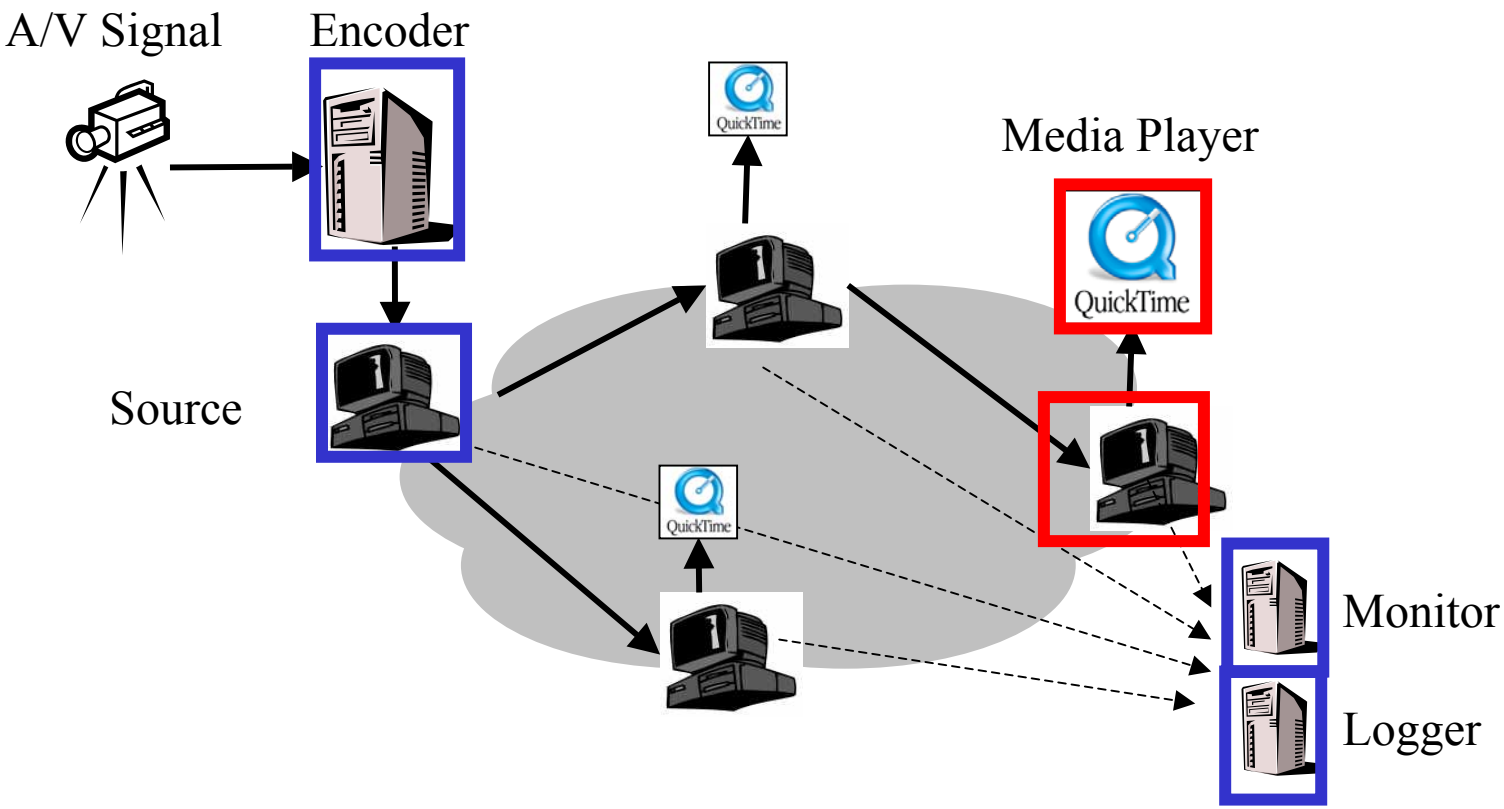
# How It Works




- **Components for two types of Users: Publisher/Event Organizer, Viewer.**

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# Deployment Experience

- **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)

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# Major Event Highlight

| Event | Duration (hours) | Unique Hosts | Peak Size |
|---|---|---|---|
| SIGCOMM '02 | 25 | 338 | 83 |
| SIGCOMM '03 | 72 | 705 | 101 |
| SOSP'03 | 24 | 401 | 56 |
| DISC'03 | 16 | 30 | 20 |
| Distinguished Lectures | 11 | 400 | 80 |
| AID Meeting | 14 | 43 | 14 |
| Buggy Race | 24 | 85 | 44 |
| Slashdot | 24 | 1609 | 160 |
| Grand Challenge | 6 | 900 | 280 |

