The HOPI Testbed

Rick Summerhill

Director, Network Research, Architecture, and Technologies, Internet2

Jet Optical Meeting

Arlington, VA

21 April 2005

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 scienc e faculty
- Support national and international R&E collaboration

Abilene Network Futures

- October 2007 - End of recent 1-year Abilene transport MoU extension
  - Sets 3rd-generation network planning timeline
    - Architecture definition: 1/1/2006
    - Transport selection: 4/1/2006
    - Equipment selection: 7/1/2006
    - Backbone deployed: 1/1/2007
    - Connector transition: 2007
  - Concurrently, review overall business plan and management model
  - Network design time frame: 2007-2012
- Note that ESnet transport agreement with Qwest Federal is on similar time line - December 2007
- HOPI testbed is expected to be in place for 3 years, to experiment with future protocols
  - Refine and evolve next generation architecture

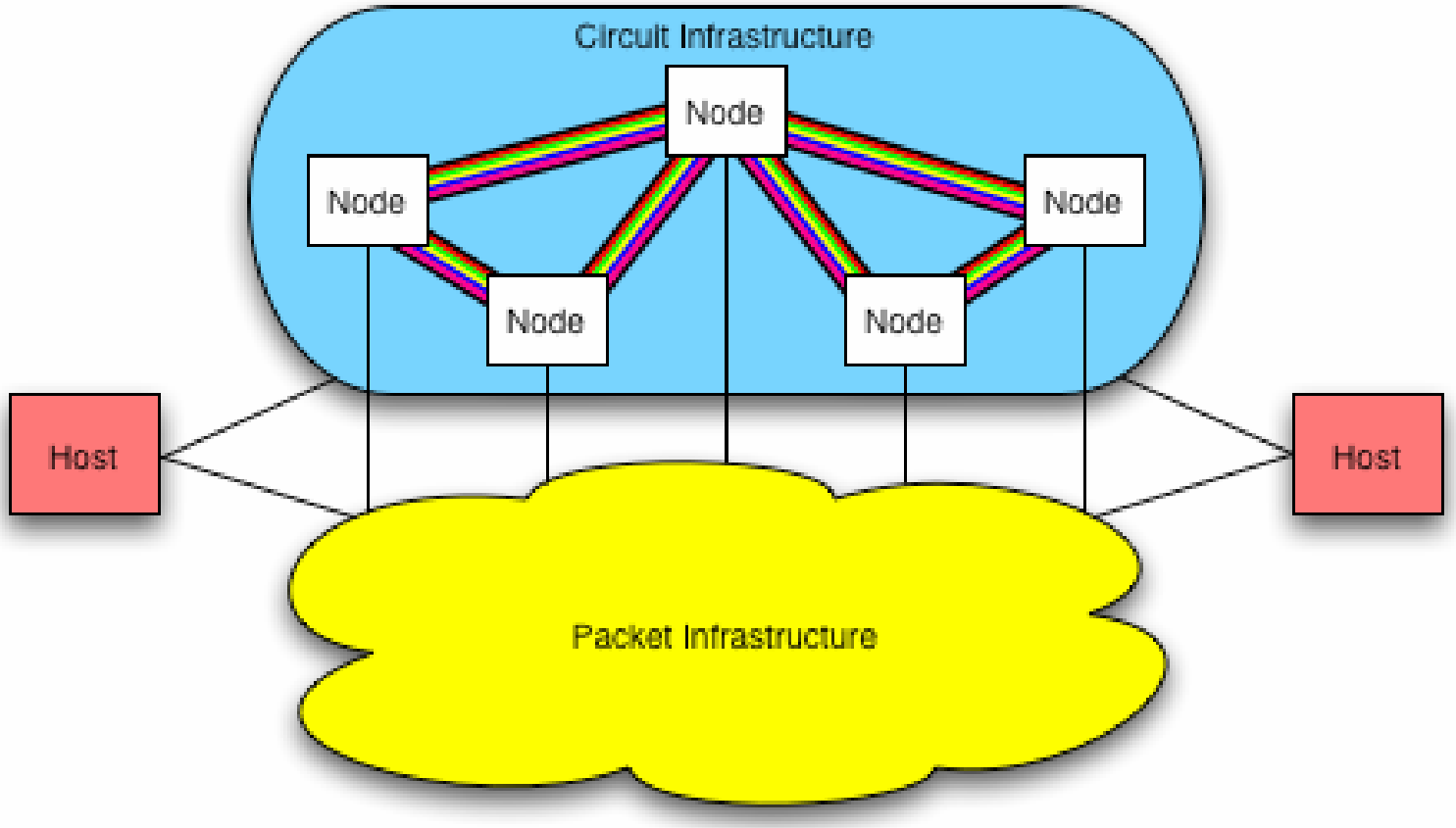
Next Generation Network Design

- Critical Factors
  - RON, Federal, and International integration
  - Advanced service support - v6, multicast, high performance throughput, measurement
  - Enhanced network research facilitation
  - Network and end-user security
  - Options for increased reliability
- Process
  - HOPI - Hybrid architecture evaluation
    - IP core using 40(?)/10 Gbps transport
    - Dedicated capabilities
  - Evaluation of optical transport capabilities
    - NLR, commercial providers, and RONs
  - Design and planning collaboration
    - U.S. and International partners

HOPI Project - Summary

- In the near future we will see a richer set of capabilities available to network designers and end users
  - Core IP packet switched networks
  - A set of optically switched waves available for dynamic provisioning
- Fundamental Question: How will the core Internet architecture evolve?
- Examine a **hybrid** of shared IP packet switching and dynamically provisioned optical lambdas
- HOPI Project – Hybrid Optical and Packet Infrastructure
  - See http://networks.internet2.edu/hopi/ for documentation.
  - Immediate Goals
    - Implement testbed over the next year
    - Coordinate and experiment with other similar projects

HOPI General Problem



HOPI General Problem

- How would one create a hybrid from these two infrastructures. The Nodes do switching and the links are point-to-point circuit like paths. Each link may have attributes – for example, bandwidth. Attributes may determine the ability to concatenate links. Examples include
