Using Advanced Networks for International Collaborations in the Arts

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Who am I?

- Artist / curator / theorist focusing on Generative Art and Complexity Theory

And at New York University

- ITS Senior Advanced Technology Architect
- Academic Computing Associate Director for Arts Technology
- Occasional Adjunct Faculty in the (Tisch School) Interactive Telecommunications Program

Chaotic Conductor - CAA 2004

for more information

- These slides are available at:

  http://www.nyu.edu/its/atg

- Also you can view my website at:

  http://philipgalanter.com

Outline

Part One

- Commodity Internet - Options and Limitations
- Advanced Networks
- Advanced Networks - Issues and Challenges
- Advanced Networks - Artistic Options
- Why Are We Doing This?

Part Two

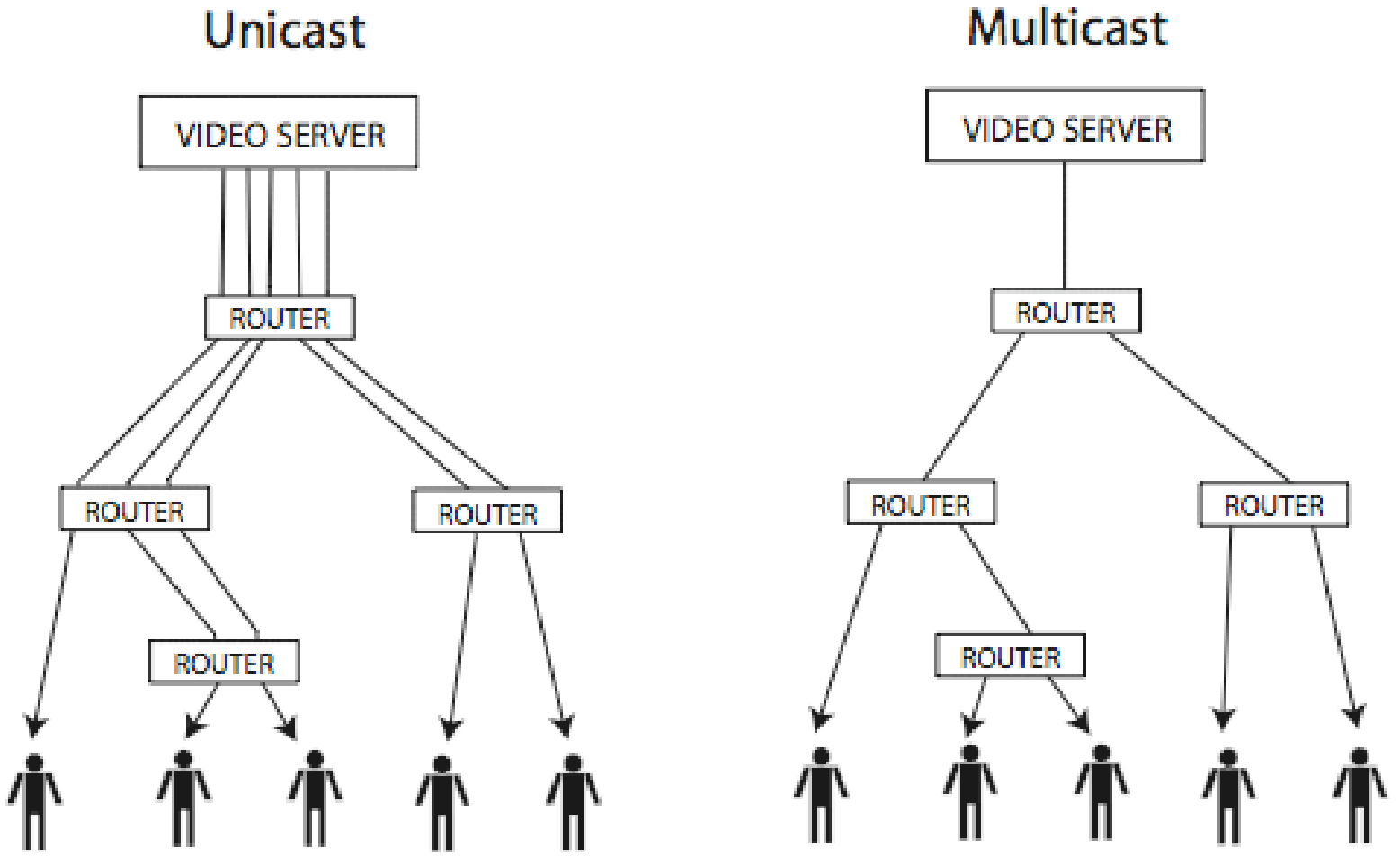
- Multi-Site Performing Arts Events

Commodity Internet Options

- E-mail and the web
- BBSs, MUDs & MOOs, Wikis, & Blogs
- Director & Flash screen based interaction
- Low bandwidth interactive applications
  - Try keyworx @ http://www.keyworx.org/
- MIDI events via network
  - Try Max/MSP @ http://www.cycling74.com
- Low Def Video for conferencing & webcams
  - iChat for Macintosh or MSN Messenger for Windows
- Low Def Streaming - live and on demand
  - RealMedia/Helix, Apple Quicktime, Microsoft Media
- Webserver on a Chip for Physical Computing

Commodity Internet Limitations

- Limited Bandwidth
  - Applications needing > 1 Mbps may be impossible
- Isochronously Challenged
  - Streaming media may be paused or broken up
- Objectionable Latency
  - Large Buffers may help streaming, but at a cost in delay time
- Multicast not enabled
  - Streaming servers must grow in proportion to the audience
- NAT & firewalls disrupt video conferencing
  - Video conferencing from home or student labs may not work


Unicast
VIDEO SERVER
ROUTER
ROUTER
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ROUTER
Multicast
VIDEO SERVER
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Advanced Networks - Internet2

From http://internet2.org

Internet2 is a consortium being led by 207 universities working in partnership with industry and government to develop and deploy advanced network applications and technologies, accelerating the creation of tomorrow's Internet. Internet2 is recreating the partnership among academia, industry and government that fostered today's Internet in its infancy. The primary goals of Internet2 are to:

- Create a leading edge network capability for the national research community
- Enable revolutionary Internet applications
- Ensure the rapid transfer of new network services and applications to the broader Internet community.

Advanced Networks - Americas

- CANARIE (Canada)
- CLARA (Latin America & Caribbean)
- CEDIA (Ecuador)
- CNTI (Venezuela)
- CR2Net (Costa Rica)
- CUDI (Mexico)
- RETINA (Argentina)
- RNP [FAPESP] (Brazil)
- SENACYT (Panama)

Advanced Networks
Europe and the Middle East

- ARNES (Slovenia)
- BELNET (Belgium)
- CARNET (Croatia)
- CESnet (Czech Republic)
- DANTE (Europe)
- DFN-Verein (Germany)
- FCCN (Portugal)
- GARR (Italy)
- GIP-RENATER (France)
- GRNET (Greece)
- HEAnet (Ireland)
- HUNGARNET (Hungary)
- Israel-IUCC (Israel)
- NORDUnet (Nordic Countries)
- POL-34 (Poland)
- Qatar Foundation (Qatar)
- RedIRIS (Spain)
- RIPN (Russia)
- RESTENA (Luxemburg)
- Stichting SURF (Netherlands)
- SWITCH (Switzerland)
- SANET (Slovakia)
- TERENA (Europe)
- JISC, UKERNA (UK)

Advanced Networks
Asia and the Pacific Rim

- AAIREP (Australia)
- APAN (Asia-Pacific)
- ANF (Korea)
- CERNET, CSTNET, NSFCNET (China)
- JAIRC (Japan)
- JUCC (Hong Kong)
- SingAREN (Singapore)
- NECTEC / UNINET(Thailand)
- TANet2 (Taiwan)
- NGI-NZ (New Zealand)
- APRU (Asia-Pacific)

