

The HOPI Testbed and the new Internet2 Network

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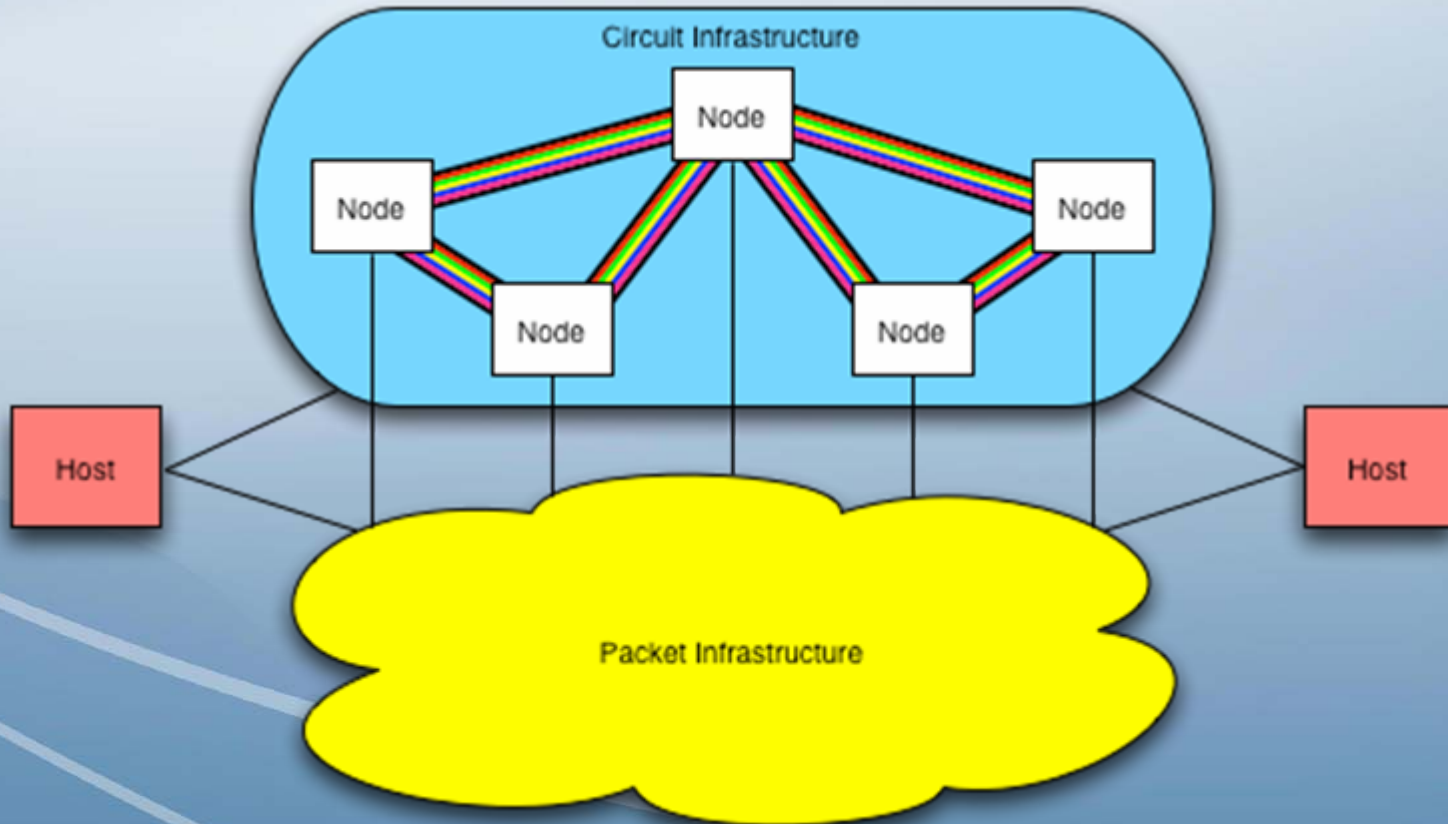
Agenda

- Review of HOPI Ideas
 - Current Status
 - Control Plane
- New Internet2 Network
 - Design Ideas
 - Topology
 - Optical nodes
 - Connections and Peerings
 - Projects

