

Internet2 Network Futures

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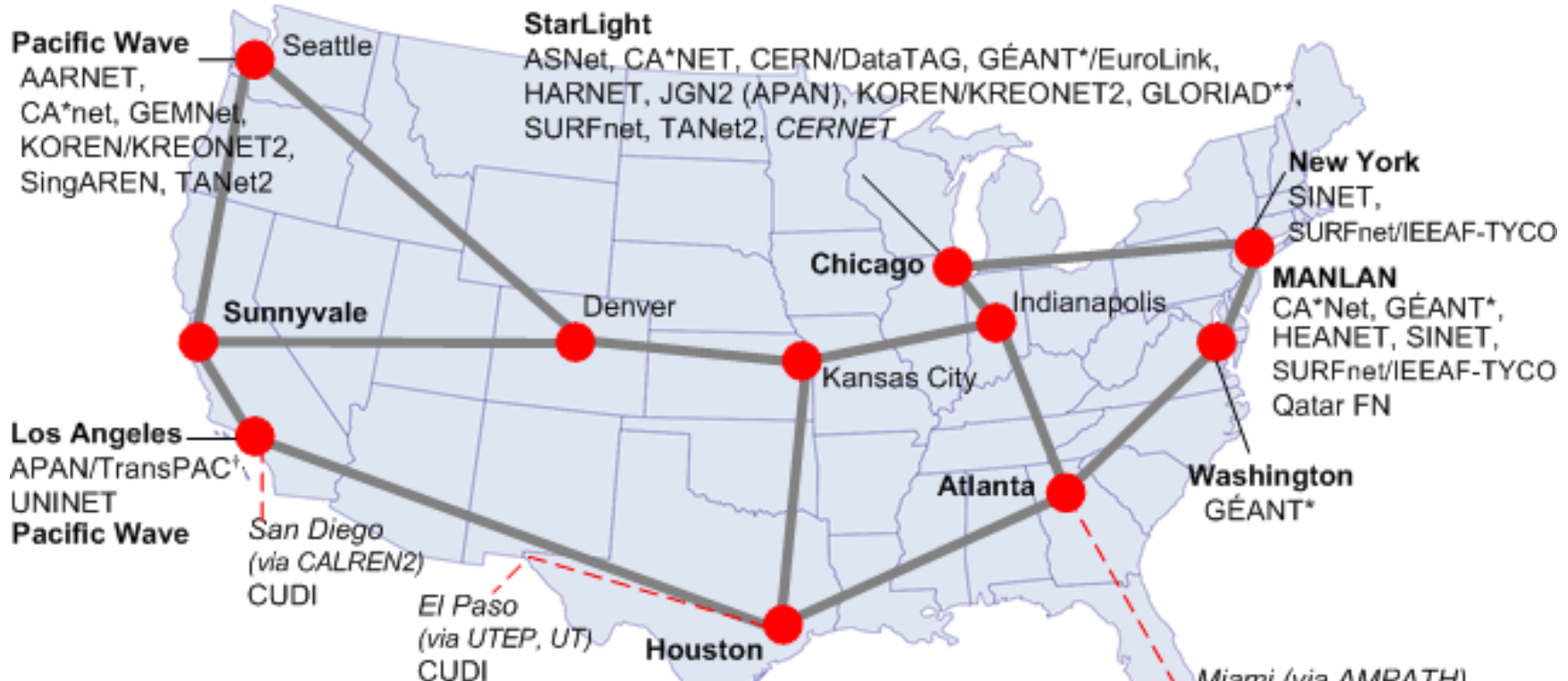
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Outline

- Abilene today
- Future network ideas
- National Lambda Rail
- The Hybrid Optical and Packet Infrastructure: HOPI
- Other activities I can't mention in detail

Abilene, with International Peers



* via GEANT: AConet, ARNES, BELNET, CARNet, CERN, CESNET, CYNET, EENet, Forskningsnett, Funet, G-WIN, GARR, GRNET, HEAnet, HUNGARNET, IUCC, JANET, LANET, LITNET, Univ. Malta, POL34, RBnet, RCTS2, RedIRIS, Renater, RESTENA, REUNA2, Rhnet, RoEduNet, SANET, SUNET, SURFnet, SWITCH, ULAKBYM, UNINETT