Advanced Networks
Issues and Challenges

- Bandwidth and Congestion
- Latency
- Feedback
- Codecs

Issues and Challenges
bandwidth and congestion

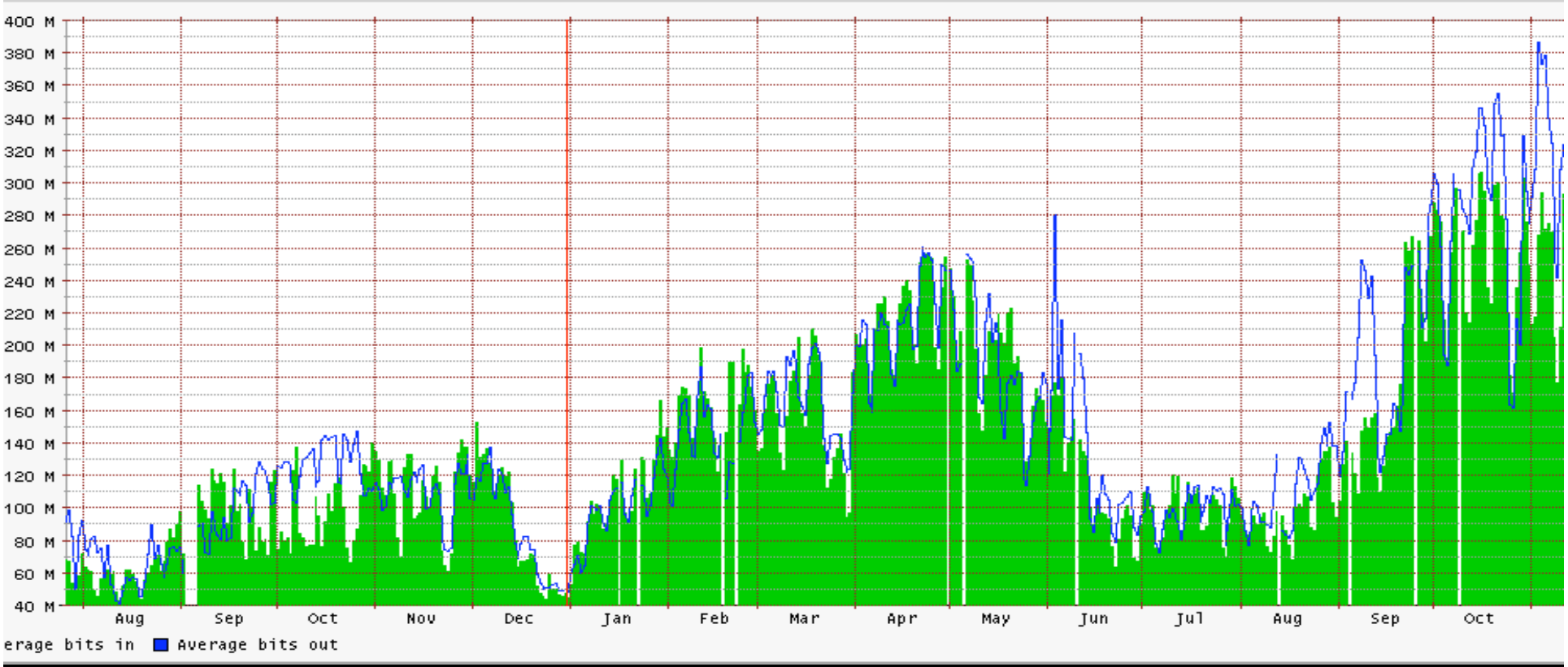
- Applications such as video transmission require both high bandwidth and very low packet loss.
  - Video applications use UDP packets
  - There is no time to retransmit lost packets anyway
  - Uncompressed “D1” video requires 168 Mbps
  - Compressed DV video requires 29 Mbps
  - NYU’s OC3 connection to Internet2 only provides 155 Mbps

Issues and Challenges
bandwidth and congestion

- The traditional Internet cannot provide the needed bandwidth or low packet loss
- The Internet2 community is developing Quality of Service protocols that will provide reserved bandwidth
- Until then Internet2 provides brute force bandwidth and low packet loss via overprovision

