The New Internet2 Network

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Internet2

GLIF Meeting

11 September 2006

Tokyo, Japan

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Agenda

- Basic Ideas
- Design Ideas
- Topology
- Optical nodes
- Control Plane
- Connections and Peerings
- Projects

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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?

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Lightpaths Across Domains
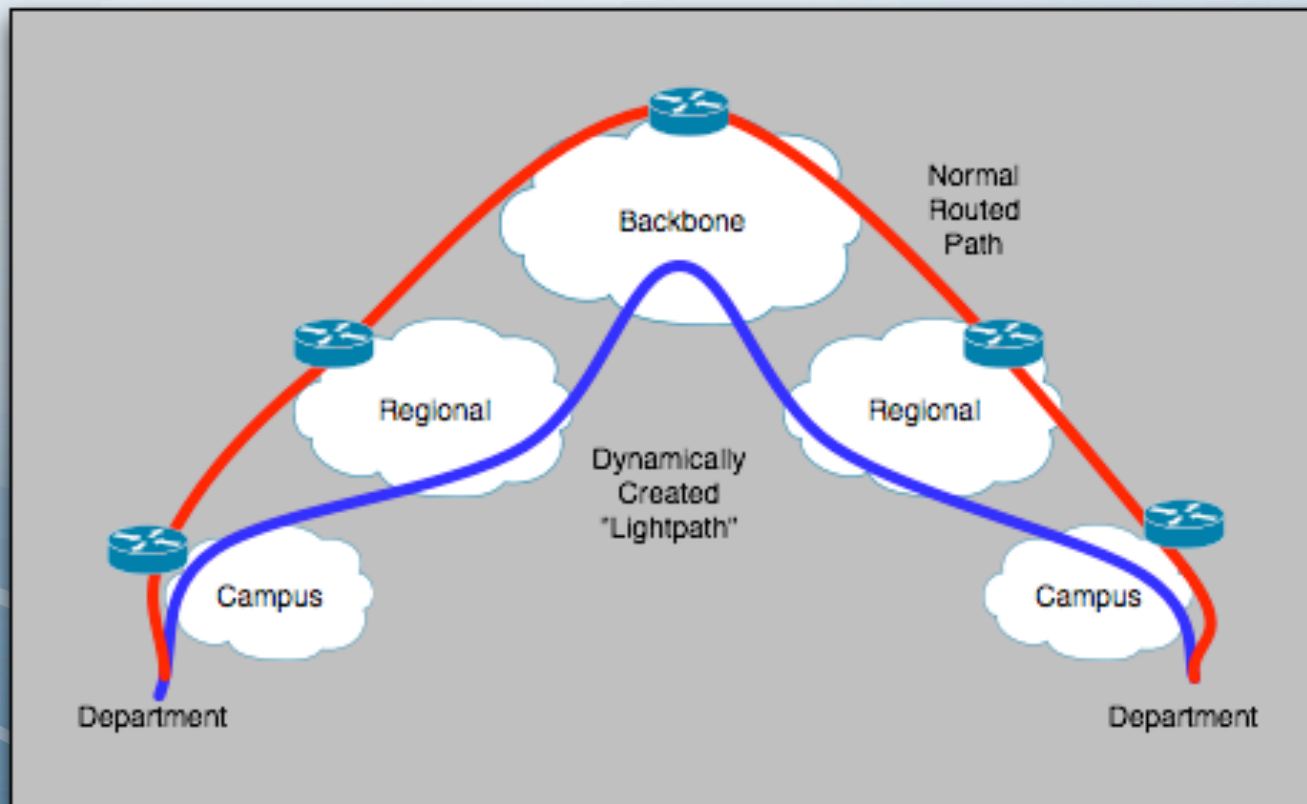
The New Internet2 Network

- Agreement with Qwest for Abilene ends in October of 2007

- Strategic Objectives
  - Ensure community control of the underlying network infrastructure
    - Control those elements that allow development of new network capabilities
  - Leverage the capabilities of a global telecommunications leader
    - Providing carrier class reliability and expanded breadth of services, along with a broad set of partnership options
  - Capitalize on the latest technological advancements in networking
  - Create an asset that benefits the entire community - researchers, universities, regional optical networks, industry, government, K-12, and the international community