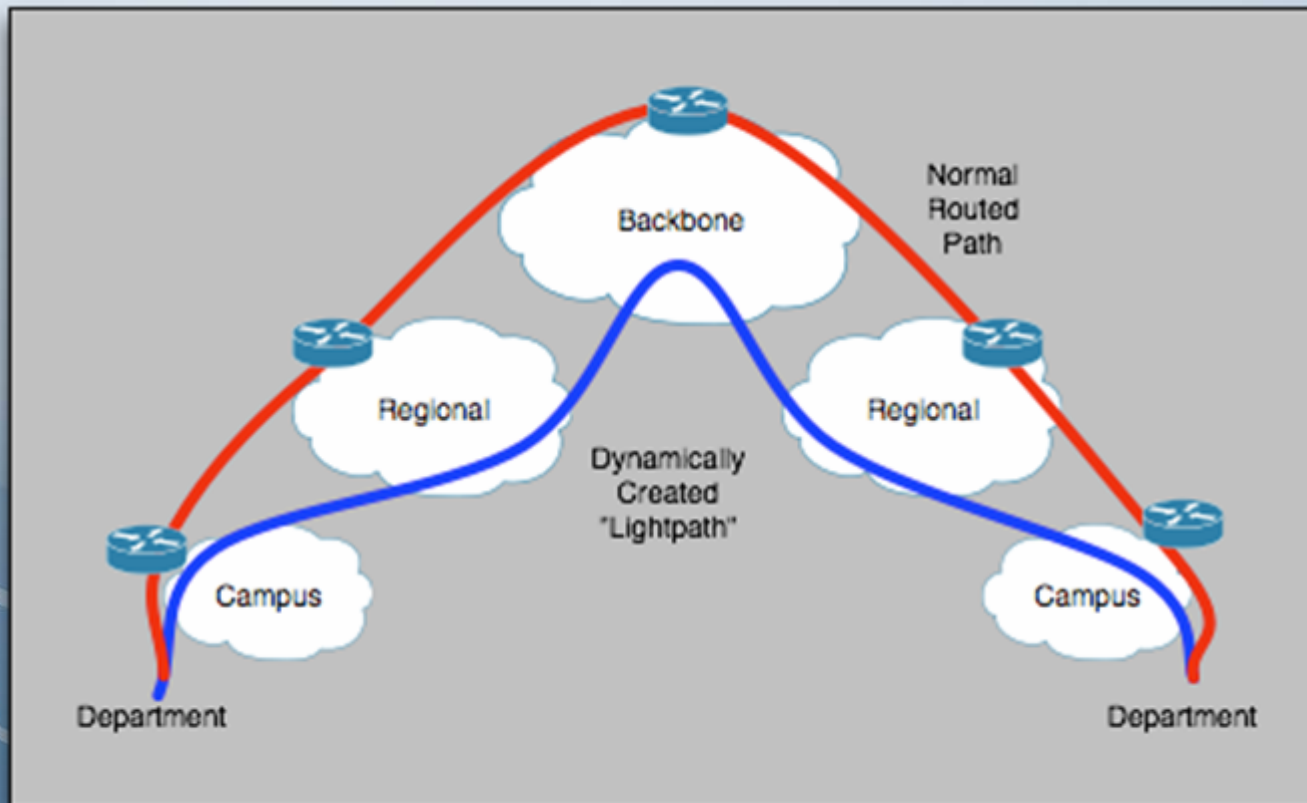
HOPI Project - Overview

- How does one effectively use a richer set of capabilities available to network designers and end users?
 - Core IP packet switched networks
 - A set of optically switched lightpaths available for dynamic provisioning
- Fundamental Question: How will the core Internet architecture evolve?
- Examine a **hybrid** of shared IP packet switching and dynamically provisioned circuits
- 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 General Problem