Issues and Challenges
bandwidth and congestion

- But congestion is still possible
  - In the following example note growth over the period of a year, and patterns that occur by hour and by day of the week
  - The graphs show congestion at the interface between CalREN2 (a regional network) and Abilene (the Internet2 long haul network)
  - Packet loss resulting in video errors occur at about 300 Mbps
  - Note that there is more outward traffic (in blue) than inward traffic (in green)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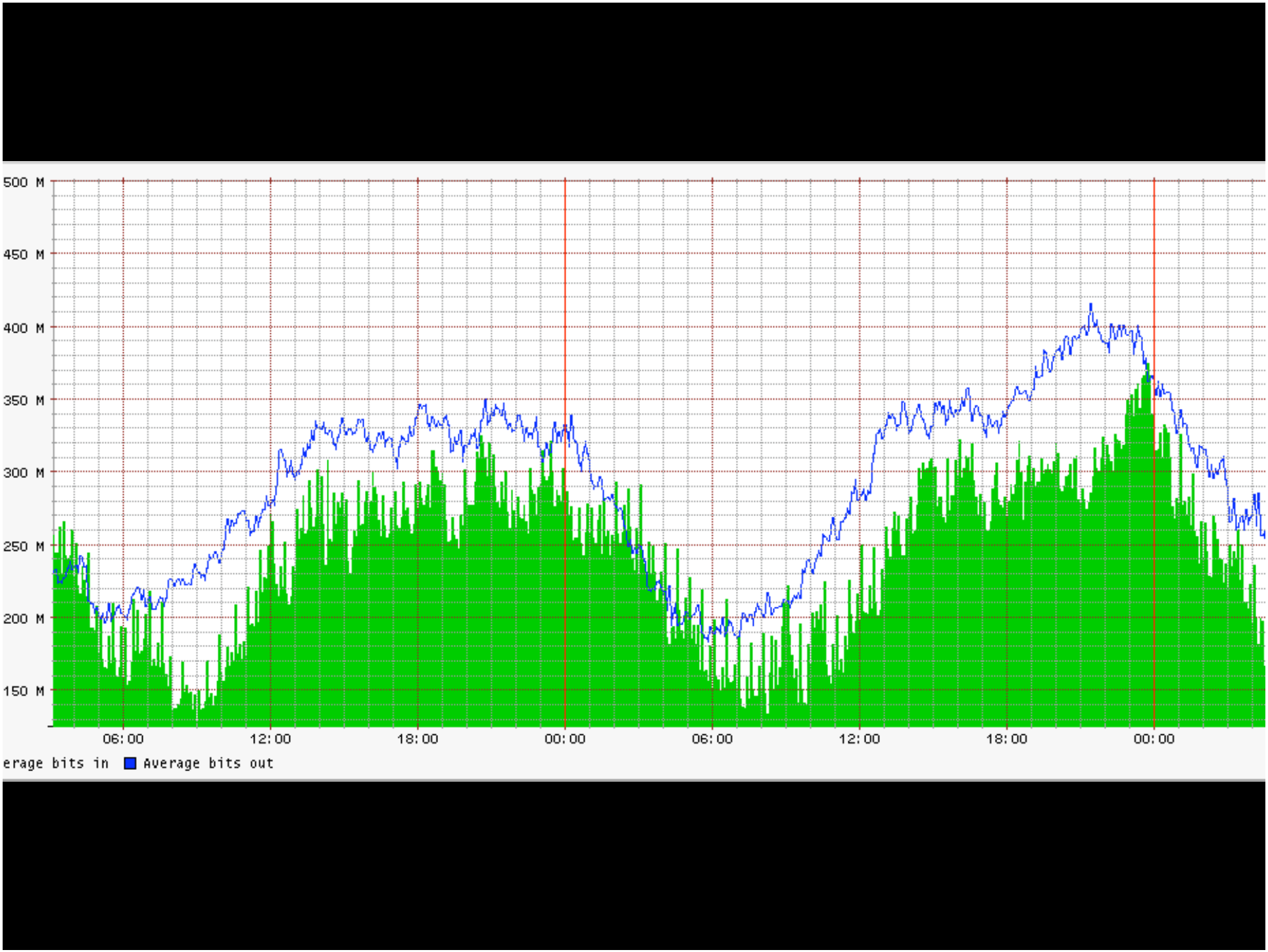
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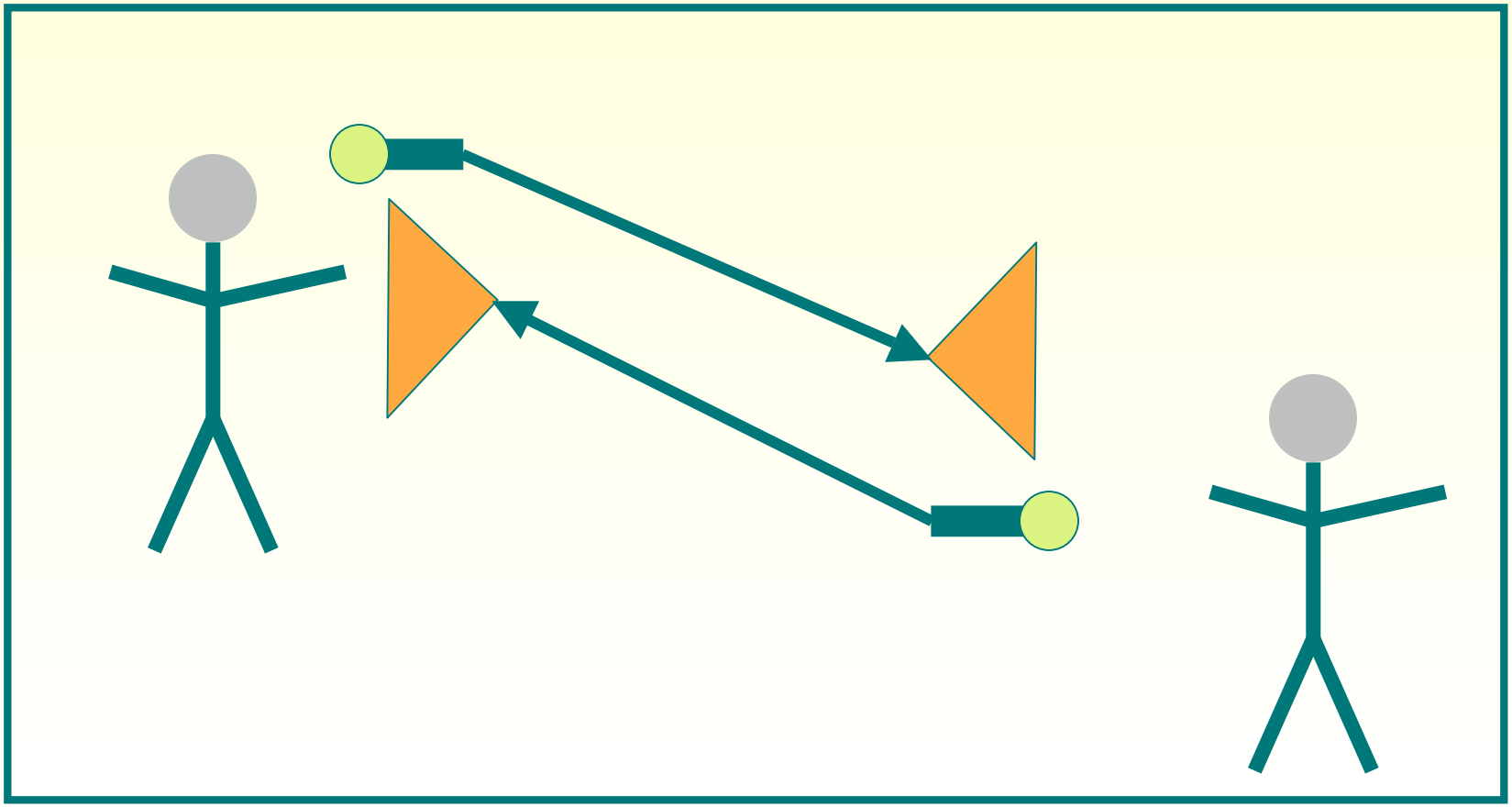
Issues and Challenges
latency

