

HOPI Network Update

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Layer1 v. Layer3

- In the US, much effort is being devoted to National Lambda Rail (NLR)
 - regional networks creating optical infrastructures to interconnect with NLR
 - provides dedicated bandwidth for high performance users
- Still much interest in Layer3 routed networks
 - optical networking is expensive
 - lambdas address the needs of a few high-resource users
 - layer1 is not as well-understood
 - lambdas are difficult to monitor
 - interoperability requirements of optical vendors is sometimes challenging
- Some networks want access to both Layer1 and Layer3 services

HOPI Solution

- The HOPI project will attempt to provide both routed and circuit-based functionality
 - Over the next year, the HOPI Design Team will test and evaluate vendor equipment in an effort to define the capabilities and implications of a hybrid network
 - The initial focus will be on “lightpath” creation
- In 2005, a HOPI testbed will be created to answer some core questions
 - What defines a deterministic path through a layer3 network?
 - latency and jitter guarantees? bandwidth protection?
 - What does the network need to do to provide a lightpath?
 - MPLS and QoS and STS/STM and ???
 - What flavor of MPLS? (L2VPN or L3VPN or stitched LSPs?)
 - How dynamic do lightpaths need to be?
 - How will the lightpaths be created?
 - GMPLS? UCLP? Human?
 - How will lightpaths cross administrative boundaries?