[†] via APAN/TransPAC: WIDE/JGN, IMnet, CERNet/CSTnet/NSFCNET, KOREN/KREONET2, PREGINET, SingAREN, TANET2, ThaiSARN, WIDE (v6)

** via GLORIAD: CSTNET, RBnet

Abilene Today

- 10-Gbps 'best effort', over-provisioned IP network
 - Current normal load < 2 Gbps
- Carrier provisioned backbone λ 's
- IPv4 and IPv6, native multicast, MPLS
- Research facilitation (data + collocation)
 - Abilene Observatory project
<http://abilene.internet2.edu/observatory/>
- Extensive domestic and international Research and Education (R&E) peering

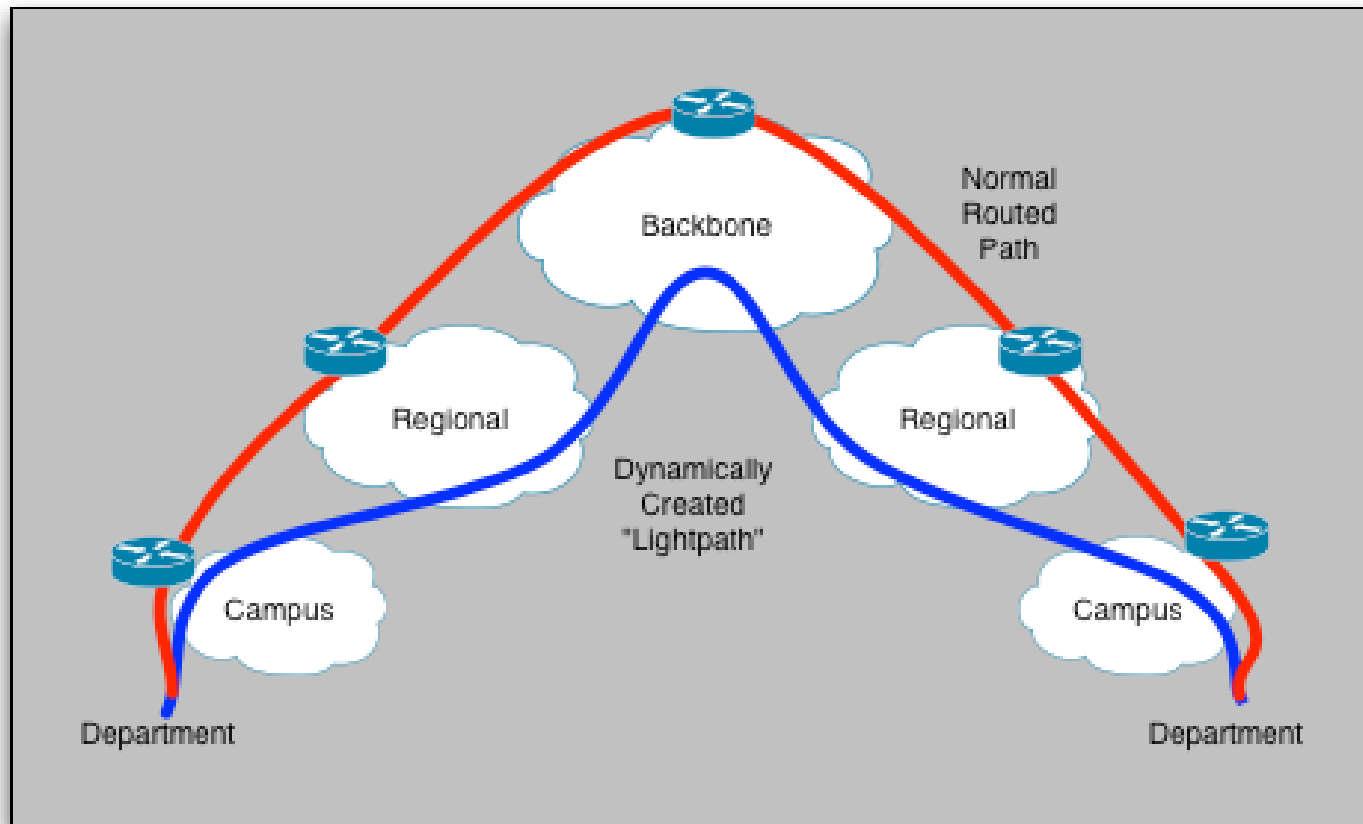
Next revision of Abilene

- October 2007 - End of current Abilene transport agreement (SONET links)
 - Replacement available by April 2007
 - Network design time frame: 2007-2012
- HOPI testbed is expected to be in place for 2-3 years, to experiment with future architectures and protocols
 - Use to refine and evolve next generation architecture