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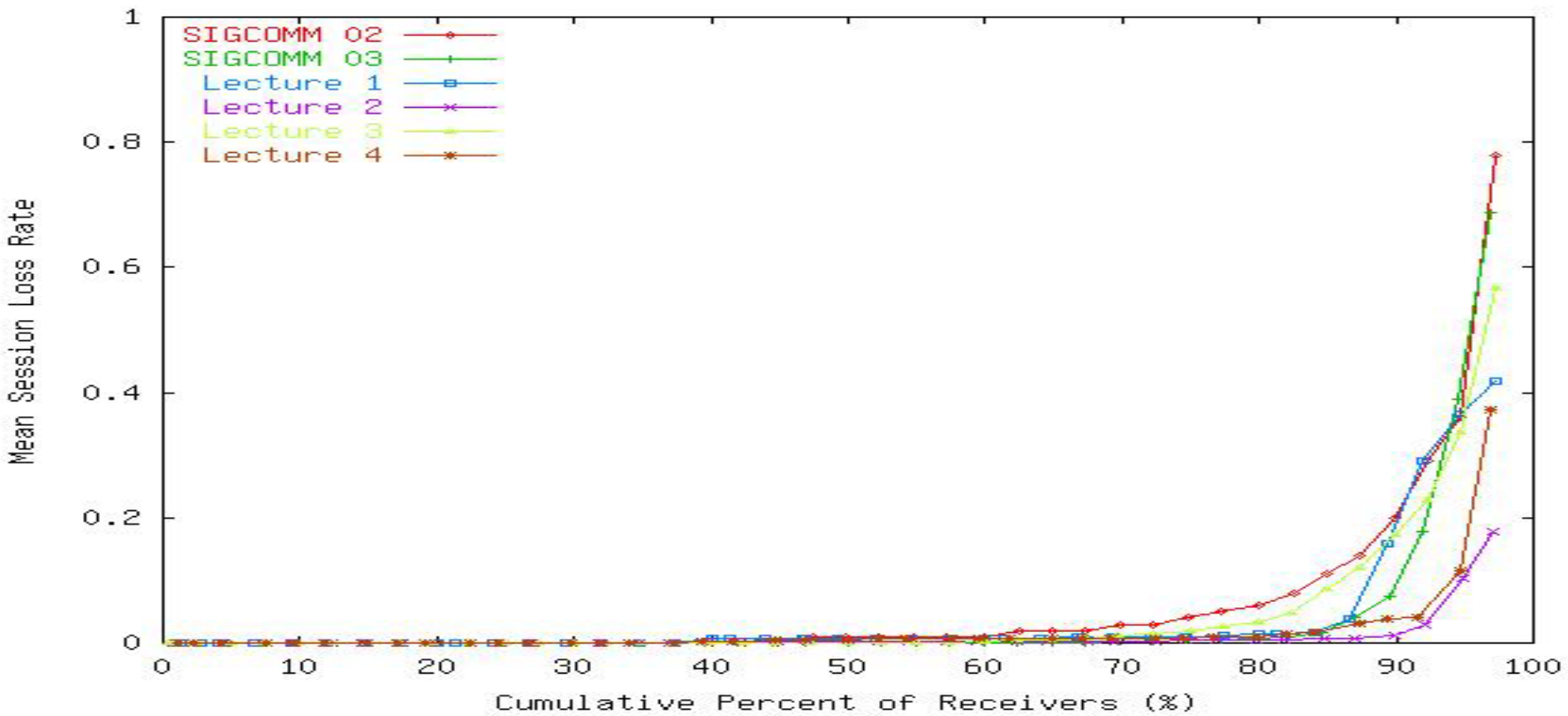