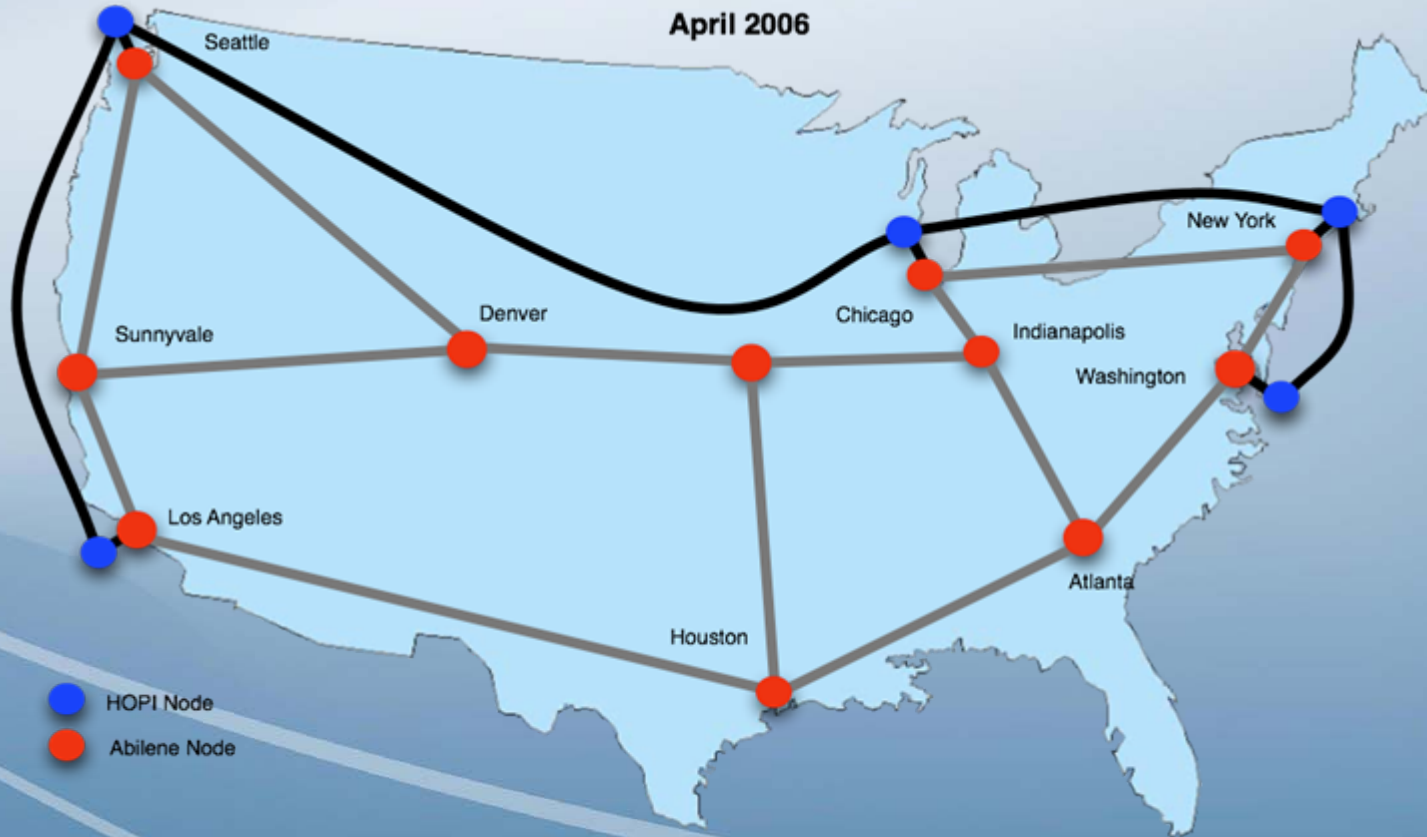
Lightpaths Across Domains



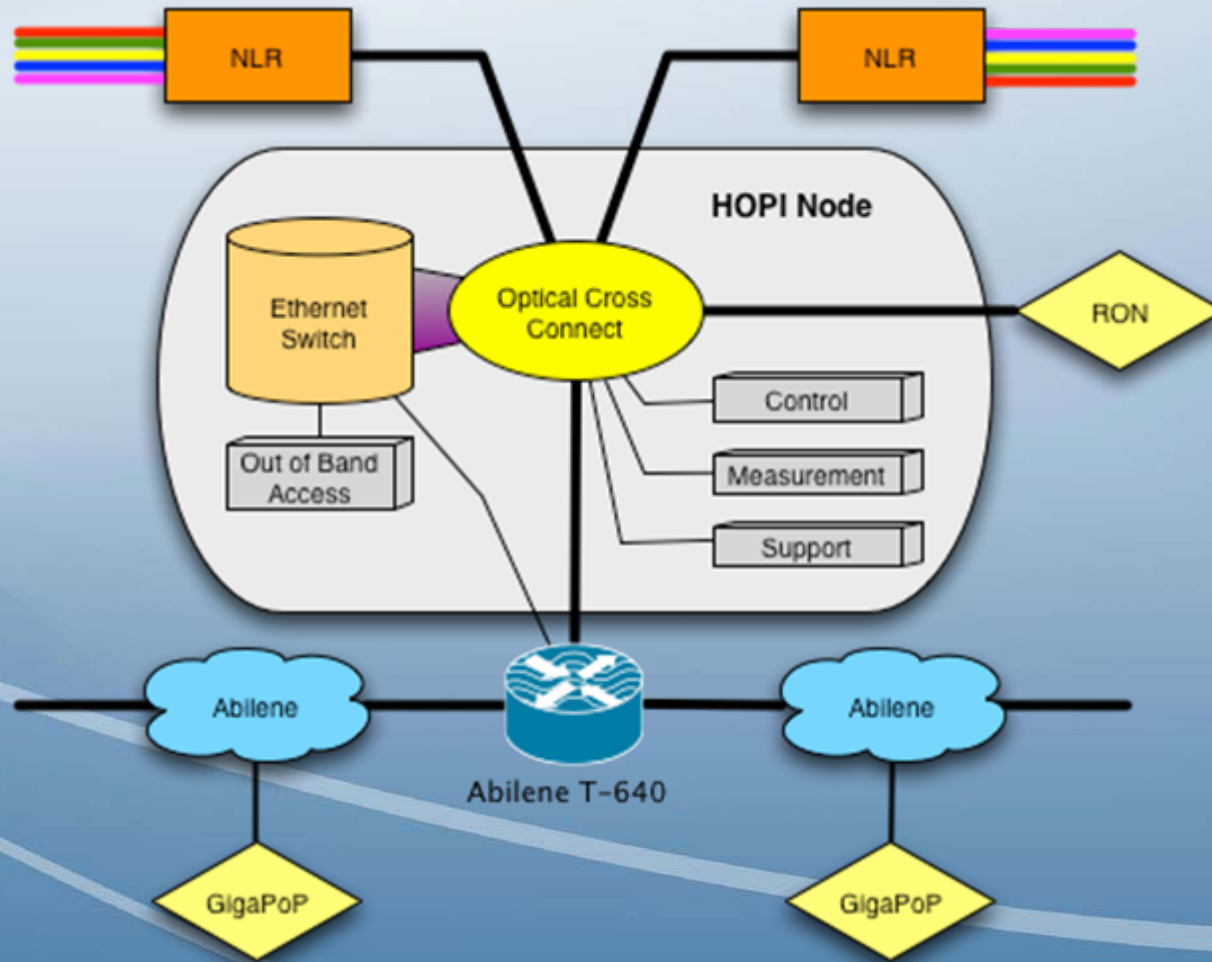
HOPi Status

- Installed Node Locations (all support International connectivity)
 - Los Angeles Equinix facility - same location as NLR node
 - Washington, DC MAX/Dragon facility - same location as the NLR node
 - StarLight in Chicago
 - The Pacific Northwest GigaPoP in Seattle - Westin Building, the new location of the NLR node
 - New York City – NYSErNet area in 32 AoA - same location as NLR node (many thanks to NYSErNet for donating rack space and power to support the HOPi project).
- Circuit from NYC to London
 - Connection to GEANT2
- New GEANT2 circuit from Paris to NYC
 - Now have 3 circuits supporting P2P services and one for IP peering, all through MAN LAN

