



# Internet2 - More than a network

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QuestNet 2005

## Overview



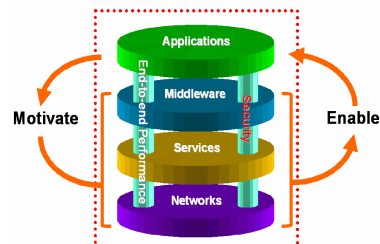
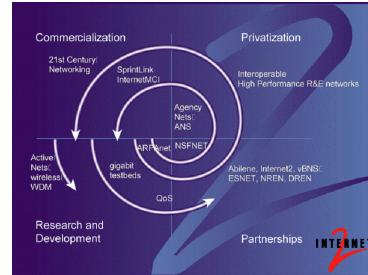
- About Internet2 15 min
- Using the Network 10 min
- The Evolving Network 15 min

Total ~40 minutes

## About Internet2 Introduction



- Internet2 is more than a network. We are a collection of people, technologies, capabilities and most importantly projects that use the network.
- Our mission is to develop and deploy advanced network applications and technologies, accelerating the creation of tomorrow's Internet
- We are advancing research by supporting researchers who are:
  - Using the network
  - Researching networking



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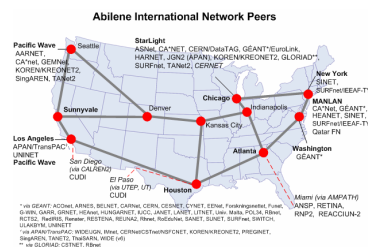
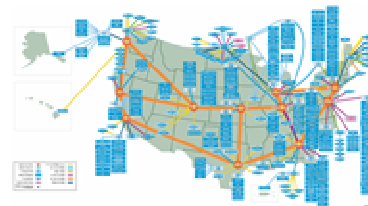
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## About Internet2 Internet2- the Community



- Participating institutions include:
  - 206 University members
  - 12 Corporate partners
  - 13 Corporate sponsors
  - 43 Corporate members
  - 45 Affiliates
- International peering agreements
  - e.g., 2x10 Gbps Australia connection
- If you are collaborating with an academic researcher, they are probably at a member institution.



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- Community outreach and support
  - Member Meetings, focused workshops (e.g. IPv6 deployment, Advanced Middleware)
  - Working groups/SIGs/BOFs (e.g., physics, digital video)
- Deployed services and technologies
  - The Internet2 Commons, Shibboleth, Detective
- Abilene and future network technologies
  - Abilene
  - HOPI, NLR, FiberCo

- Advanced Networking Goals
  - Provide high-performance, cost-effective network infrastructure for the U.S. research universities and the affiliated community
  - Advance the state of network capabilities - architecture, end-to-end performance, and innovative services
  - Contribute to the concurrent evolution of advanced regional and campus networking
  - Facilitate network research through infrastructure access and collaborations with computer science faculty
  - Support national and international R&E collaboration

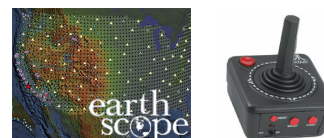
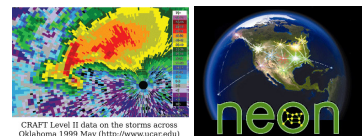
## But what does/can it do...

- Advanced networks are often known and trumpeted for their bandwidth alone.
  - The Internet2 Land Speed Record 46,156 terabit-meters per second
- However, we are more than “fat pipes”
  - Multicast, IPv6, Jumbo Frames, QOS/Scavenger service, access to core router data (e.g., cflowd)
- *These capabilities exist to support research and researchers*

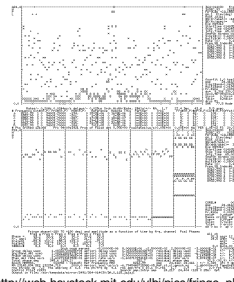
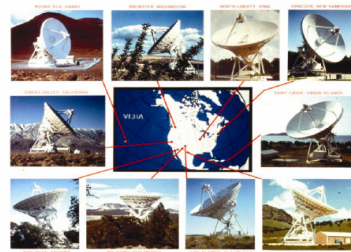


## Community Activities

- Progress is driven by those who see ways in which advanced networking technologies can benefit their research communities
- These applications require a variety of foundational tools and technologies in order to successfully leverage the network
- The degree to which advanced networking is integrated into the process of research and education is proportional to the amount of time a community has invested



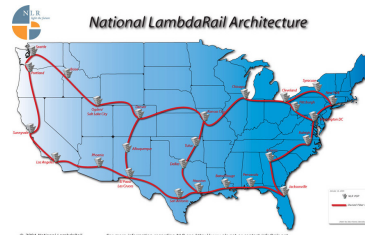
- e-VLBI: Electronic Very Long Baseline Interferometry (radio astronomy)
- Astronomers collect data about a star from many different earth based antennae and send the data to a specialized computer for analysis on a 24x7 basis.
- VLBI is not as concerned with data loss as they are with long term stability.
- The end goal is to send data at 1Gb/s from over 20 antennae that are located around the globe.