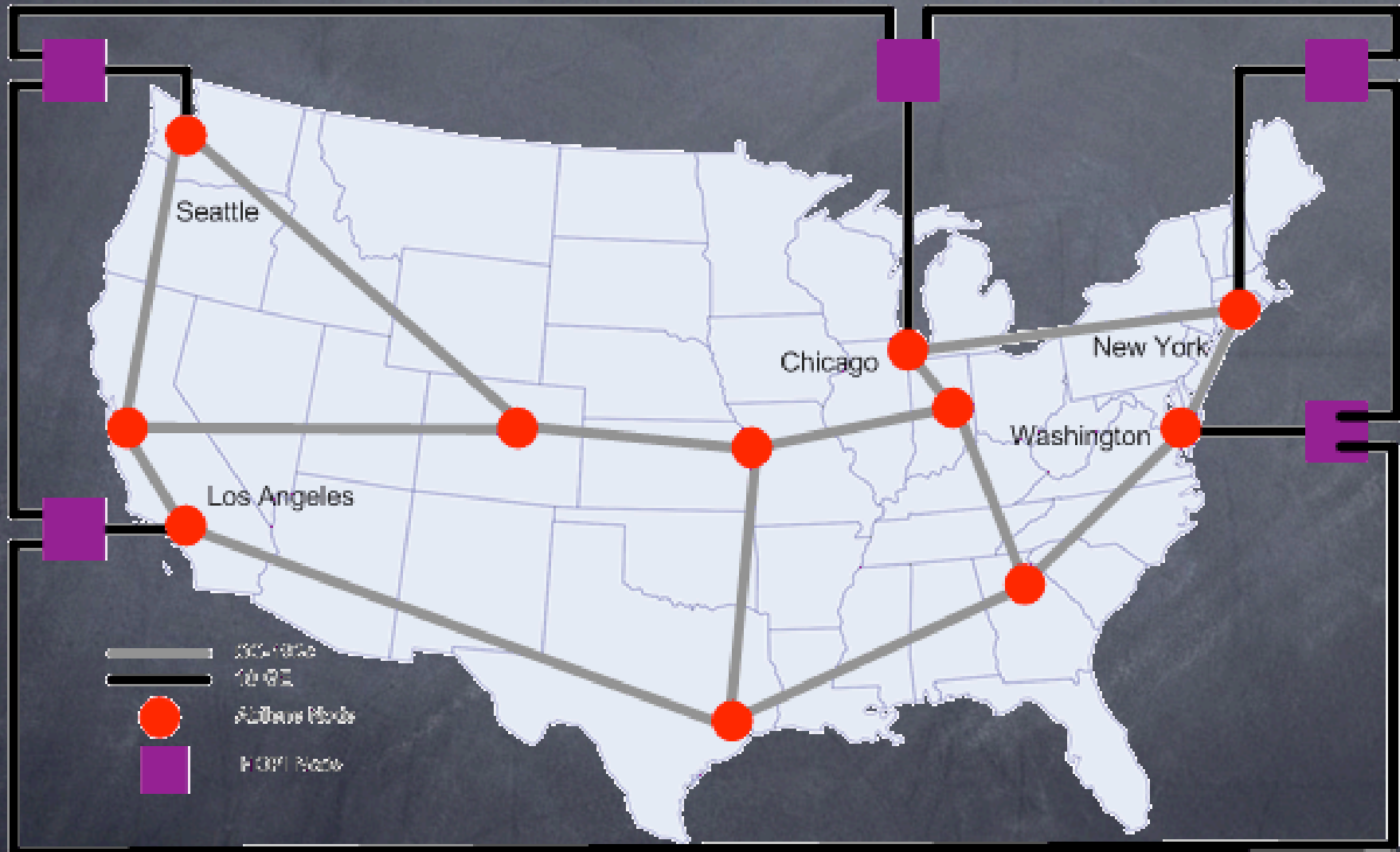
HOPI Resources

- Internet2 Abilene Network
 - provides layer3 components
- NLR 10G lambda
 - Internet2 has purchased a 10GigE lambda on the entire NLR footprint
 - Northern portion of NLR has been installed with the HOPI transponders in place
 - Southern portion to be installed in 2005
 - Discussion of replacing 10GigE with OC-192 on all or part of the NLR network
 - If the southern portion of NLR is OC-192, it will allow for greater testbed flexibility
 - Lambda resource pool is expected to increase as HOPI expands into a production network
- Vendor support
 - Internet2 has been negotiating evaluation and donated equipment from different vendors
 - A HOPI Corporate Advisory Committee (HOPI-CAT) has been formed to solicit industry input

HOPI Testbed Topology

- While the final HOPI network is likely to have nodes in the same cities as the current Abilene network, the testbed will focus on five initial locations
 - Each of these locations has some layer1 or layer2 exchange points to interconnect with the testbed
 - Los Angeles - Pacific Wave
 - Seattle - Pacific Wave
 - Chicago - Starlight
 - New York - MANLAN
 - Washington, D.C. - NGIX-East and the DRAGON project
- HOPI Design Team is currently looking at each city to determine the best colocation facility for the HOPI node
 - option 1: near Abilene in Qwest space
 - option 2: near the layer1/layer2 exchange point
 - option 3: near NLR equipment in Level3 space