- Data is delayed every step of the way
- Sources of latency include
  - Switches and routers
  - Cameras and other digitizers
  - Video standard converters and timebase correctors
  - Codecs
  - The speed of light
- Typical latency is about 1/4 - 1/2 sec

Issues and Challenges
feedback



Issues and Challenges codecs

- For live events hardware codecs are needed
  - Streaming servers use large buffers, which result in large latency (many seconds)
- Vendors include Vbrick and StarValley
  - Vbrick 3000 uses MPEG 1 @ 1.5-3 Mbps - $10K/pair
    - 30 field per second 1/4 frame video
  - Vbrick 6000 uses MPEG 2 @ 6-10 Mbps - $20K/pair
    - 60 field per second full frame video
- There are also do-it-yourself codecs
  - Requires technical sophistication to assemble, install, and configure

Issues and Challenges
alternatives to hardware codecs

- All exhibit some lack of arbitrary artistic control over audio and picture
- H.323 Video Conferencing
  - Extension of ISDN based technology for the internet
  - Ubiquitous adoption via “Polycoms” and “Tandbergs”
  - Internet2 Commons effort supports very large conferences
- SIP based Video Conferencing
  - Wave of the future, but spotty current adoption
- Access Grid
  - Open source “room metaphor” tool that requires Multicast
- VRVS
  - Less stable (?), multi-standard, room metaphor tool
- The Research Channel
  - Broadcasts university research to about 20M households

Advanced Networks - Artistic Options multi-site I2 performances

- Includes 2 or more locations with performers simultaneously active
- The locations are linked via picture and sound, usually video projection
- There is an audience at each location that can see and hear both the local and remote performers

nyu performance events

- Internet 2 Performance Workshop
  with MIT, Spring 1999
- Demonstration project for the Audio Engineering Society
  with McGill University, Fall 1999
- Performance event for the Internet2 Member Meeting
  with many others, Fall 1999
- Association for Technology in Music Instruction
  with Indiana University, Winter 2000
- First Internet 2 Distributed Musical
  with RPI, Spring 2001

nyu performance events

- 11th International Computer Music Tech. Conf.
  with Indiana University, Summer 2001
- Songs of Sorrow, Songs of Hope
  with UC Irvine & European Inst. of Design, Fall 2001
- Conversations with Artists Series
  with University of Delaware, Spring 2002
- Distance Education Tests
  with NTT Japan and NTT USA, Spring 2002