  - Nodes are lambda switches with waves forming circuits – attributes include colors and bandwidth, etc.
  - Nodes are SONET switches with paths being SONET links – attributes include channels, etc. For example, OC-3, OC-12, etc.
  - Nodes are Ethernet switches with paths being point-to-point VLANS – attributes include bandwidth, etc.
    - HOPI will use this environment to examine different architectures
  - Nodes are routers on a packet infrastructure and the point-to-point paths are MPLS L2VPNs

HOPI Questions

- Examine how to build an architecture
  - A lot is known about how to do various pieces
  - The main question is how would one put it all together into a network
- Problems to understand
  - When does a host use the circuit switched infrastructure and when does it use the packet infrastructure?
  - Temporal degree of dynamic provisioning
  - Temporal duration of dynamic paths and requirement for scheduling
  - Topological extent of deterministic provisioning
  - Examine backbone, RON, campus hierarchy – how will a RON interface with the core network?
  - Understand connectivity to other infrastructures – for example, international or federal networks?
  - Network operations, management, measurement, and control plane across administrative domains?

HOPI Advisory and Management Groups

- HOPI Design Team
  - Engineers, managers and designers long associated with Internet2
  - Have designed HOPI testbed and created a HOPI whitepaper
- HOPI Corporate Advisory Team
  - Bring the considerable mindshare from the corporate community into the project.
  - HOPI CAT is open to all Internet2 Corporate Members
- HOPI Research Advisory Panel
  - To be announced in near future
  - Bring research expertise to the project

HOPI Management

- Focus Groups
  - Applications
    - Focus on several applications
  - Demos
    - iGrid and SC2005
  - Control Plane
  - Measurement
  - Security
- HOPI Testbed Support Center
  - Soon to be chosen
  - Advanced engineering and design focus
    - Implement control plane activities
    - Manage and engineer the facility

HOPI Project Design Team

- Linda Winkler, Argonne (CoChair)
- Rick Summerhill, Internet2 (CoChair)
- Cees de Laat, U of Amsterdam
- Rene Hatem, CANARIE
- Mark Johnson, MCNC
- Tom Lehman, USC/ISI
- Peter O'Neil, NCAR
- Bill Owens, NYSERnet
- Philip Papadopoulos, UCSD
- Sylvain Ravot, Caltech/CERN
- David Richardson, U Washington
- Chris Robb, Indiana U
- Jerry Sobieski, U Maryland
- Steven Wallace, Indiana U
- Bill Wing, Oak Ridge
- Internet2 Staff – Guy Almes, Heather Boyles, Steve Corbato, Chris Heermann, Christian Todorov, Matt Zekauskas