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Architecture Goals

- Develop an innovative optical system on a national footprint to serve the broad research and education community
- Develop a hybrid network capable of providing point-to-point services together with an IP network
- Community should have complete control of the layer 1 optical system including provisioning and switching of wavelengths
- Internet2 should not have to concentrate on reliability and sparing
  - The community focus should be on networking and research, not on managing devices like amplifiers

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Architecture Goals

- The system should be capable of supporting network research in wide variety ways
- Minimal Conditions of Use (CoU), allowing full participation from the entire community in providing new services and capabilities
- Platform support for highly experimental projects to production services

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The New Internet2 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

- Initially provisioned with ten 10-Gbps wavelengths, with unlimited capacity; scalability potential for 40 and 100 Gbps interfaces

- Flexible add-drop wave capabilities for RON's and other networks

- Simplified and rapid wave provisioning, within hours for full waves

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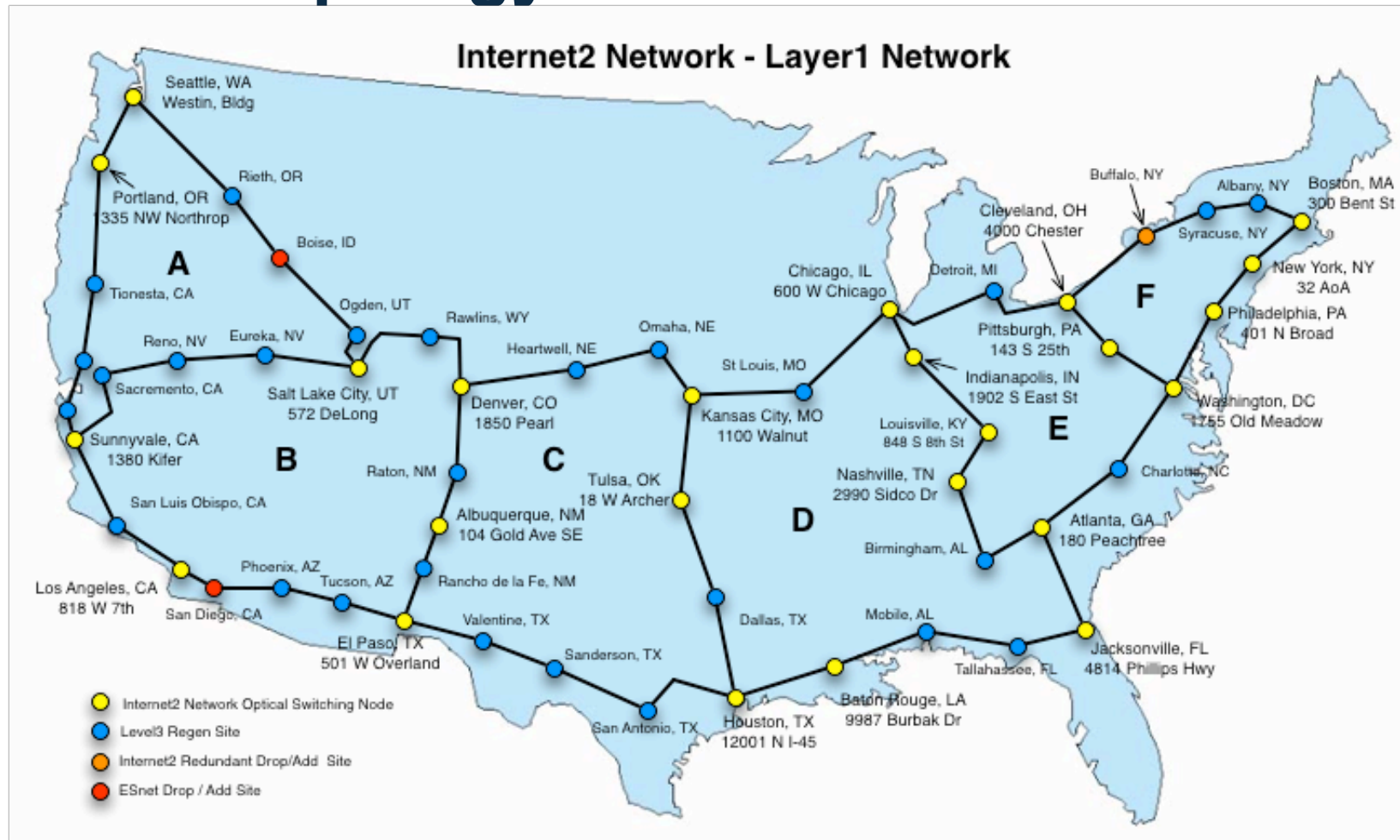# Internet2 Network