Basic Requirements

- Requirements multi-dimensional, for example:
 - Provide capabilities at all network layers (layer)
 - Provide capabilities for both short term and long term applications or projects (duration)
 - Provide capabilities at a variety of different levels of robustness, from production to experimental (robustness)
- An infrastructure consisting of dark fiber, a significant number of waves, and a production quality IP network
 - Create a new architecture for the R&E community
- New features: dynamic provisioning, hybrid models (combinations of circuit and packet switching)

Next Generation Overview



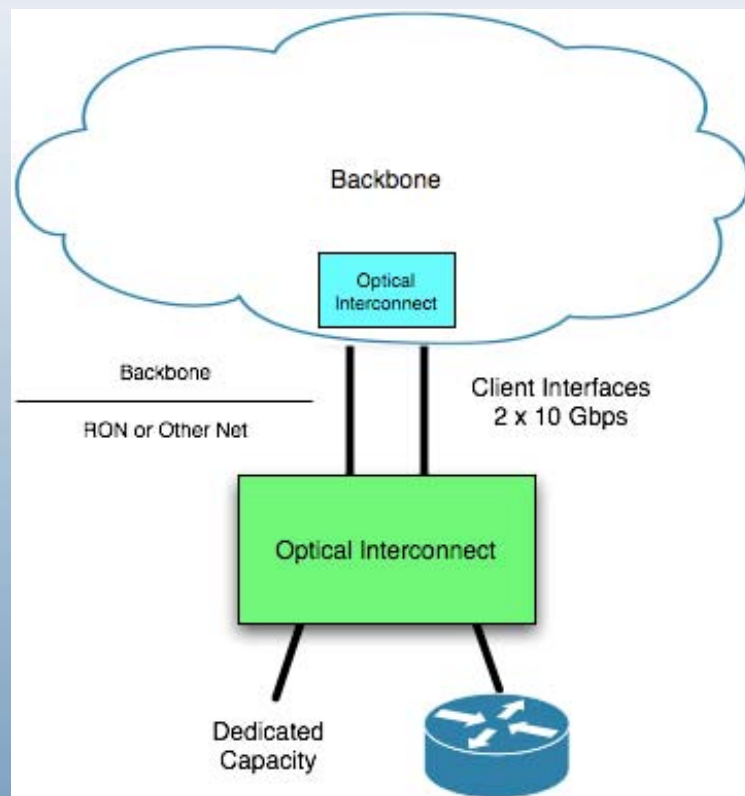
Next Generation Ingredients

- ITU grid waves, interconnecting nodes on a national fiber footprint
 - Numbering at least 10 to 40
 - Expect 10 Gbps initially, possibly 40 Gbps
- Optical interconnect device to provide
 - Switching; access to waves on network
 - Client interface to connecting network
 - Provide support for subchannels (VLANs, SONET paths, possibly using GFP/VCAT/LCAS)

Connector (RON) Interface

The interface to the backbone:

- Two or more client interfaces between optical interconnects (analogous to router-to-router connections today)
- Requirements:
 - Support connectivity to IP Network
 - Support multiple sub channels through backbone to other connectors up to capacity of interface
- Potential for arbitrarily framed (“alien”) waves in the future



Dynamic Provisioning

- Dynamic provisioning across administrative domains
 - Setup on the order of seconds to minutes
 - Durations on the order of hours
 - Eventually understand the need for more dynamic capabilities
 - Control plane development will be a key
- Switching may require unique partnerships and development of capabilities on hardware platforms
 - For example, being able to isolate user capabilities at switching nodes
 - There is interest from commercial carriers from the point of view of providing additional services
- All this should be transparent to the user
 - View as a single network
 - Hybrid aspects must be built into the architecture

A Few Words About NLR

- My personal, unofficial, view
- National LambdaRail (NLR) is a facility to provide dedicated capacity and experimental networks for research
 - WaveNet: Layer 1, “lambdas”
 - FrameNet: Layer 2, 1 Gig Ethernet services
 - PacketNet: Layer 3, IP services



— NLR-owned fiber

— Managed Wave

● NLR WaveNet, FrameNet and PacketNet PoP

● NLR WaveNet and FrameNet PoP

● NLR WaveNet Pop

□ PoP for primary connection point by a member (MetaPop)