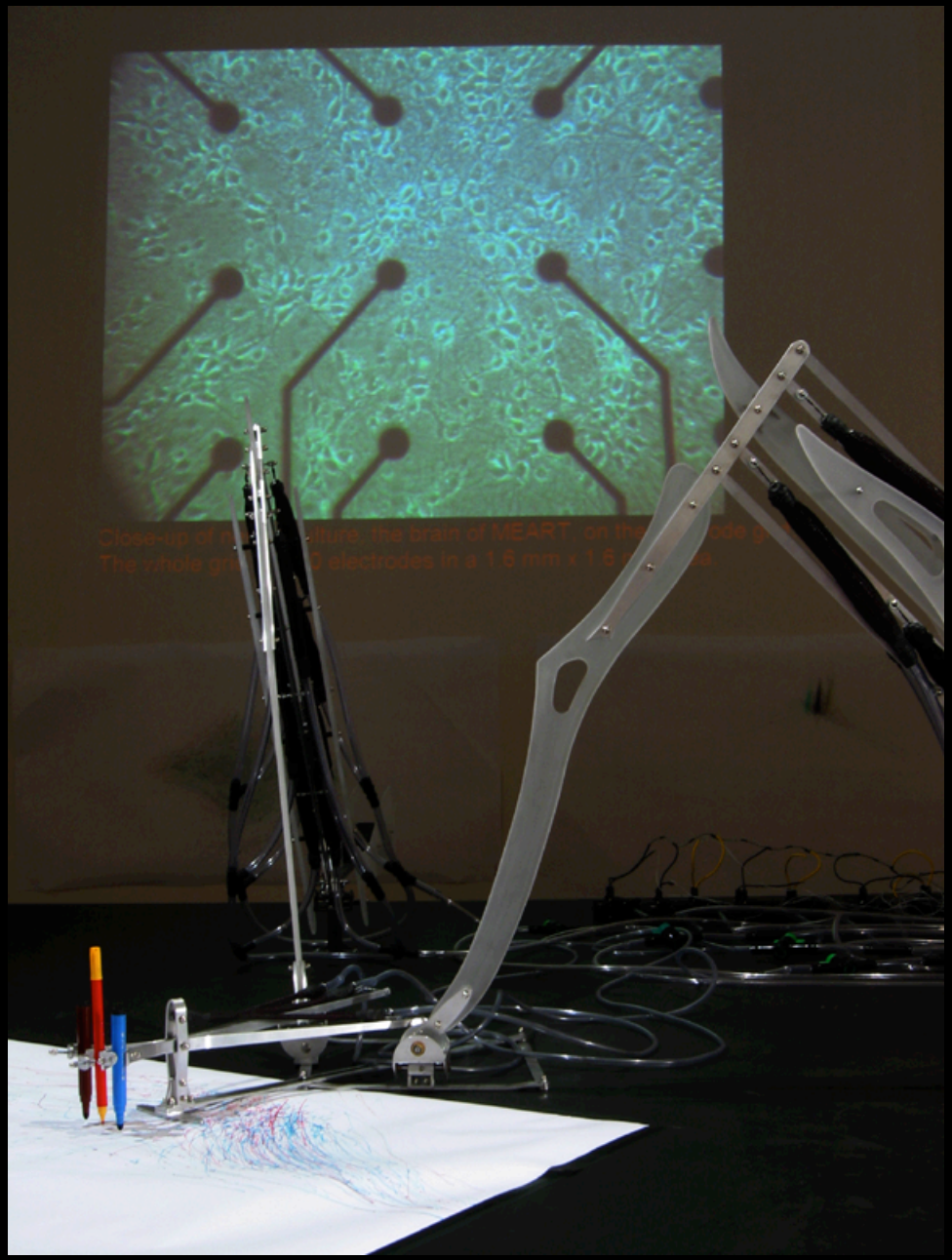
NYU Collaboration with York University (Canada) and Bergen College (Norway)

“The Technophobe and the Madman”
NYU and RPI in 2001

Current & future developments

- Motion tracking as dance interface
- Real time graphics and video synthesis
- Virtual actors and musicians
  - Via puppetry
  - Via artificial intelligence
- Virtual sets
- Robotics

MEART at ArtBots 2003



Why are we doing this?

- Artistic reasons
  - Push boundaries and break paradigms
  - Cultural exchange and interaction
  - New modes of man/machine interaction
  - Discover new truths about all performing arts by participating in a new and mediated performance environment

Why are we doing this?