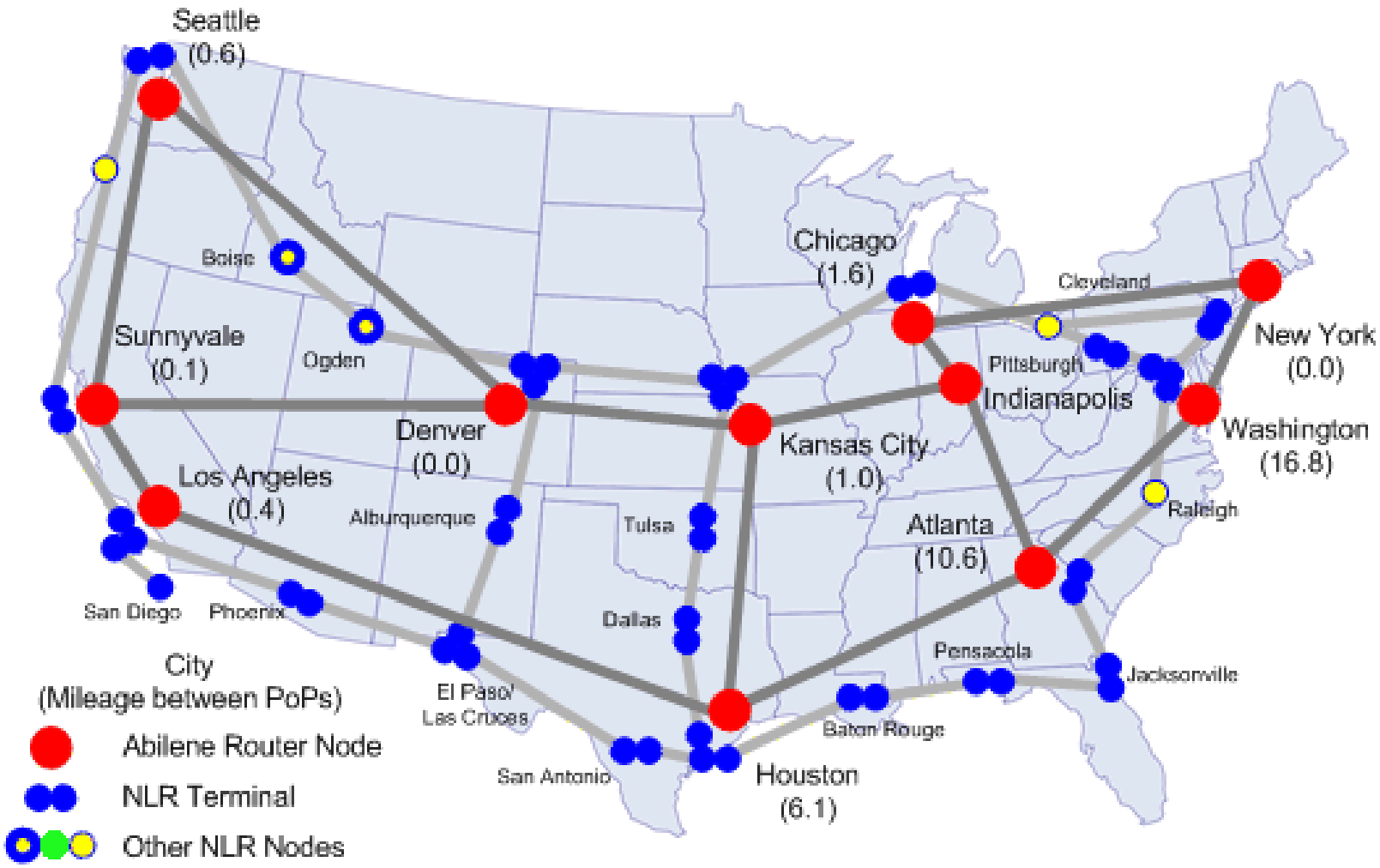
HOPI CAT

- Peter Ashwood-Smith, Nortel Networks
- Scott Beaudoin, Wiltel Communications
- Javad Boroumond, Cisco Systems
- Dennis Gallant, Meriton Networks
- Waqar Khan, Qwest Communications
- Drew Perkins, Infinera
- Marty Schulman, Juniper Networks
- Raju Shah, Force10
- Madan Shastri, Global Crossing
- Richard Solis, Movaz Networks
- Jeff Verrant, Ciena
- Abdul Kasim, ADVA