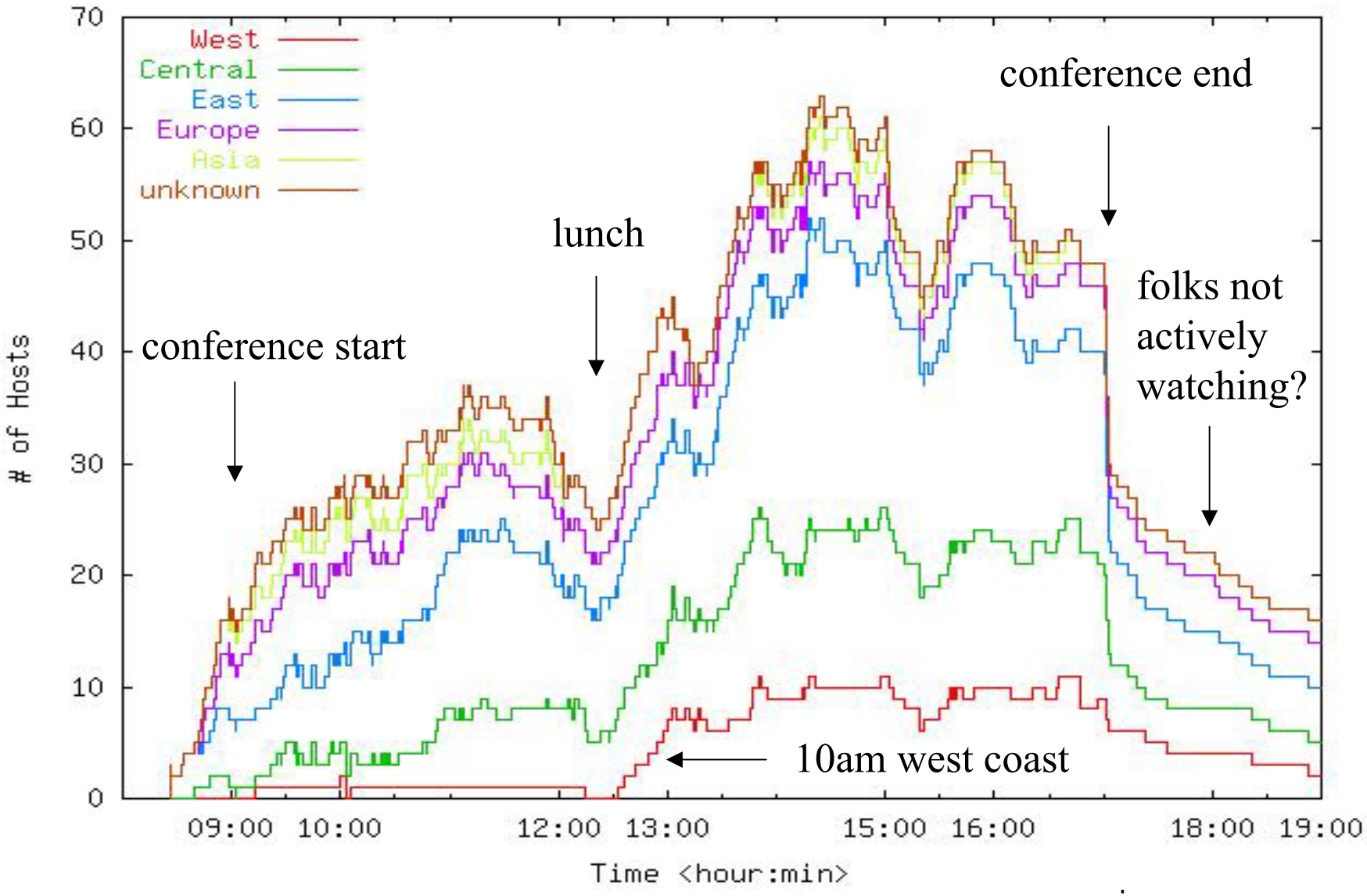
# Performance