HOPi Topology



HOPi Node



Control Plane

- Control Plane Activities - Uses DRAGON software
 - Uni for applications
 - VLSR - Virtual label switched router
 - NARB - Network access resource broker
 - ASTs - Application specific topologies. Successful demonstrations of these at Internet2 member meeting
- Specific types of services
 - Immediate reservation
 - Advanced reservation
- Monitoring and managing an open layer1 network
- Data collection similar to Abilene observatory
- AAA development
- Measurement activities
 - Similar active measurements to those on Abilene
 - Dynamically setup channels for iperf measurements, eventually using circuit types of TCP protocols

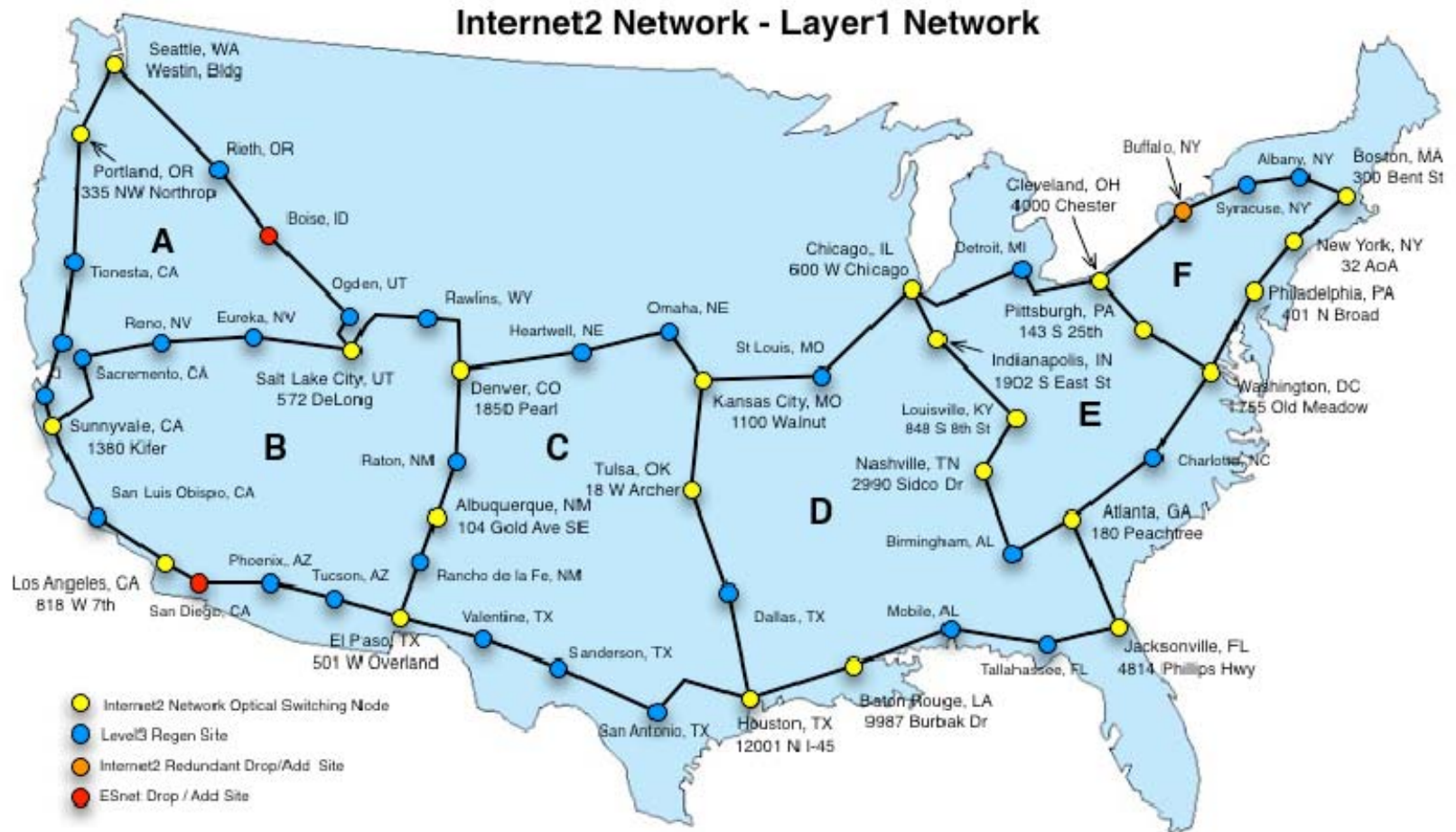
The New Internet2 Network

- Abilene Network ends 10/2007. New network:
- Hybrid IP and Dedicated Wave System utilizing Level3 optical fiber platform; equipment and fiber dedicated to Internet2, sparing and equipment maintenance by Level3, including SLA for wave system
- Control at layer 1
- Platform support for highly experimental projects to production services
- Initially provisioned with ten 10-Gbps wavelengths, with unlimited capacity; scalability potential for 40 and 100 Gbps interfaces

Internet2 Network

- Flexible add-drop wave capabilities for RON's and other networks
- Simplified and rapid wave provisioning, within hours for full waves
- Grooming capabilities through STS-1 granularity SONET services (GFP, VCAT, LCAS).
- Dynamic provisioning of sub channels and waves across the network within seconds
- HOPI testbed will continue as an experimental facility for the network