- Simplified connections to all exchange points
- Grooming capabilities through STS-1 granularity advanced 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

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DWDM Topology

Internet2 Network - DWDM Layer1 Network
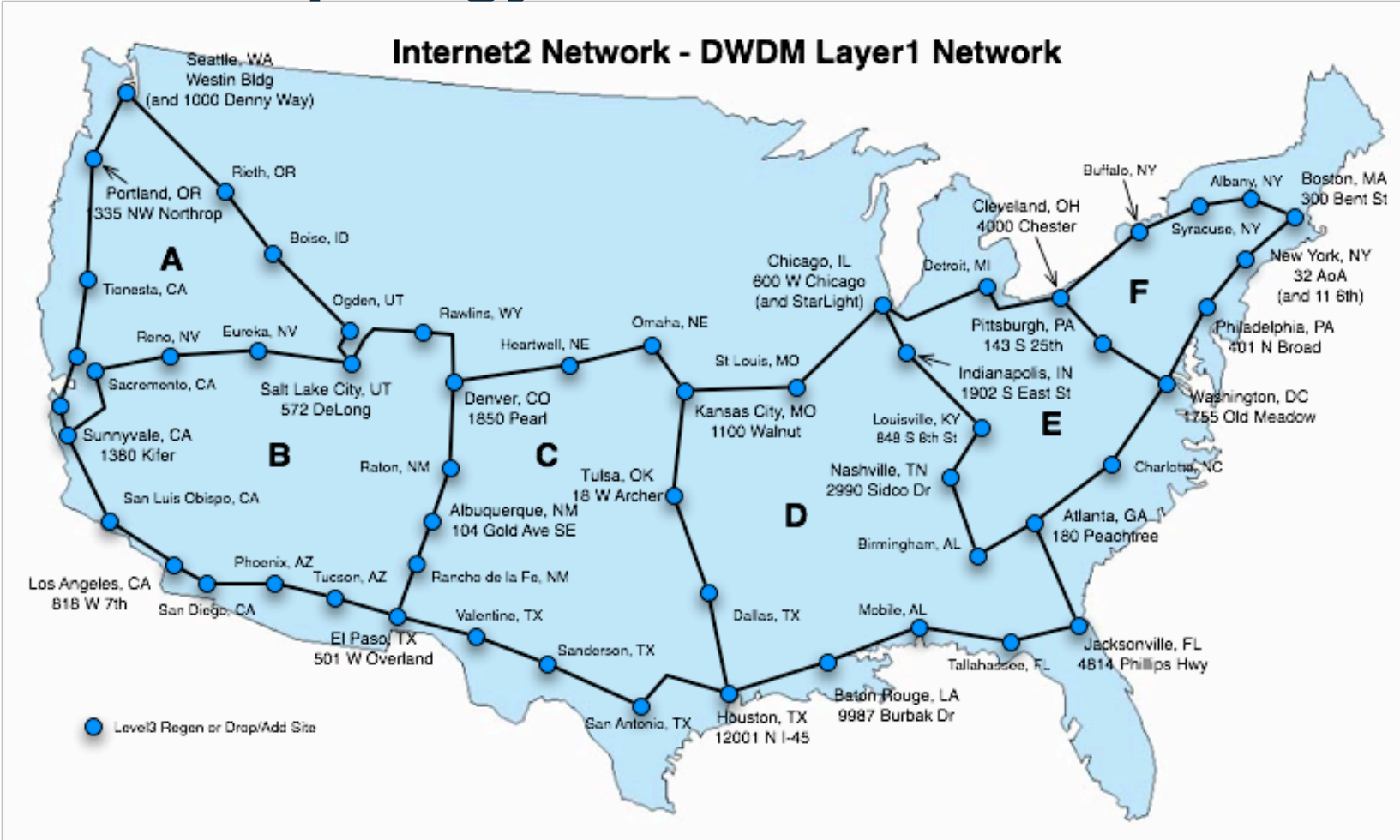
DWDM Network

- 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 - SDN
- 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