HOPI Testbed Resources

- The Abilene Network – MPLS tunnels and the packet switched network
- The Internet2 Wave on the NLR footprint
- MAN LAN Exchange Facility
  - TYCO/IEEAF 10 Gbps lambda NYC – Amsterdam
  - Nortel and Cisco optical and Ethernet equipment
- Collaborations with Regional Optical Networks (RONs) and other related efforts (GLIF, DRAGON, etc.)
- A 10 Gbps circuit between NYC and London
  - Provides experimental capabilities between Internet2 and GEANT
- Other facilities as they become available

Abilene/NLR Map



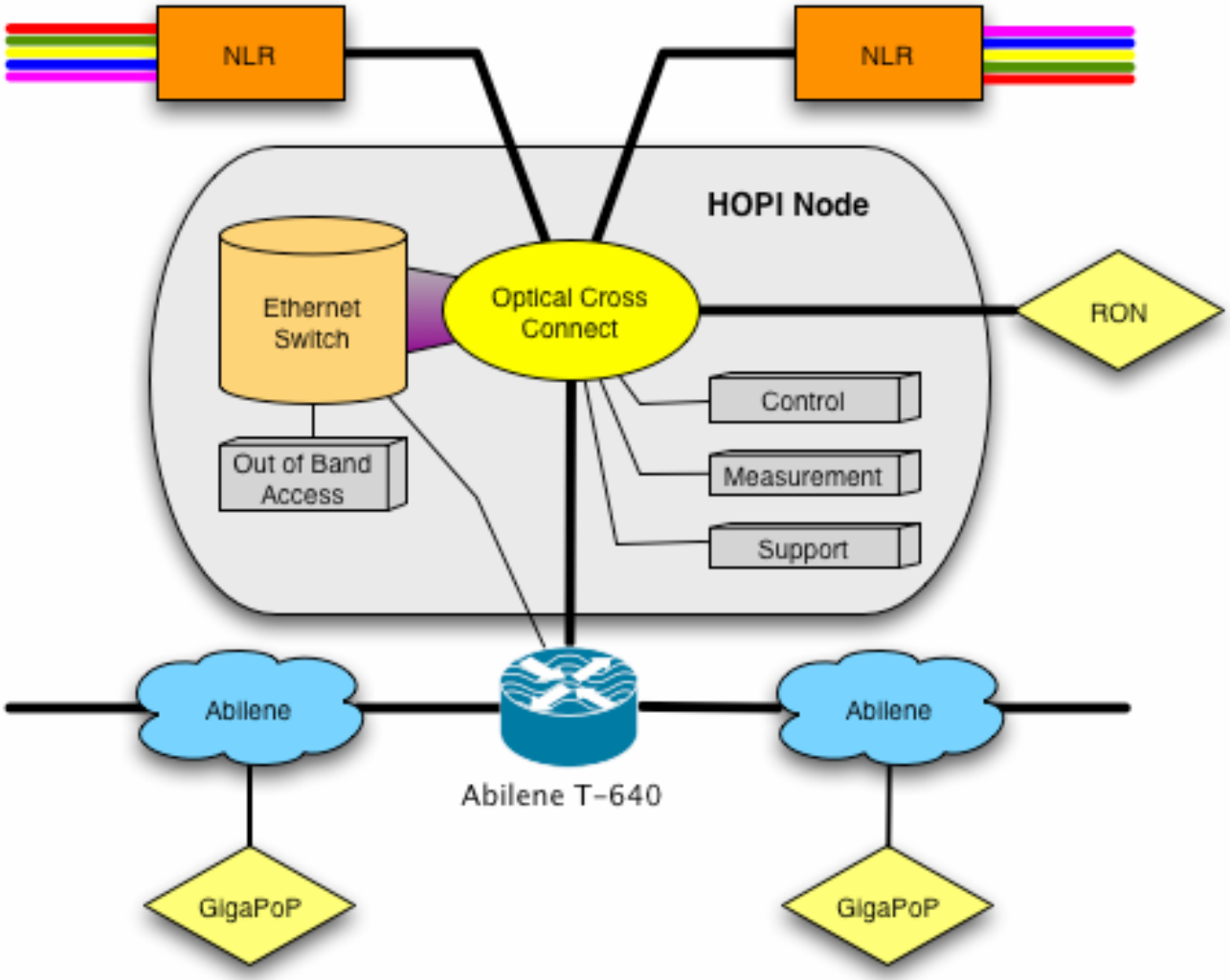
HOPI Participation

- Plan to create an open testbed for experimenting with new ideas
  - Start with Optical and Ethernet Devices in an initial configuration
  - Corporate community can locate additional devices to experiment with basic ideas and further the goals of the project
  - Will put out a call for participation in the near future
- Force10 and HP have provide substantial support for the project

HOPI Node

- A fiber cross-connect switch (a white light switch)
  - Ability to switch the entire NLR wave to Abilene, to a RON, or to pass through the wave
  - Two Glimmerglass switches being installed
- An Ethernet switch device to partition the wave into 1 GigE or to use the entire wave
  - Force10 Ethernet switches deployed
- Control devices
  - Ad hoc control plane computer
  - Measurement computer
  - Experimental computer
- Control and data planes are disjoint
- Out of band access