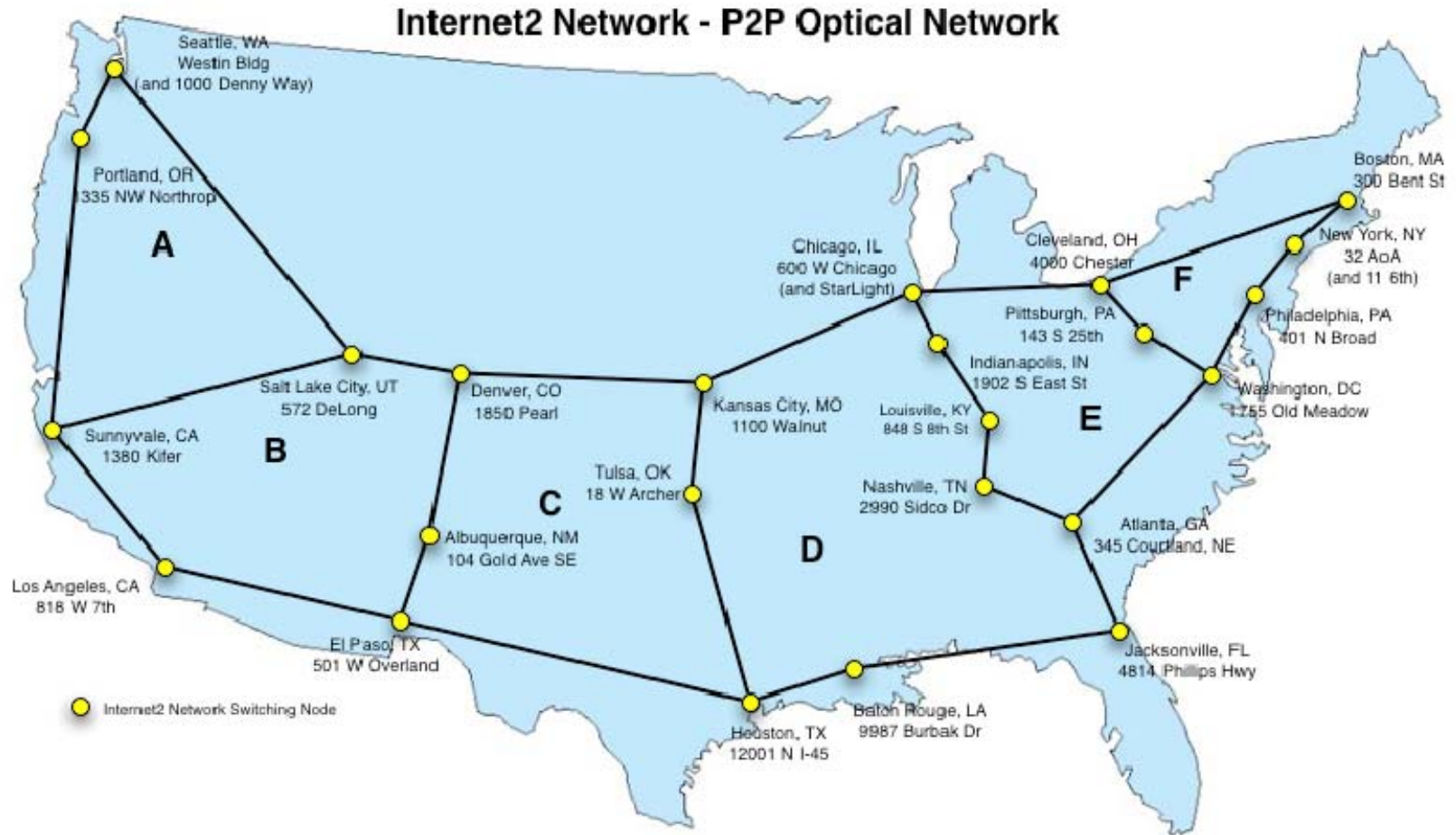
DWDM Topology



DWDM Network

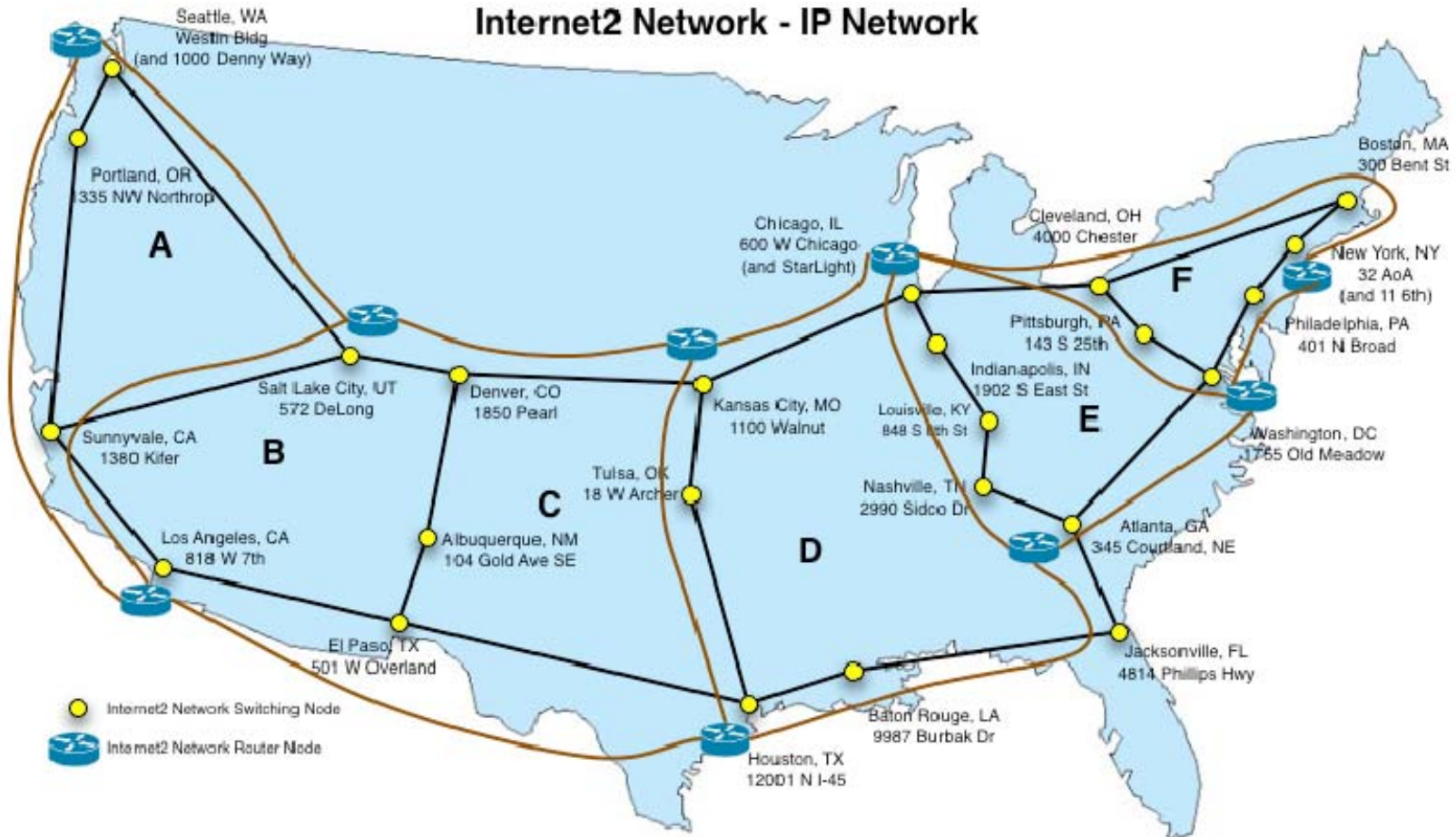
- Internet2 and ESnet have formed a partnership to build their respective networks on this DWDM footprint
- ESnet hybrid network
 - An IP network connecting the labs
 - An lower layer network for deterministic services
- Internet2 hybrid network
 - An IP network similar to the existing Abilene network
 - A layer 1 dynamically provisioned network providing HOPI like services
- Static and Dynamic services will be available to other partners