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DWDM Topology

Internet2 Network - Layer1 Network

P2P Optical Topology
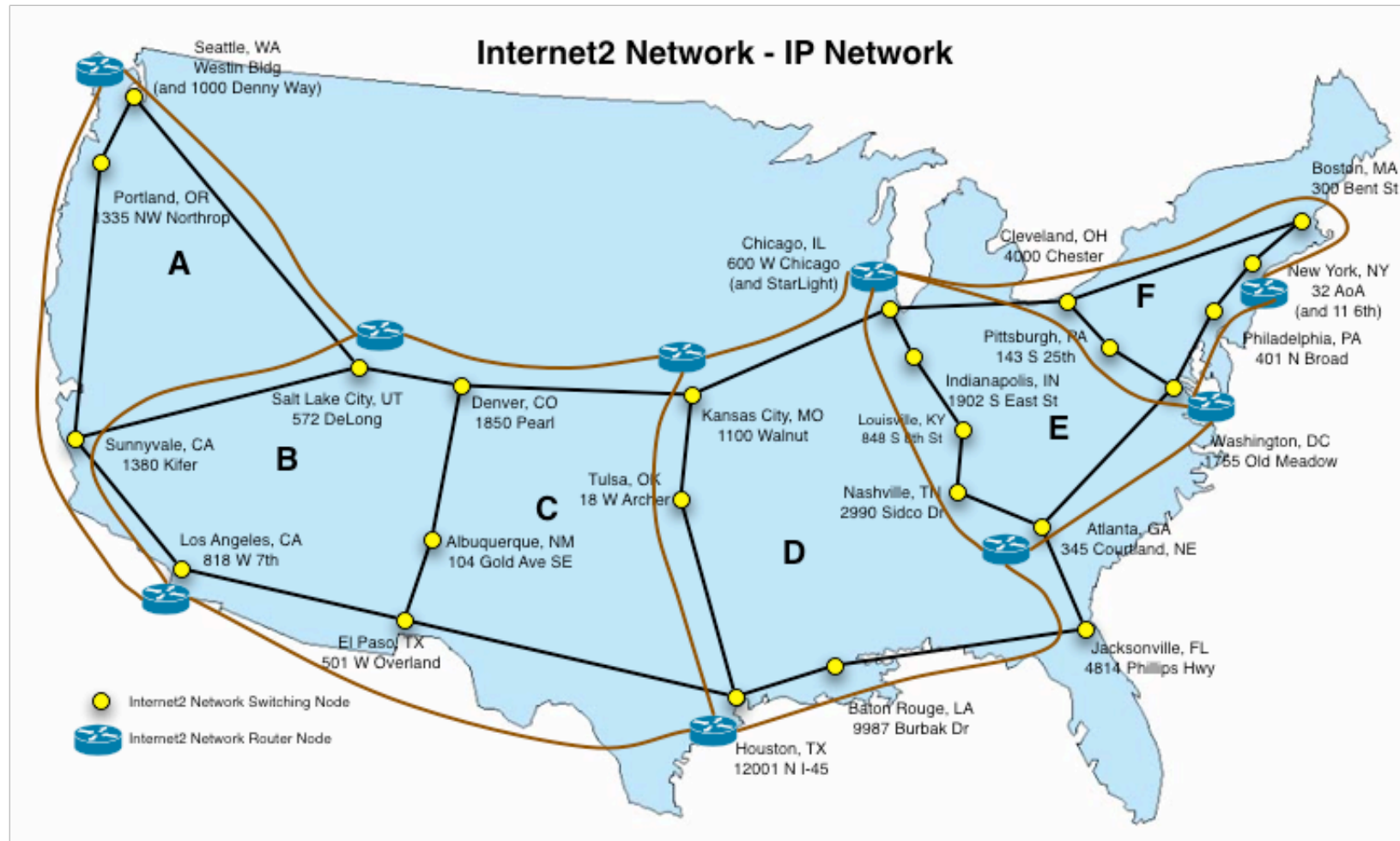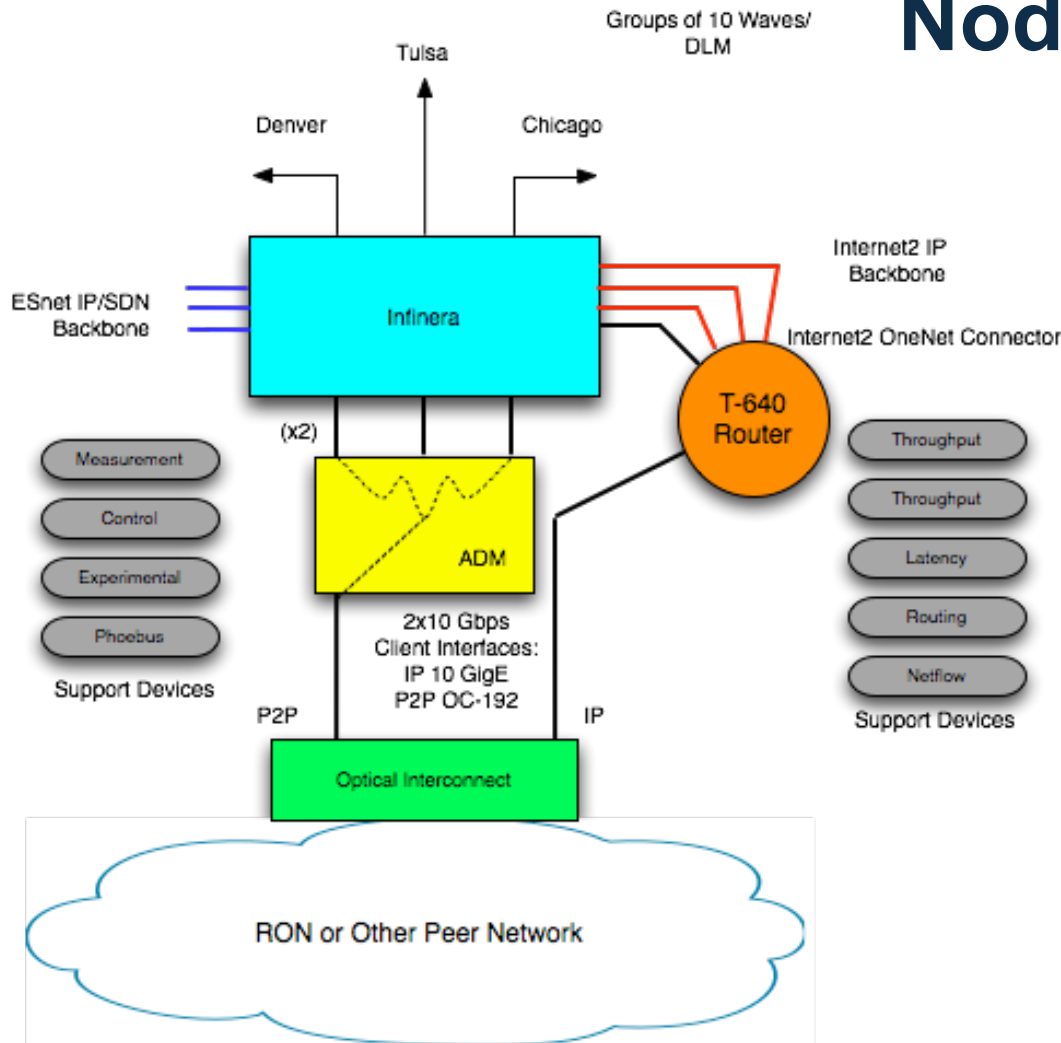