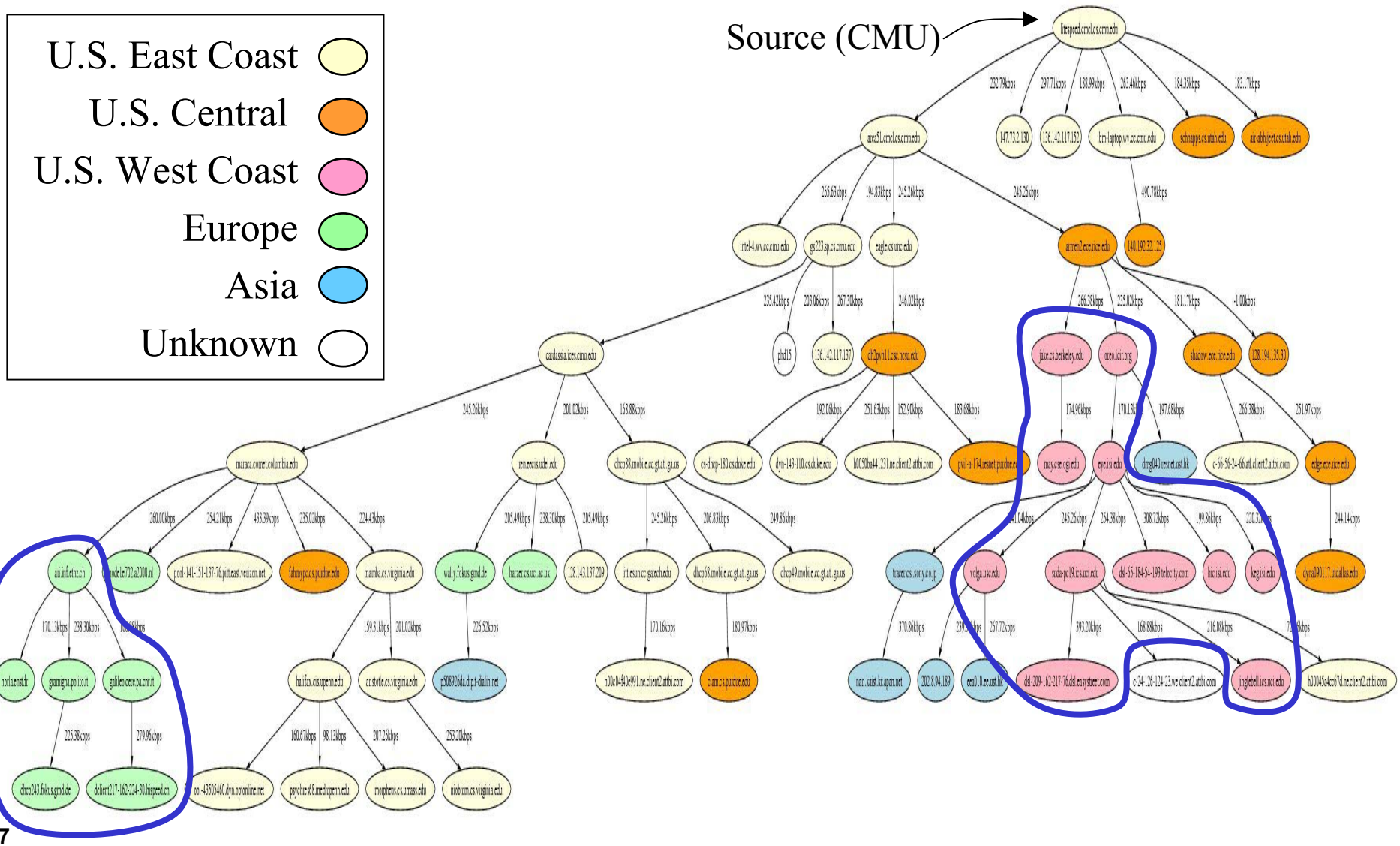
- **User feedbacks: very positive**
- **Measured performance metrics**
  - over 80% viewers do not see any loss of Audio or Video. 90% of viewers saw loss less than 5%.