- Technical reasons
  - Artists will test the limits of quality
  - Artists will test the limits of quantity
  - Artists will ask for unusual configurations
  - Multi-site performing arts anticipates the future of telepresence

Why are we doing this?

- Democratization of cultural exchange
  - Webs rather than hierarchies
  - Exploring the up-side of globalization

for more information

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Part Two
Multi-Site Performing Arts Events

A Team Approach

- Initial Planning
- Structure via Project Teams
- Notes About Project Teams
- Creative Team Notes
- Video Team Notes
- Audio Team Notes
- Internet2 Team Notes
- Documentation Team Notes
- Streaming Team Notes

Initial Planning
aspiration and intent

- What kind of a performance will this be?
  - Enhanced panel discussion
  - Demonstration
  - Workshop
  - Dress rehearsal or showcase
  - Formal performance event

Initial Planning
leadership buy in

- Get all essential players to sign on early
- At every location engage all of these
  - Creative Leaders - director, conductor, etc.
  - Performance Space Management
  - Media Production Management
  - Local (Departmental) Networking support
  - Central (University) Networking support
    - This can be problematic as most central units prefer to be application agnostic. But early participation here is absolutely critical.

Initial Planning
asap network check

- Consult with central networking staff as early as possible and prior to the end-to-end test
  - Verify gigapop & backbone capacity
  - Verify robust “last mile” connection
    - Must be specific to actual performance space
    - Individual 100 Mbps switched port per device preferred
    - Beware of old wiring, hublets, shared ethernet
    - Beware of jacks that aren’t activated
    - Beware of intermediate router bottlenecks
    - Jacks must be located near audio and video mixing area
    - Beware of duplex auto-negotiation with codec
  - Make a best guess as to total codec needs and verify there is enough in the “bandwidth budget”

Initial Planning
logistics and timing

- Develop a shared project timeline
  - Set performance and rehearsal dates
    - Reserve performance and rehearsal spaces
    - Reserve any media equipment rentals
    - Trickle down dates so all players can set their calendars
  - Set technical testing dates
    - Allow for at least 4 weeks of network and codec debugging before first rehearsal

Initial Planning
logistics and timing

- Who leads and who follows?
  - Traditionally creative leaders are empowered to shift dates and times on the fly and at will
  - Key networking or other technical staff similarly autonomously shift the timing of their work to juggle multiple priorities
  - This can lead to significant problems

Initial Planning
logistics and timing

- Suggested course of action
  - Have all significant rehearsals and performances scheduled well in advance
  - After the schedule is set don't allow unilateral changes, but require sign-off by key leadership
    - Creative Leaders - director, conductor, etc.
    - Technical Team Leaders
    - Performance Space Management
    - Media Production Management
    - Local (Departmental) Networking support
    - Central (University) Networking support

Initial Planning communications

- Good project communications is crucial
- Don't forget about time zone ambiguities
- Use an e-mail list that includes everyone
  - Push not pull, e-mail not web page
- Send weekly reference e-mail that compiles:
  - Project timeline with milestones and deadlines
  - All contact information
  - Phone numbers in performance spaces
    - Verify all performance spaces have a telephone!
  - IP addresses of codecs and other network objects
  - News announcements and new team members

structure via project teams

- Creative Team
  - Composer, director, dancers, actors, musicians, etc
- Video Team
  - Mixers, camera crew, lighting crew, projection techs
- Audio Team
  - Stage techs, mixers
- Internet2 Team
  - Network engineers, codec techs
- Streaming Team
  - Mixers, camera operators, streaming techs
- Documentation Team
  - Recording techs, camera operators

notes about project teams

- Designate a Technical Director
  - To coordinate among technical teams
  - To act as primary liason to creative team

notes about project teams

- Those working on video, lighting, and projection make up the video team
  - Cameras want a lot of light
  - Projectors want to be in the dark
  - Set designers want highly variable light
  - The human eye and cameras have differing light responses
  - The stage lighting crew will find balancing these needs to be very challenging

notes about project teams

- If the event is to be documented, don't task the Video Team with this
  - Camera angles good for projection screens may not be good for post-production work
  - In camera audio is problematic
  - The Video Team will be so busy with the live event that documenting the performance will be left to last…perhaps forgotten!
  - The Documentation Team should use their own cameras, and record submixes provided by the Audio Team

notes about project teams

- If the event is to be streamed to an Internet1 audience, don't task the Internet2 team with this
  - The streamed version of the event may require its own video and audio mix
  - The I2 team may have their hands full up to the last minute, and may neglect streaming tasks