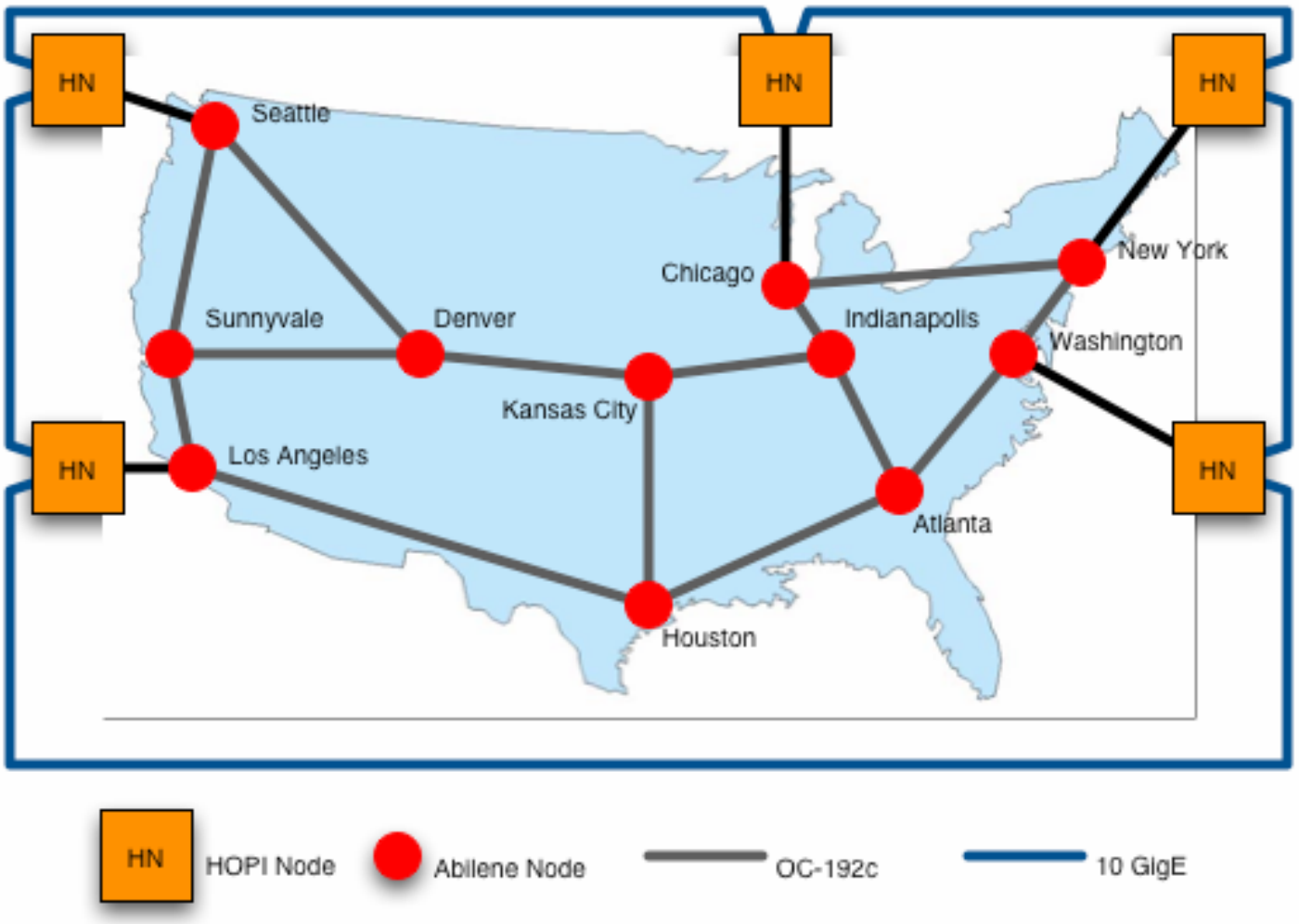
HOPI Node


NLR
NLR
HOPI Node
Ethernet Switch
Optical Cross Connect
RON
Control
Measurement
Support
Out of Band Access
Abilene
Abilene
Abilene T-640
GigaPoP
GigaPoP

HOPI Deployment

- Node locations
  - Los Angeles Equinix Facility – Support for CalTech and the HENP connection - end of April, 2005
  - Washington, DC MAX/Dragon facility - end of April, 2005
  - StarLight in Chicago - end of May, 2005
  - The Pacific Northwest GigaPoP in Seattle - end of June, 2005
  - New York City – NYSERNet area in 32 AoA (Same location as MAN LAN, same building as Abilene Node) - end of September, 2005
    - Many thanks to NYSERNet for donating rack space and power to support the HOPI project
- Circuit from NYC to London
  - End of July, 2005

HOPI Topology



Control Plane

- Phase 1 – Manual Configuration
  - Ad hoc control of devices that don't support control plane protocols
  - Understand control plane ideas
- Phase 2 – Intra-domain Configuration
  - Automate software control of setup – UCLP ideas
  - Investigate temporal and topological extent of paths
- Phase 3 – Inter-domain Configuration
  - Examination of protocols such as GMPLS
  - Extensions to standards based protocols

Experiments

- Planned Experiments – 15 to 20 initial experiments
  - Dynamic Provisioning
  - Deterministic Paths
  - Applications Based
  - Miscellaneous