# Group Dynamics



# Example Overlay Tree (SIGCOMM '02)



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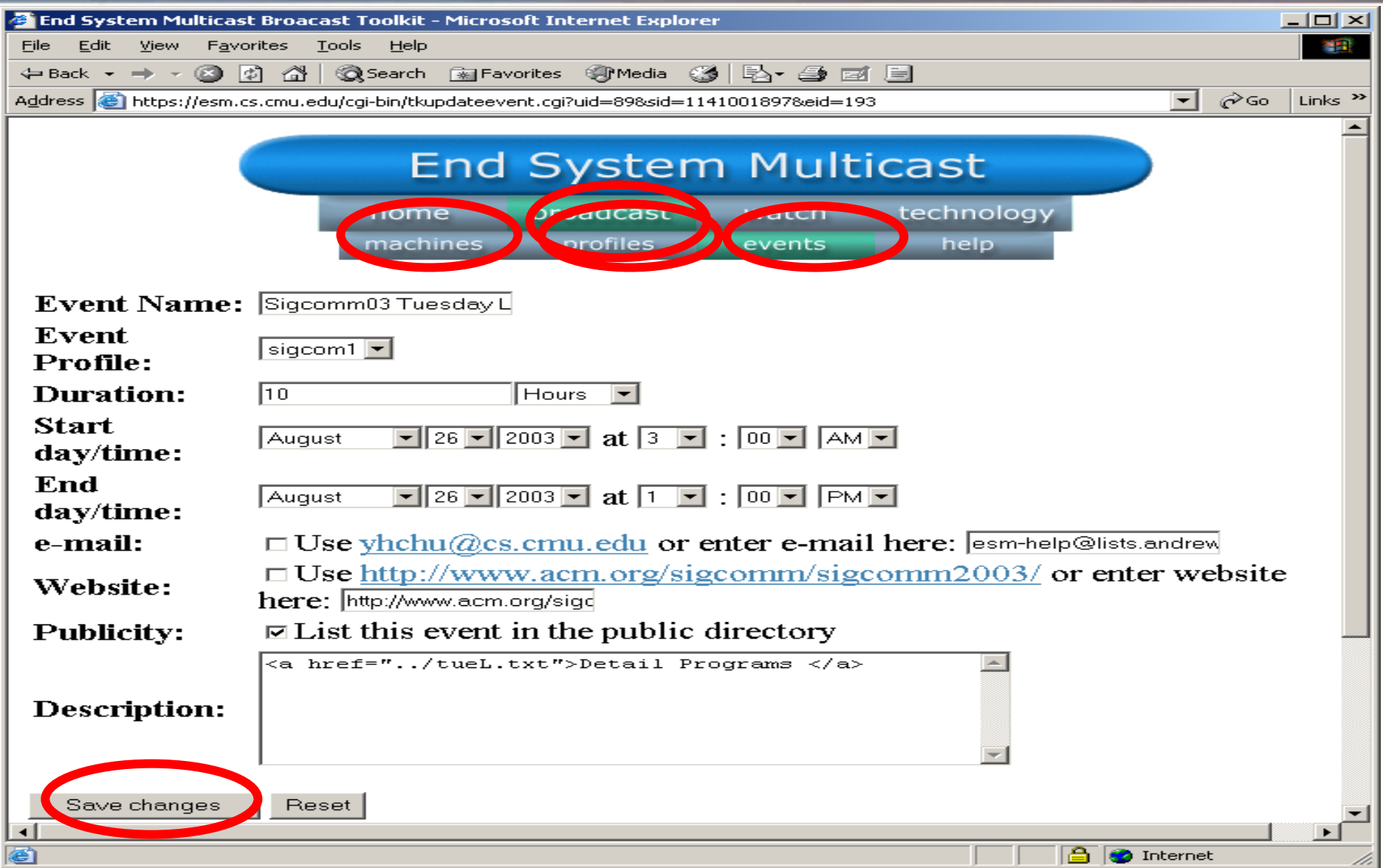