creative team notes

- The primary challenge is dealing creatively with latency (network and codec delay)
  - For music (or dance) having 2 or more sites playing very tight parts together will not work well
  - Strategies where one site leads and other sites play parts that are somewhat loose work well
- Commit to a media topology early and stick to it
  - Compose for the available medium
  - Adding more channels of video or audio at the last minute invites technical problems and failures

video team notes

- Rear screen projection often problematic due to lack of stage depth
- DLP projectors are very light weight and bright … good for flying front projection
- Performers will likely require video monitors near the footlights showing the far site. The rear screen is out of sight and not useful for performance cues.
- MPEG-1 video using 30 fps rather than NTSC 60 field video will exhibit a very slight strobe effect

video team notes

- For international events you will have to deal with NTSC/PAL/SECAM conversion problems
- Remember that video isn't always a camera, and may include video synthesis or sampler playback
- Use good standard practice
  - White balance all cameras before use
  - Turn off auto-focus and use manual focus
  - Use power supplies and not batteries
  - Beware of camcorders that turn off when not in record mode

audio team notes

- Multi-Site audio feedback - big problem!
  - Each site should send audio which fully uses available headroom but doesn't clip
  - On stage monitor levels should be controlled locally, not by turning down at far site
  - Note however that musicians do have a creative respond to loudness
  - Use headphones or in-ear monitors whenever possible
  - Put PA speakers and monitors in front of the microphones
  - Use directional mics and sound barriers where possible

audio team notes

- Multi-Site audio feedback - more!
  - Video conference oriented echo cancellation doesn't help
    - e.g. Gentner units are designed to allow one speaker at a time to be heard
  - Sound reinforcement feedback eliminators are of limited use
    - e.g. Sabine units use a dynamic notch filter to remove resonant frequencies, but not echoes
  - Noise gates or careful manual muting on individual microphones can be very helpful

audio team notes

- Setups and sound checks
  - Multi-site sound checks can be very time consuming. Begin 2 hours prior to rehearsal.
  - Sound checking one day, and performing the next usually doesn't work
  - Making technical adjustments in mid-rehearsal should be avoided. Don't disrupt the artists.
  - Suggested sequence of events at each site
    - Create mix of local sources first
    - Adjust local monitors to as low a level as possible
    - Send that mix (or sub-mixes, or solo feeds) at full volume to far sites
    - Add sources from other sites to local mix
    - Keep local monitors to as low a level as possible

internet2 team notes

- Hardware Codecs
  - Commit to a specific brand of codec early
  - Most hardware codecs now work well
  - Open source codecs can work well, but also can require sophisticated installation
  - All audio and video mixing should be done outside of the codec by the other teams

internet2 team notes

- Interface Issues
  - Monitor the video and audio right at the codec
    - There will be disputes as to where problems are
    - Be able to pull the physical cable going to/from the Video or Audio Team and quickly verify the signal by plugging it into a video or audio monitor
    - This will quickly eliminate disputes
    - The alternative of using cable splitters may introduce impedance mismatch problems, so be careful
  - Where possible use DV or component (S-) video
  - Beware of using equipment with a mix of consumer (-10 dBV) and pro (+4dBu) audio levels

internet2 team notes

- Team management
  - Keep the number of people allowed to configure the codecs to a minimum
  - Have an explicit agreement between sites about remotely configuring codecs at far sites

internet2 team notes

- Troubleshooting
  - Do end-to-end tests as early in the project as possible.
  - Setting up an Internet2 performance event the first time may well uncover problems such as:
    - Substandard wiring
    - Intermittent hardware failures
    - Old firmware in need of updates
    - Router buffer sizes in need of adjustment
    - Low quality hubs
  - Allow for enough time to fix such problems

internet2 team notes

- More troubleshooting
  - Try to fully debug the network before scaling back on codec quality settings
  - If quality must be sacrificed reduce video, not audio, bandwidth
  - Unlocking video and audio sync can solve some problems with minimal impact on quality
  - Have a fallback plan with the Creative Team to eliminate and consolidate video and/or audio channels in case of failures on the day of the performance

documentation team notes

- The audio mixes for the house may not be what you need for post-production
- Optimally get individual tracks on multi-track deck
- Alternately get sub-mixes from house mixing board on multi-track deck
- Put tapes in any Video Team camcorders for extra footage
- But also use your own cameras because the video used for projection may not be useful in post-production

streaming team notes

- Get video feeds from the Video Team
- But also use your own cameras
- Get audio feeds from the Audio Team
- Create your own audio/video mix
- Don’t let the streaming server grab so much bandwidth that the performance of the Internet2 Team’s codecs are endangered!

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