HOP1 Testbed Topology

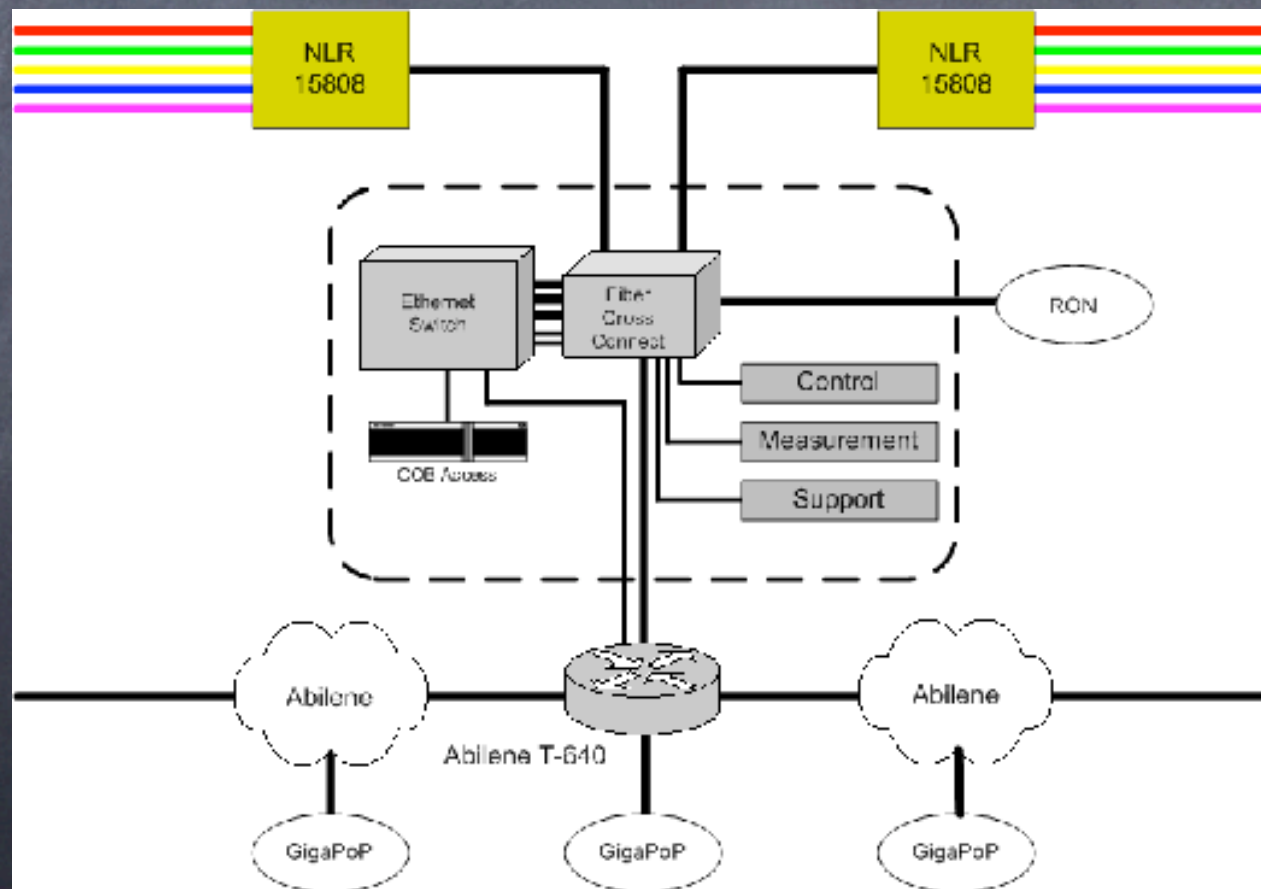


HOPI Node Topology

- Exact equipment topology not yet finalized
 - Since the initial five nodes are meant to be part of a test, there may be dissimilar sets of equipment in each location
- Initial plans call for some or all over the following types of equipment
 - remotely manageable fiber cross-connect device (MEMS switch?)
 - ethernet or TDM switch
 - this will largely depend on the framing of the NLR HOPI wave
 - measurement and control PCs
 - small out of band router and racklan switch
 - if Abilene is used for management channel, possibly a 1550/1310 optical splitter/combiner

HOPi Node Interconnects

- If a MEMS device is installed, all fiber connections will pass through it
 - allows engineers to change termination point of circuit without waiting for hands and eyes
 - NLR east and west lambdas will pass through device so that a node can be dynamically added or removed from the network



Connecting to HOPI

- Two immediate possibilities
 - via existing Abilene connection
 - via direct HOPI node connection
- During the testbed phase, we expect that the majority of connections will be made via Abilene's packet-based network
- As HOPI grows and becomes more production, US regional optical networks (RONs) and international networks will likely move connections to the HOPI node

Connecting via Abilene

- Abilene will maintain a 10GigE or OC-192 connection to the HOPI node via the fiber cross-connect device
- Abilene participants that don't have direct fiber connectivity to a HOPI node will be "piped" across Abilene to the closest HOPI node
 - What flavor of MPLS? GRE tunnels?
 - Creation of MPLS tunnels is currently done by hand, though Internet2 has developed an application that will provide some automation in this area
- Once the tunnel reaches the HOPI node, it will be "cross-connected" to the HOPI network
- The goal is to make the end to end path as seamless and deterministic as possible

Connecting Directly to HOPI

- Direct HOPI connects will land on the fiber cross connect device
 - The network will have access to lightpath "timeslots" on the TDM device
 - Alternatively, their entire lambda can be switched onto the HOPI NLR lambda, bypassing the HOPI equipment completely
 - This will become more practical when HOPI acquires more lambdas between node locations
- Many US RONS are already working on dark fiber contracts to NLR locations, so if HOPI is located closeby, the connection is much easier

International Connections

- Since international networks have more expensive connections to the US, the initial connections will likely be via Abilene
 - as trans-oceanic prices drop, it will be more practical for direct HOPI connections
 - additional challenge of obtaining clear-channel SONET service from carriers
 - 10GigE LANPHY connections aren't available
- Some initial work has been done to simulate the HOPI technologies
 - MPLS from Abilene Los Angeles to Abilene Chicago
 - TDM GigE from Canarie to MANLAN
 - TDM GigE from MANLAN to GEANT via SURFNET OC-192
 - IP with QoS across GEANT backbone to CERN
 - multiple technologies used to expose their difficulties and challenges

Abilene-CERN lightpath

Lessons Learned

• MPLS

- no way to guarantee bandwidth unless entire backbone is MPLS-based
- Juniper CCC has requirements on VLAN IDs at each end (>512)

• TDM

- international circuits are rarely configured to allow customers to dynamically reconfigure the STS partitioning

• IP with QoS

- service works OK on uncongested circuits, but needs to be tested when traffic loads are higher

• In general, when working with five different administrative entities, coordination is difficult and time consuming

- >250 e-mails to set up initial circuit!!

Current Status

- HOPI Design Team will meet in Houston at the end of February 2005
 - initial discussion of installation logistics
 - experiment definition
 - final topology definitions
- HOPI Support Center RFP
 - currently in draft form to be sent out shortly (this week?)
 - Two components
 - operational support
 - software development support

References

- HOPI Testbed Webpage: <http://networks.internet2.edu/hopi>
 - contains presentations, HOPI whitepaper, and Corporate Advisory Team information
- National Lambda Rail: <http://www.nlr.net>
- Abilene: <http://abilene.internet2.edu>