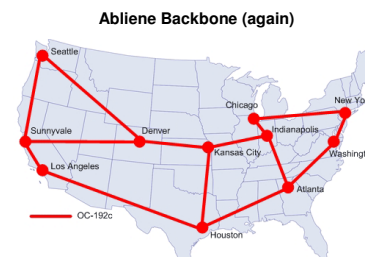
[http://web.haystack.mit.edu/vlbi/pics/fringe\\_plot.gif](http://web.haystack.mit.edu/vlbi/pics/fringe_plot.gif)

- NoNet -> ARPAnet -> Internet -> ...
- Kbps -> Mbps -> Gbps -> ...
- Circuits -> Switched -> Packets -> Virtual Circuits -> ...
- Copper/Electronics -> Fiber/Optronics -> Hybrids -> ...
- Text -> Image -> Audio -> Video -> ...
- Asynchronous -> Synchronous -> Real time
- Change continues, with current efforts focusing on fiber paths and optronics.

- Timing
  - Existing fiber was available for purchase
  - Competing technologies were emerging
- NLR was created to provide participants with Layer 1 access to network services.
  - Ownership and operational control of the infrastructure
- Membership consists of consortiums, many of whom are also members of Internet2
- Internet2 is also a (2x) member



- Many network users and institutions saw duplication, redundancy and finite resources.
- Internet2 and NLR commissioned two reports
- “Group A” focused on identifying the services and technical requirements necessary for a national, R&E network
- “Group B” took as input the Group A report and focused on how the two groups would best provide requirements and facilities through the future



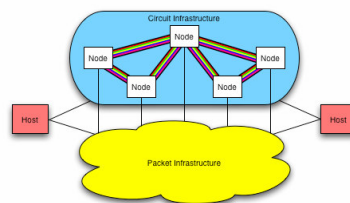
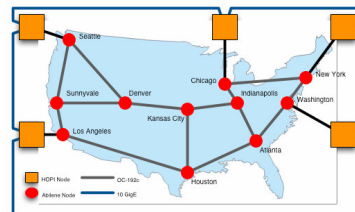


- The result of the Group B report is a recommendation to the NLR Board and the Internet2 Network Planning and Policy Advisory Council (NPPAC)
  - “The goal... must be a single national entity responsible for the collective high-performance production networking and experimental networking needs of Higher education and the larger research community”
- From Van Houweling’s letter:
  - ...advanced networking has become fundamental to the work of research and education, and that maintaining a solid foundation for its continued progress is vital to our shared community... [W]e can best secure that foundation by bringing our organizations together, and are hopeful we can do so quickly. We will be working diligently over the next few months... to develop a plan...

- Currently, only a recommendation to the respective organizations exist
  - A variety of laws restrict the types of discussions and planning that can occur between the two organizations
- Both the Group A and Group B reports identified a variety of challenges and opportunities, not limited to:
  - Governance
  - Finances
  - Membership

- Internet2 and NLR provide interesting new opportunities and approaches
  - HOPI
  - BRUW
- This is important in light of a new community of users who can saturate the network
  - HENP, e-VLBI

- Hybrid Optical Packet Infrastructure
- In the near future we will see a richer set of capabilities available to network designers and end users. Fundamentally: how will the core Internet architecture evolve?
  - Core IP packet switched networks
  - A set of optically switched waves available for dynamic provisioning
- Immediate goals include implementing test bed (this year) and coordinate experiments with other similar projects