◇ PoP needed for signal regeneration requirements, can also be used as secondary connection by a member

△ PoP established by NLR for members' regional needs

☆ Pop established at exchange points



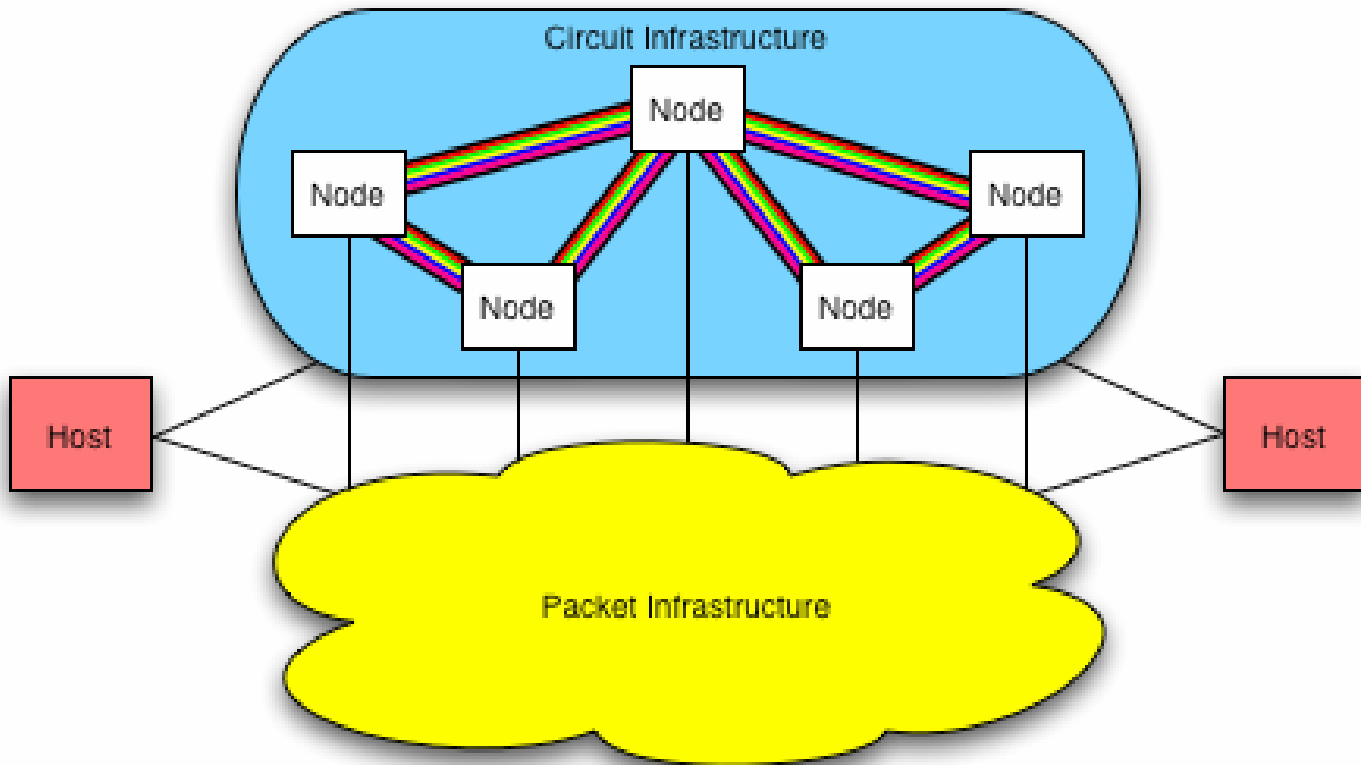
NLR and Internet2

- Internet2 is an NLR investor
- The NLR and Internet2 organizations have announced an intent to merge
 - Negotiations underway
- NLR facilities will likely be a part of what is used for next-generation Abilene
- HOPI uses NLR WaveNet