P2P Optical Topology



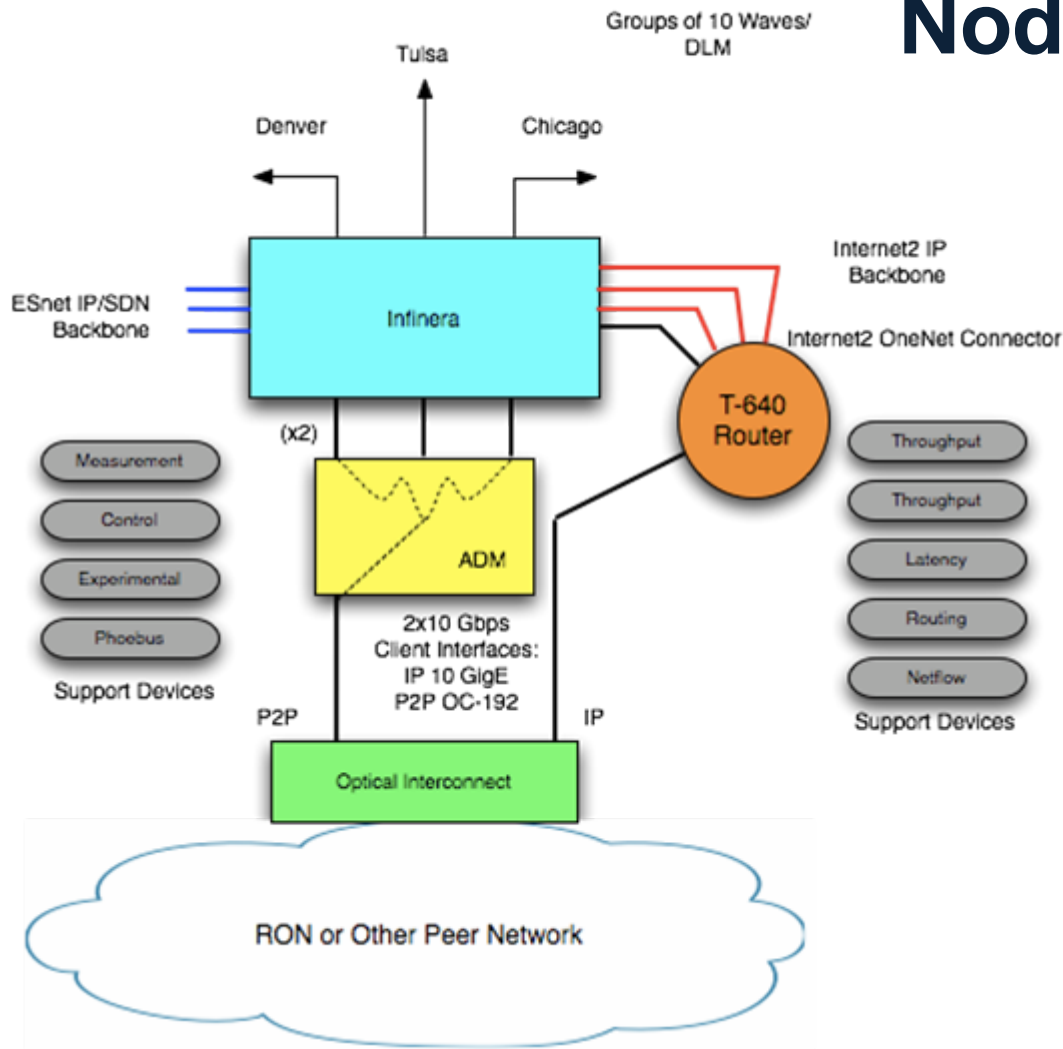
IP Network

Internet2 Network - IP Network



Kansas City, MO

Connector: GPN



Node Architecture

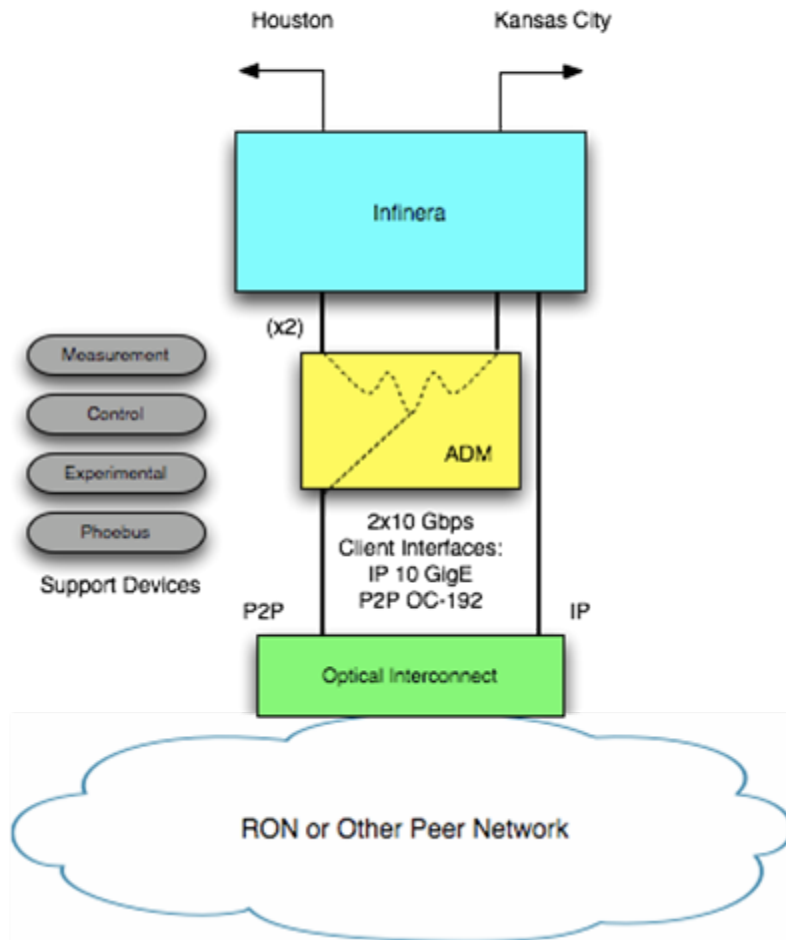
- Infinera DWDMGear - Static at the start
- Grooming capabilities in ADM to provide sub channels and HOPI types of activities at the start
- Simplified and standardized interface to connectors, exchange points, and other global research and education networks - 2 x 10 Gbps interfaces
- Measurement and control servers will support the node

Tulsa, OK

Connector: OneNet

Groups of 10 Waves/
DLM

Node Architecture



- Example of Optical only Node for connected RON or Peer Network