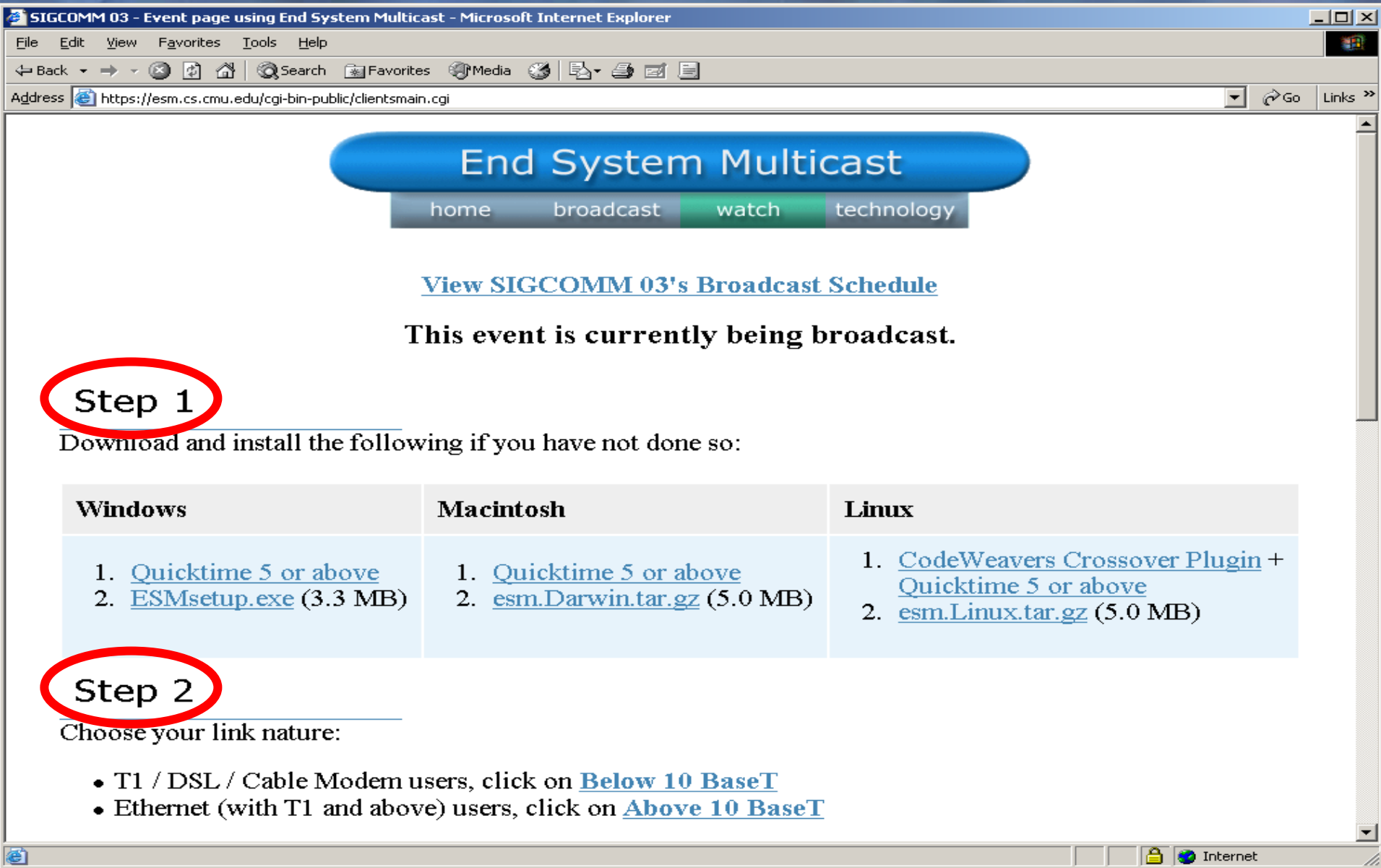
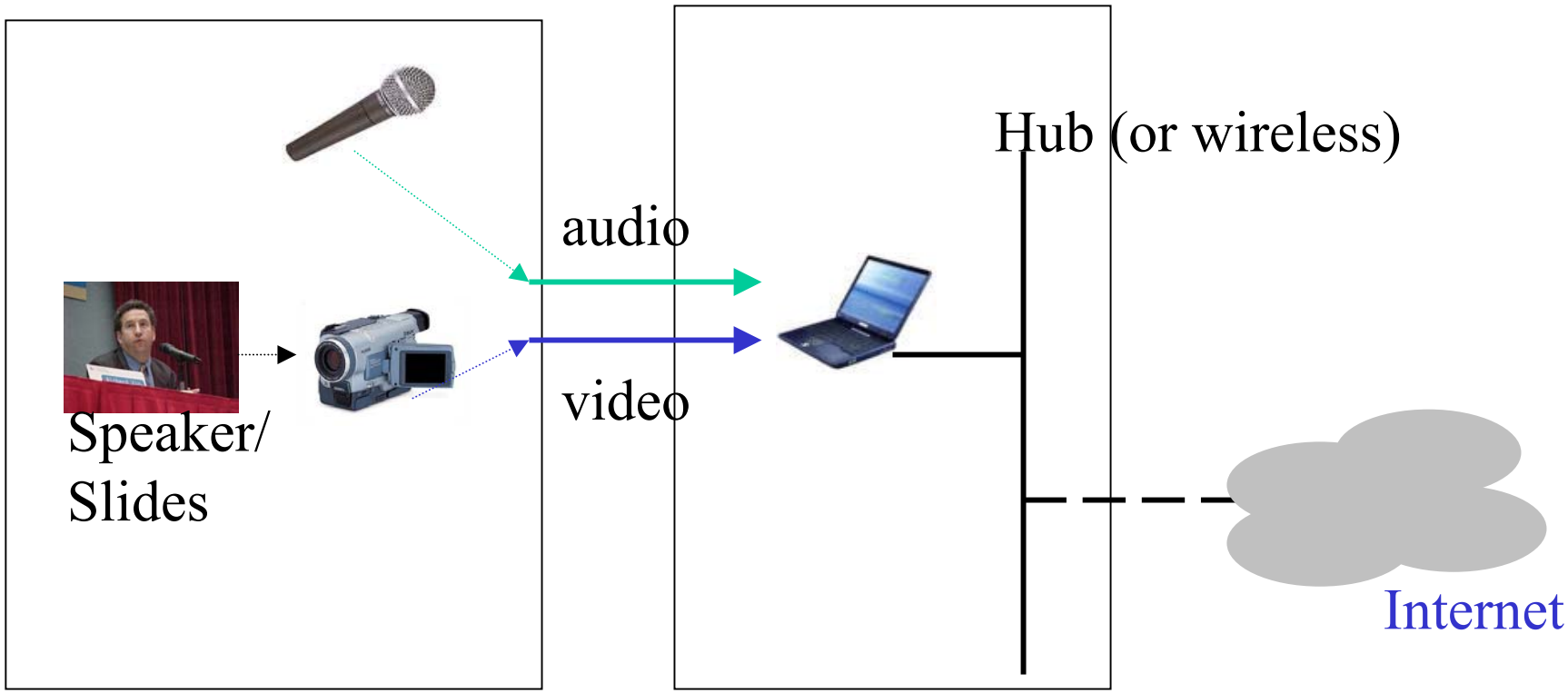
# Publisher UI: Configure A Broadcast