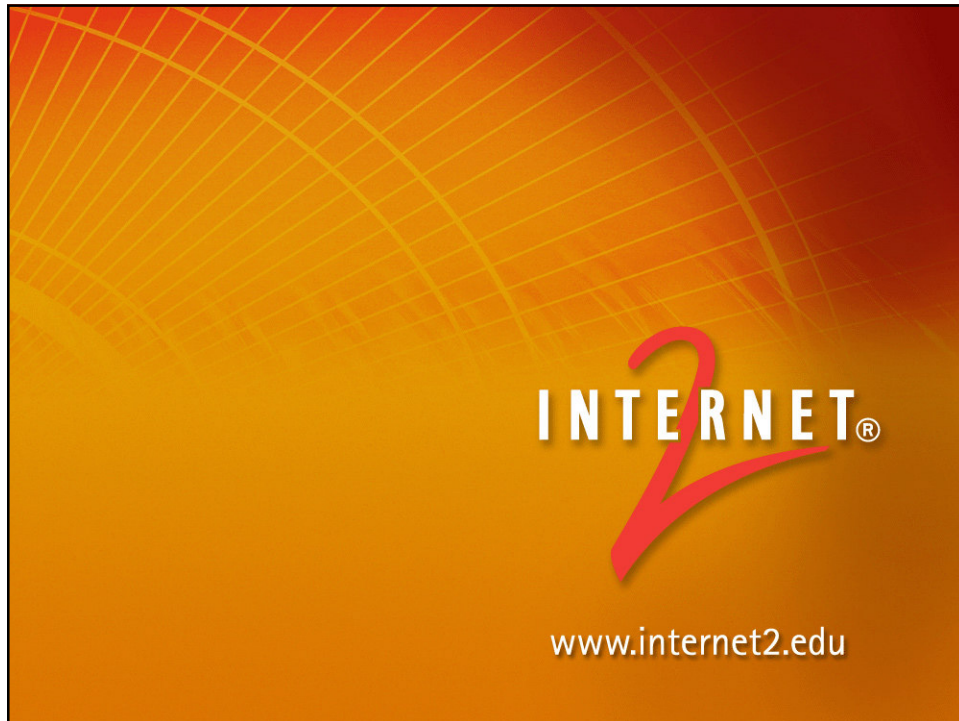


- Bandwidth Reservation for User Work
- Allow **authorized users** to **reserve bandwidth** across the Abilene backbone that is necessary to support advanced applications
- Positioning ourselves for cross-domain service taking advantage of the cross-domain authentication and authorization services provide by Shibboleth.
- More info at:  
[people.internet2.edu/~bdr/bruw/](http://people.internet2.edu/~bdr/bruw/)

## Contact Info, Q&A

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## Hidden slides

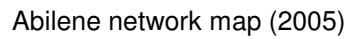


- The following slides are links:
  - Larger images of the maps used in the presentation
  - Additional applications and communities who use advanced networking

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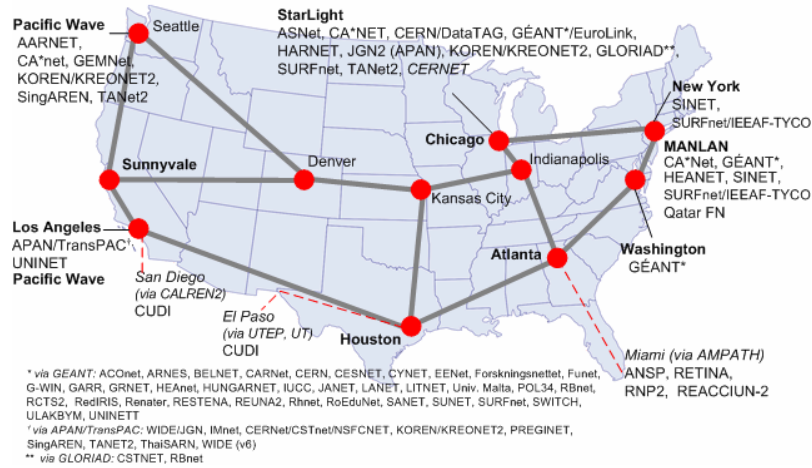
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A human readable list is available at <http://members.internet2.edu/>

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## Abilene International Network Peers



A human readable list is available at <http://international.internet2.edu/>

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## National LambdaRail Architecture

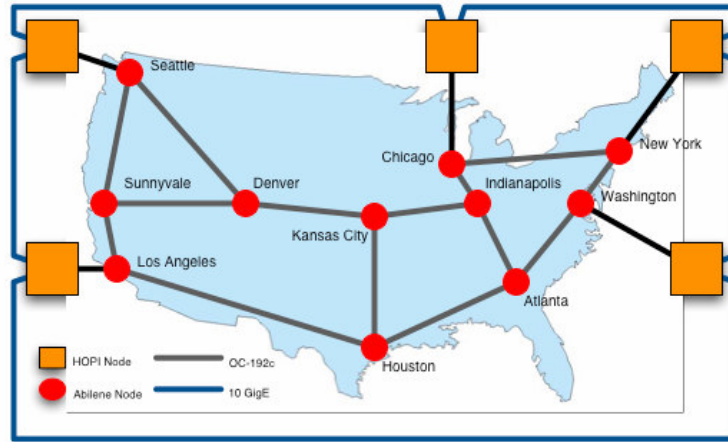


For more information regarding NLR see <http://www.nlr.net> or contact [info@nlr.net](mailto:info@nlr.net)