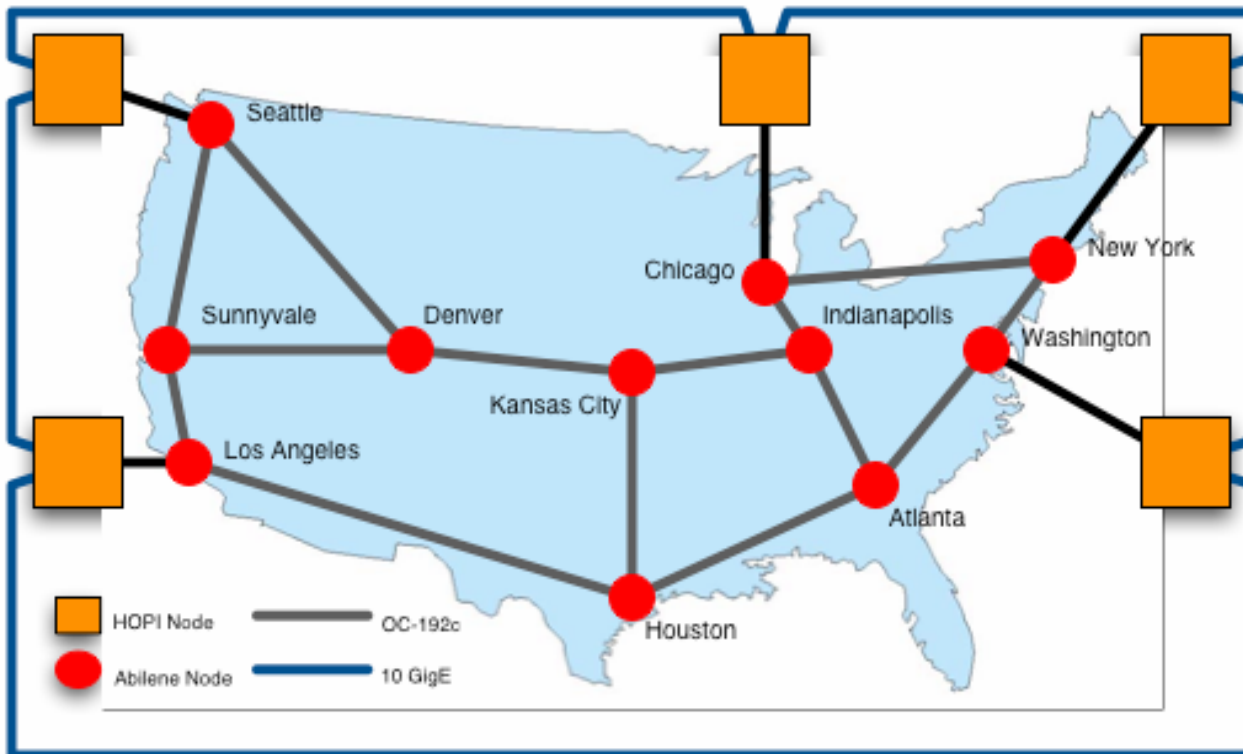
HOPI Project - Overview

- We expect to see a rich 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
- Examine a **hybrid** of shared IP packet switching and dynamically provisioned optical lambdas
- HOPI Project – Hybrid Optical and Packet Infrastructure - how does one put it all together?
 - Dynamic Provisioning - setup and teardown of optical paths
 - Hybrid Question - how do end hosts use the combined packet and circuit switched infrastructures?
 - HOPI is a testbed for experiments, not a production network
 - We will use some of the experiment results to guide the next generation of Abilene