Internet2 Network - P2P Optical Network

IP Network

Internet2 Network - IP Network

Seattle, WA
Westin Bldg
(and 1000 Denny Way)

Portland, OR
335 NW Northrop

A

Boston, MA
300 Bent St

Chicago, IL
600 W Chicago
(and StarLight)

Cleveland, OH
4000 Chester

F

New York, NY
32 AoA
(and 11 6th)

Salt Lake City, UT
572 DeLong

Denver, CO
1850 Pearl

Kansas City, MO
1100 Walnut

Pittsburgh, PA
143 S 25th

Philadelphia, PA
401 N Broad

Sunnyvale, CA
1380 Kifer

B

Louisville, KY
848 S 8th St

Indianapolis, IN
1902 S East St

E

Washington, DC
1755 Old Meadow

Tulsa, OK
18 W Archer

C

Nashville, TN
2990 Sidco Dr

Los Angeles, CA
818 W 7th

Albuquerque, NM
104 Gold Ave SE

D

Atlanta, GA
345 Courtland, NE

El Paso, TX
501 W Overland

Jacksonville, FL
4814 Phillips Hwy

Baton Rouge, LA
9987 Burbak Dr

Houston, TX
12001 N I-45

○ Internet2 Network Switching Node

Internet2 Network Router Node

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Node Architecture

Kansas City, MO

Connector: GPN

Groups of 10 Waves/ DLM

Tulsa

Denver

Chicago

ESnet IP/SDN Backbone

Internet2 IP Backbone

Internet2 OneNet Connector

Infinera

T-640 Router

(x2)