Circuit Services

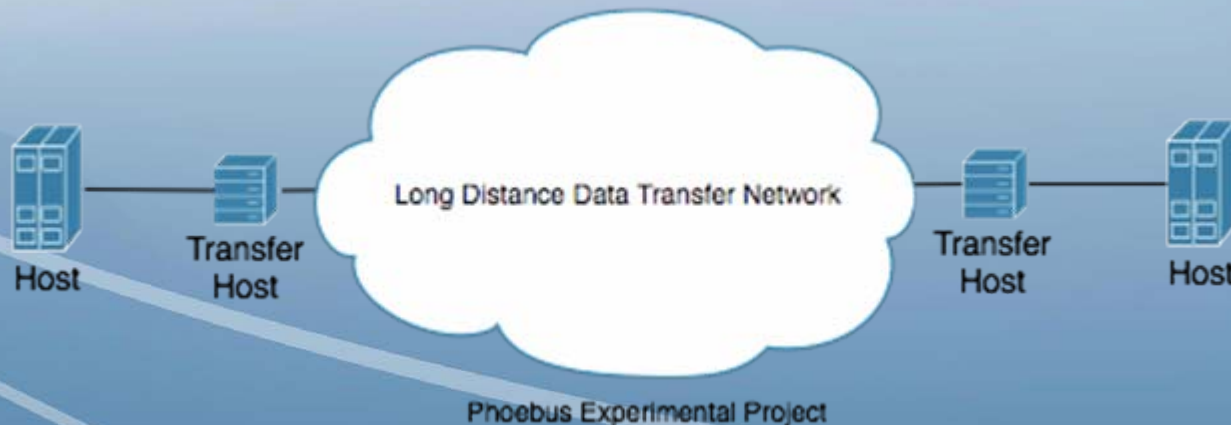
- Short Term Dynamically Configured STS-1 Granularity deterministic circuits using two waves on the full footprint, with framing either SONET or GFP mapped Ethernet. There is no additional cost to use these capabilities. They are included in the base connectivity Costs. There may be call blocking in the use of these capabilities.
- Long Term Circuits configured as above. There is an extra fee for these circuits, proportional to bandwidth, and charged on a day-by-day basis. The shortest term is one day, and there is no call blocking for these capabilities.
- Long Term full waves configured and provisioned for a minimum of a year.