HOPi General Problem



HOPi Topology



FORCE10

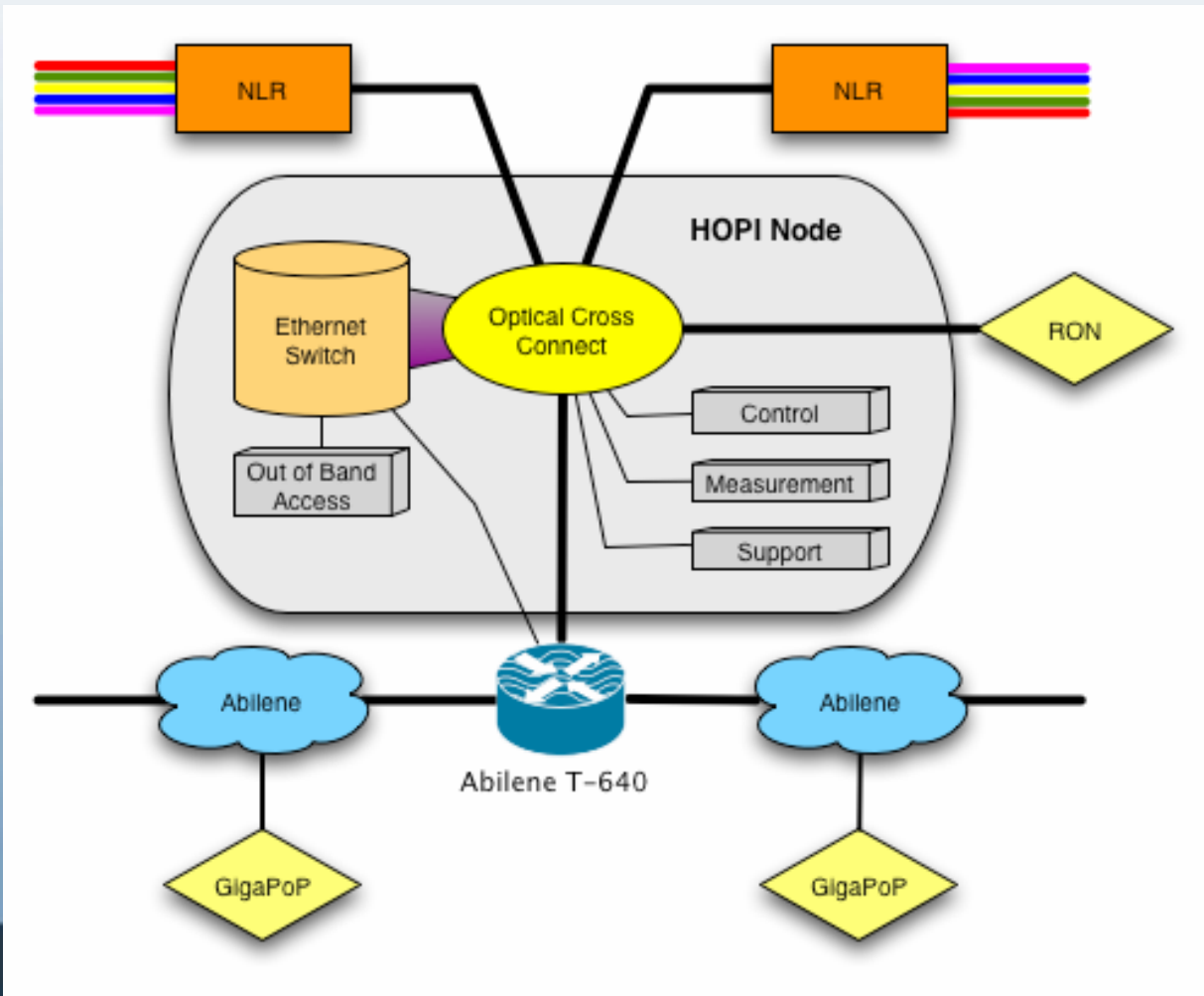


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HOPi Node



HOPPI Deployment

- Additional nodes possible as the southern route of NLR is installed - potentially Houston
- Connections to other US testbeds:
 - UltraLight (High-energy Physics)
 - UltraScienceNet (Department of Energy)
 - CHEETAH (National Science Foundation funded project)
 - DRAGON (another NSF funded project)
- Anticipate a circuit from NY to London (through MANLAN) to attach to GEANT2 testbeds (~March 2006)
- First experiments: cross-domain control plane