- Encourage use by the community for experimentation – both operational and research communities
- Can start in near future by using MPLS tunnels from Abilene

HOPI Basic Service

- Given the available resources, we cannot use multiple waves to study new architectures – have only a single wave
- Instead we'll model waves using lower bandwidth "deterministic" paths – paths that resemble circuits – "lightpaths"
- Basic service – A 1 or 10 GigE unidirectional point-to-point path with reasonable jitter, latency, and loss characteristics (that is, a lightpath).
- Access – Direct to HOPI node or an MPLS L2VPN tunnel through Abilene

Connector Interface

- A 1 or 10 GigE connection to the fiber cross connect, either dark fiber or a provisioned service
- An MPLS L2VPN service through Abilene to the Ethernet switch
  - Provides immediate connection to the Internet2 NLR wave from Abilene

Question

- Isn't this just an Ethernet testbed? Are we simply creating an Ethernet network?
- No really, although Ethernet comes into play. Two features distinguish the testbed from an Ethernet network, however:
  - Dynamic provisioning aspect of the project
  - The hybrid nature of the project

References

- Request for Comment – We would like your feedback on the HOPI testbed
  - hopi@internet2.edu
- More Information
  - http://abilene.internet2.edu
  - http://www.nationallambdarail.org
  - http://hopi.internet2.edu
  - abilene@internet2.edu


INTERNET®
www.internet2.edu