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# Full size images HOPI Topology

INTERNET<sup>2</sup>



<http://networks.internet2.edu/hopi/>

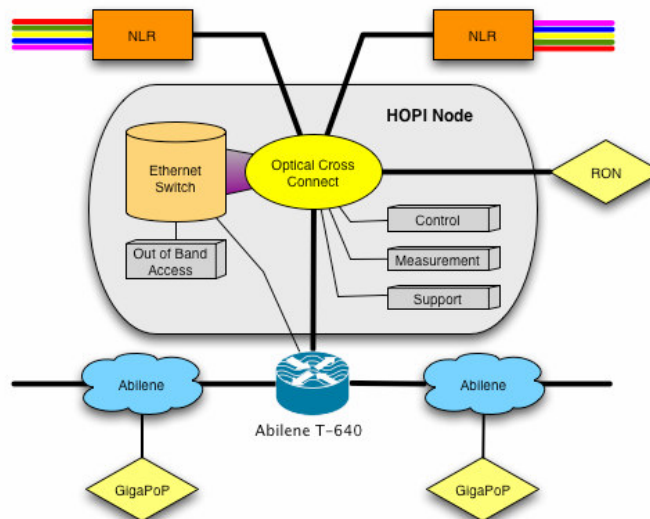
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# Full size images HOPI Node

INTERNET<sup>2</sup>



<http://networks.internet2.edu/hopi/>

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- High Energy and Nuclear Physics
- Physics has traditionally been one of the “power users” of all networks
- Physicists are generating Terabytes of data (1,000,000,000,000 or  $1 \times 10^{12}$ ) per experiment from the CERN lab in Switzerland
- Types of network usage:
  - Bulk data transfers that are extremely sensitive to data loss.
  - VRVS expects multicast and low-latency/jitter networks for effective video conferencing



<http://doc.cern.ch/archive/electronic/cern/others/PHO/photo-si/9105065.jpeg>

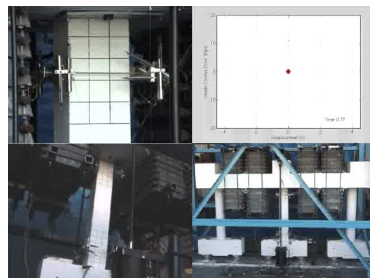


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- Earthquake research using real buildings and computer simulations
- Remote control of physical experiments requires extremely reliable and consistent network characteristics
- Video will be crucial: both for conferencing and data collection
- Requires ability to synchronize and time-stamp multiple data sources from different locations



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## Conducting Conservatory

- Michael Tilson Thomas
  - Music Director of the San Francisco Symphony, Artistic Director of the New World Symphony, Principal Guest Conductor of the London Symphony Orchestra
- A collaboration with:
  - New World Symphony
  - Columbia University
  - Manhattan School of Music



### Showcases:

- Distance Teaching and Learning
- Video (and audio) as data
- Extending the reach of resources

## Live Performance Events

- The Arts and Networking manifest themselves quite differently than in the traditional sciences. Networking emerges as a technology in support or in supplemental to the event.
  - Live performance events
  - Collaborative meetings
  - Mixing media (dance, network, video) and artists (dancers, engineers, programmers, choreographers)



## “Wired” EMS Vehicles



- Using high quality video and physiological telemetry
  - Creating adequate level of situational awareness
  - Physicians tele-mentor emergency medical personnel onboard the ambulance
- Transit time is no longer wasted
  - Sensors transmit information back to central base
- Combining multiple technologies: Advanced Networking (at base stations), Mobile WiFi (802.11a/b/g, military radio-data, etc.)



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## Remote Electron Microscope



- Provide wider access to limited resource
  - Multiple locations can leverage investment in hardware
- Improves teaching and learning
  - Provide access to tools that are prohibitively expensive, fragile, etc. for general use through safeguards in the interface
- Create a dynamic resource
  - Share equipment
  - Dynamically analyze data with remote collaborators



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- 
- Internet2 Detective**
- File View Help
- Abilene Access: Yes**
- 3 Mbps - MPEG1 Test
- Speed: 3.1 Mbits per second as of 7/25/2002, 3:16:02 PM.
- Multicast Capable: No** Test
- No MCast Test has been run yet.
- 11:12 AM

- 2005 July