iGrid 2005 and SC2005 Demo

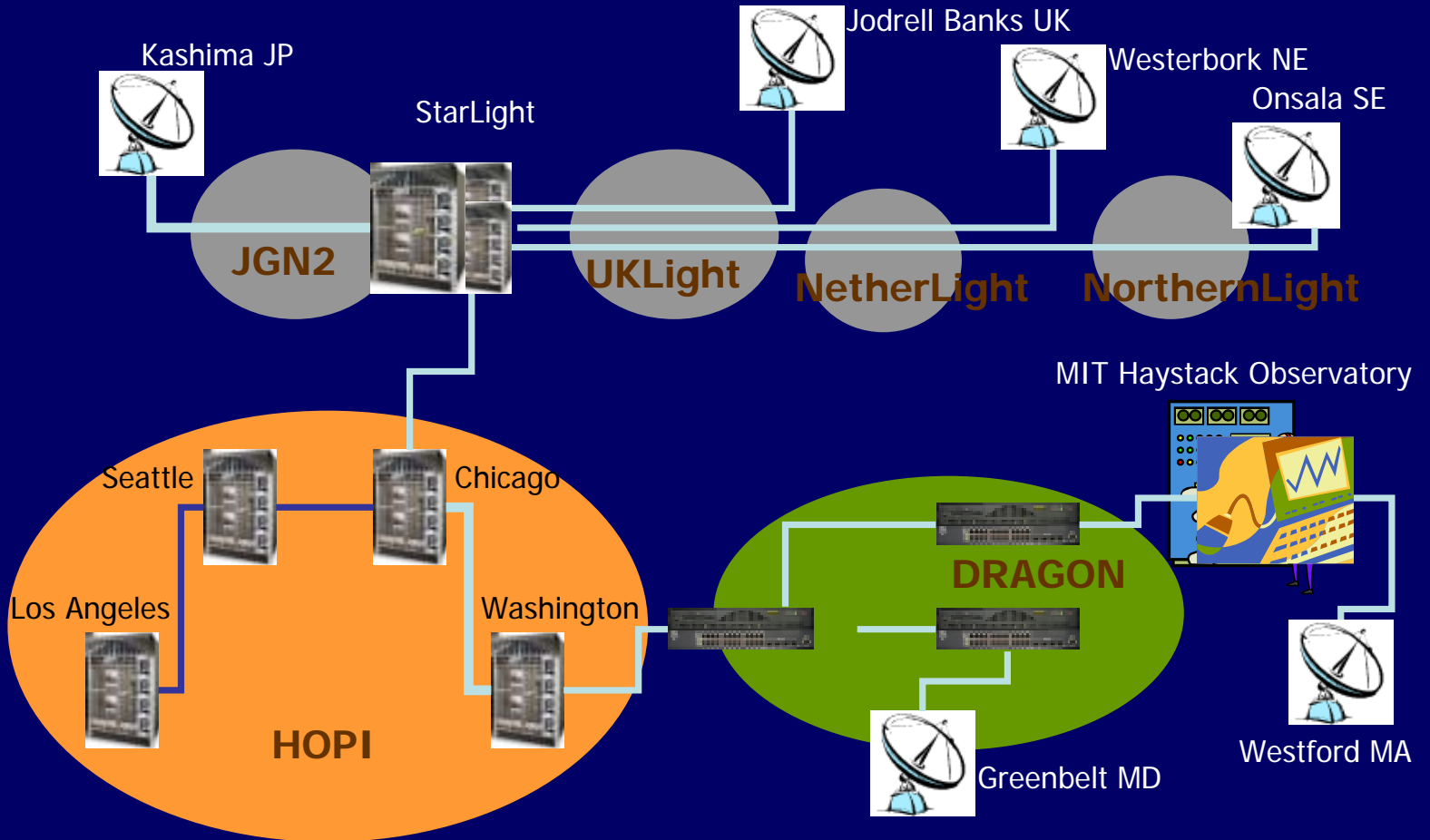
- E-VLBI Application – real time access to radio telescopes, linking them to correlators at MIT Haystack Observatory
- GMPLS control plane – Porting the DRAGON protocol stacks to manage the Force10 E600 switches
- Inter-domain provisioning – Three exemplar administrative domains part of the demo: international, national, and regional
- International scope –
 - Telescopes in Onsala SE, Westerbork NL, Jodrell Banks UK, Kashima JP, Greenbelt MD, and Westford MA.
 - Networks: UKLight, NetherLight, NorthernLight, SUnet, StarLight, HOPI, DRAGON, BOSnet, JGN2
- Persistent infrastructure - A new type of demo: The infrastructure remains in service for use by the end user community after the demos are over [for experiments]

HOPI: *iGrid2005 and SC2005*



Diagram courtesy Jerry Sobieski

Slightly More Detail



Other Activities

- MANLAN: The Manhattan Landing – an R&E exchange point in New York City
- perfSonar: measurement and debugging infrastructure, opportunistically working with GEANT2 JRA1 group (we intend to use it for the next-generation “piPEs” infrastructure)

Other Activities

- Federated Authentication and Authorization infrastructure
 - Shibboleth
 - GEANT2 research activity
 - EduRoam

For More Information

- <http://www.internet2.edu/>
- <http://abilene.internet2.edu/>
- <http://networks.internet2.edu/hopi/>
- <http://www.nlr.net/>
- <http://e2epi.internet2.edu/> (performance)
- <http://middleware.internet2.edu/>
(Authentication and Authorization)