# Viewer UI: Join the Broadcast



# A Very Simple System Setup




Conference floor

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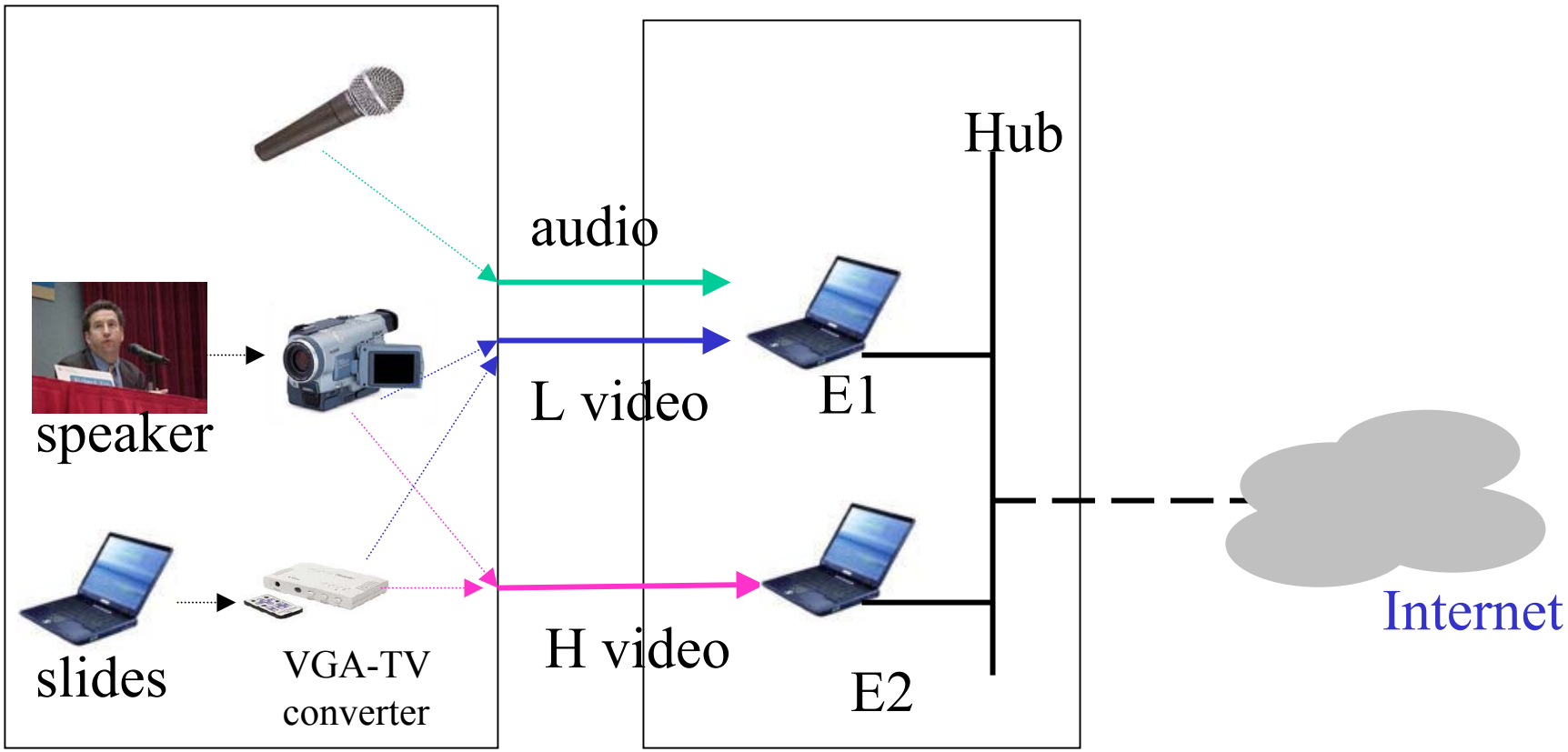
# More Professional Setup