Peerings with the Internet2 Network

- Most open exchange points now have both layer 2 and layer 1 functionality
 - Layer 2 to support IP peerings
 - Layer 1 to support P2P “peerings”
 - And Example is MAN LAN
- Internet2 prefers peerings that connect through these types of open exchanges
- The new Internet2 network design supports IP peerings and layer 1 peerings through the optical nodes
- Currently examining the layer 1 analogy to Abilene as an International Transit Network (ITN)

Other Projects on Internet2 Network

- Phoebus - TCP data flows
 - File transfers over long distance segments not requiring congestion control



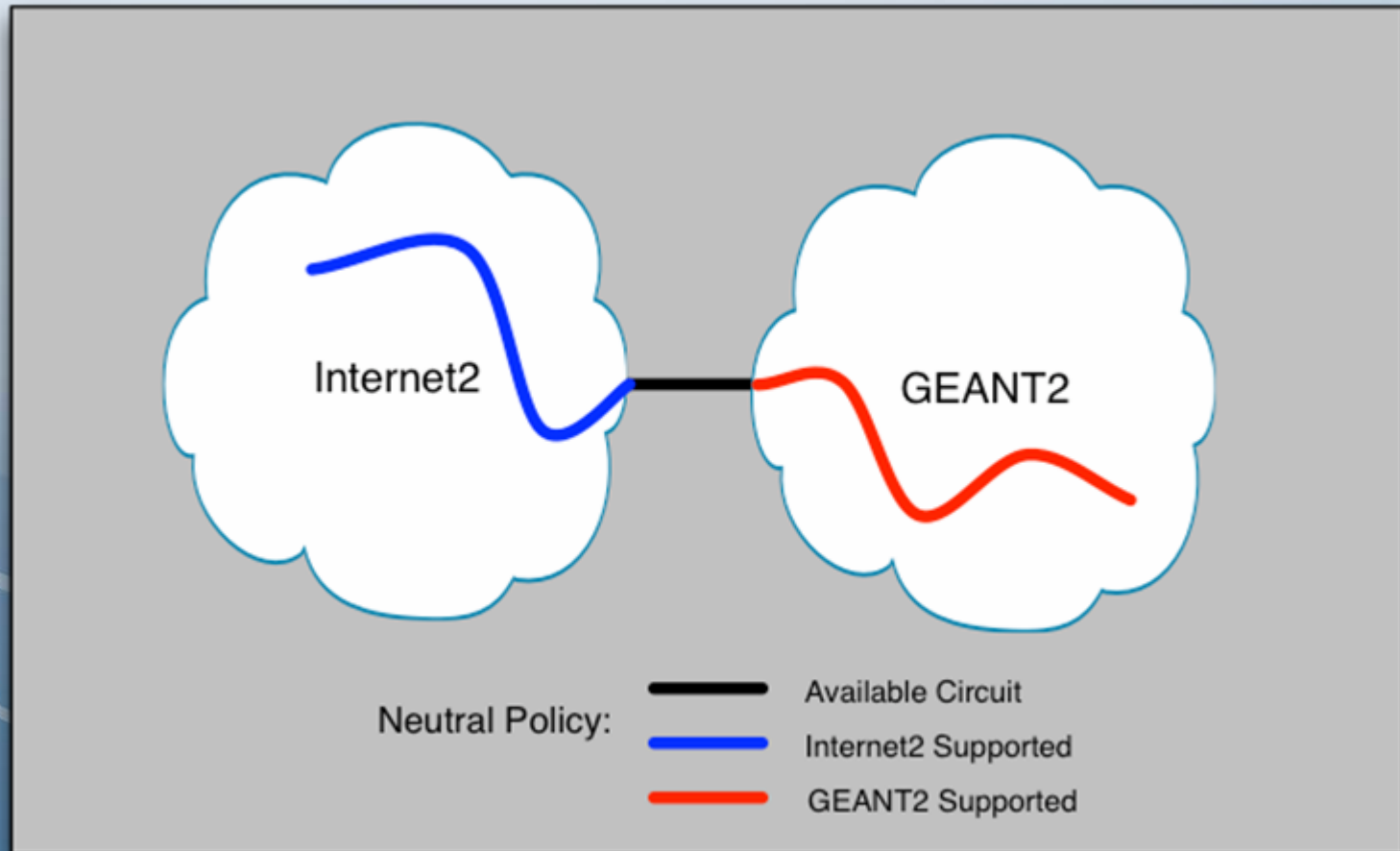
Network Research Projects

- Network research projects deploying programmable Ethernet capable chipsets at each optical node using “NetFPGA” cards from Stanford
 - Programmable chipsets for experimenting with new protocols
- The Abilene observatory will be expanded to include the new capabilities of the network
 - Data collection at all layers of the network, with datasets made available to network researchers
 - Support for collocation of equipment in optical nodes

Service Trial

- Service trial with GEANT2 on provisioning of 1 GigE circuits across Internet2 and GEANT2
 - Canarie, Esnet, GEANT2, Internet2 developing common request schema for inter-domain circuits
 - Applications identified
 - Participation by RONS and campuses in the trial
 - MAGPI and LONI RONS participating
 - Trial involves setup of long term circuits as well as experimenting with dynamic setup across administrative domains
 - The following diagram illustrates the ideas

Internet2/GEANT2 Service Trial



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