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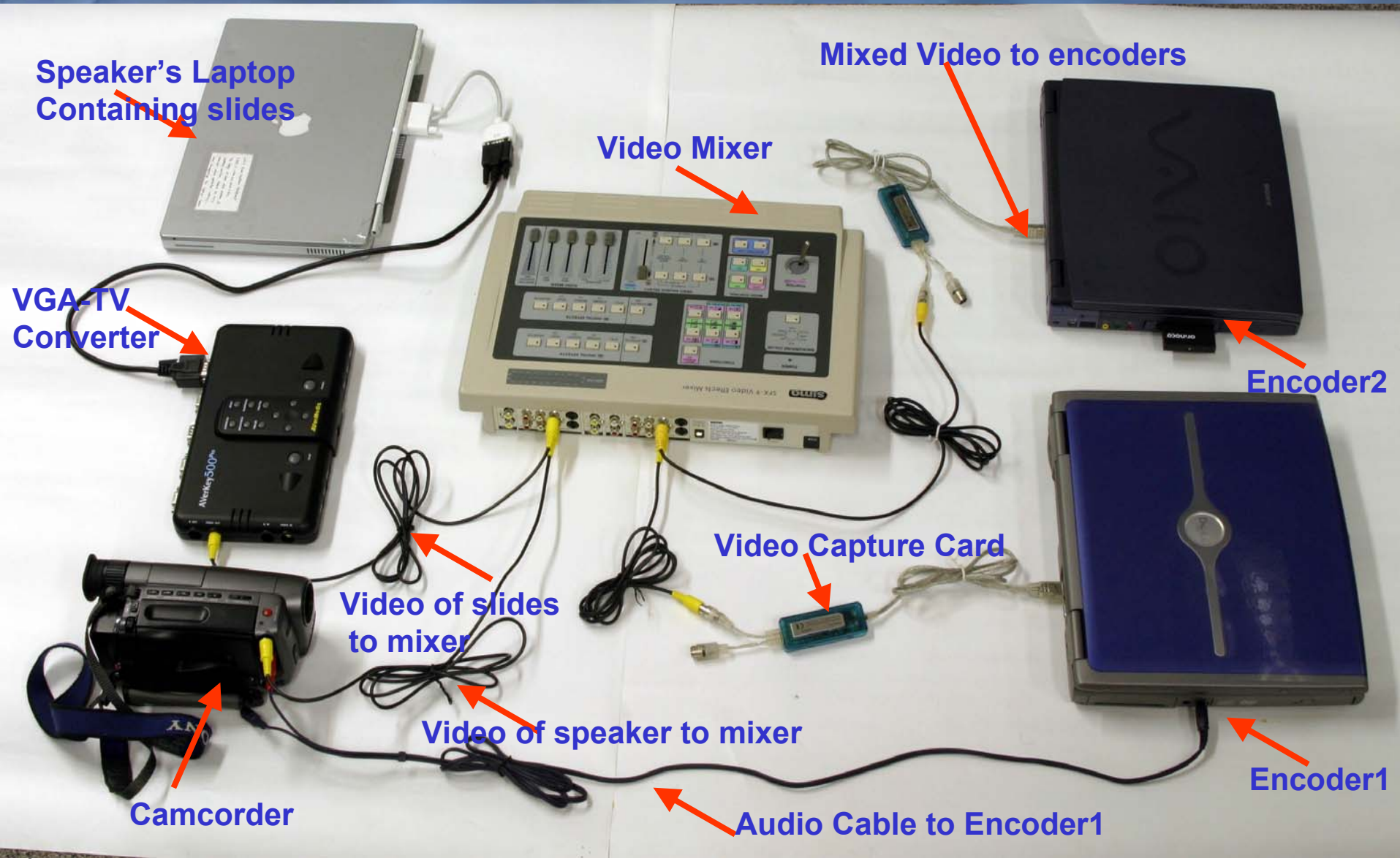
# Example Professional Setup



# Cost

- **One Time Cost**

| Equipment/Software | Brand and website | Price Estimation |
|---|---|---|
| Video Selector & Mixer (O) | SFX-9 www.simacorp.com/ | $500.00 |
| VGA->TV converter (O) | AVerKey300 Gold: www.aver.com/products/ | $250.00 |
| Video capture card (O) | Viewcast osprey-50: www.viewcast.com/products/ | $100.00 |
| Encoding software: Mpegable broadcaster (M) | www.mpegable.com Free Evaluation | $300.00 |
| Camcorder (1 or 2) (O) | Any reasonable camcoder should be fine | $400.00 - |
| Encoding Machine I/II (O) | Window 2000/XP, Pentium IV | |

- **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.

# Summary

- **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**

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