Measurement

Control

Experimental

Phoebus

Support Devices

ADM

2x10 Gbps Client Interfaces: IP 10 GigE P2P OC-192

P2P

IP

Throughput

Throughput

Latency

Routing

Netflow

Support Devices

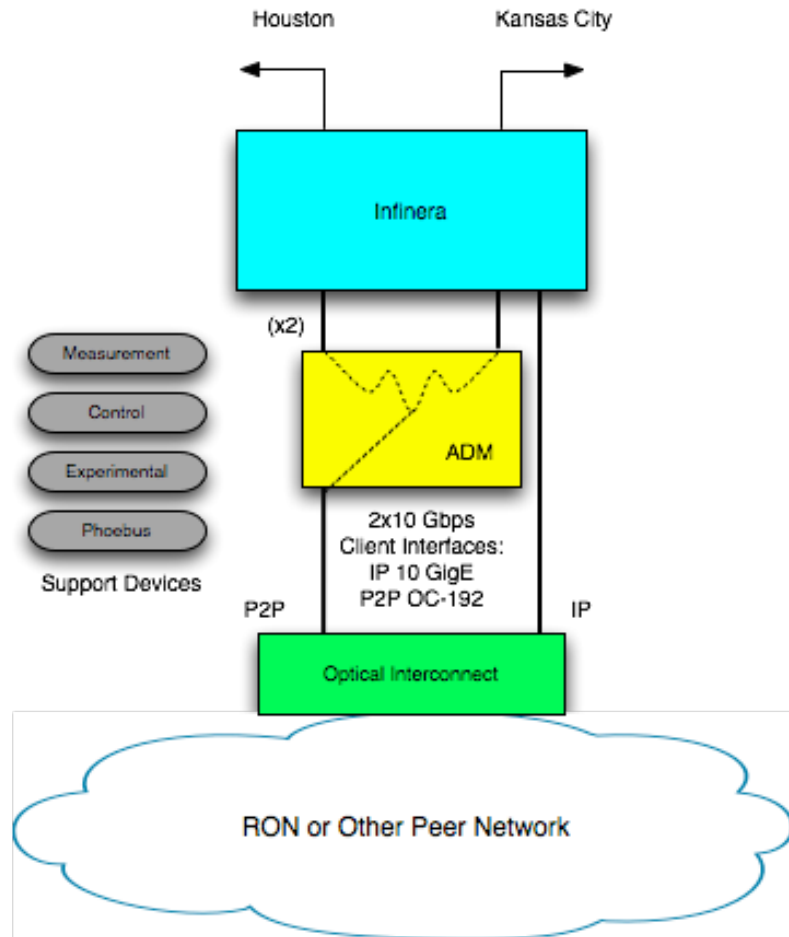Optical Interconnect

RON or Other Peer Network

- 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

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Node Architecture

Tulsa, OK

Connector: OneNet

Groups of 10 Waves/ DLM

Houston   Kansas City

Infinera

(x2)

Measurement

Control

Experimental

Phoebus

Support Devices

ADM

2x10 Gbps
Client Interfaces:
IP 10 GigE
P2P OC-192

P2P   IP

Optical Interconnect

RON or Other Peer Network

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

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Control Plane

- Nodes
    - Infinera DWDM Equipment - GMPLS control plane
        - Will be static at the beginning
    - Grooming Equipment (e.g. Nortel OME6500 or Ciena Core Director)
        - Will use Dragon at the start
        - Will provide dynamic service at the start using DRAGON high level services
    - At router nodes, Juniper Routers - GMPLS implementation
- Integration of control planes
- Internet2 is now a member of the OIF

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Control Plane

- Control Plane Activities - 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
- AAA development
- Measurement activities
  - Similar active measurements to those on Abilene
- Data collection similar to Abilene observatory

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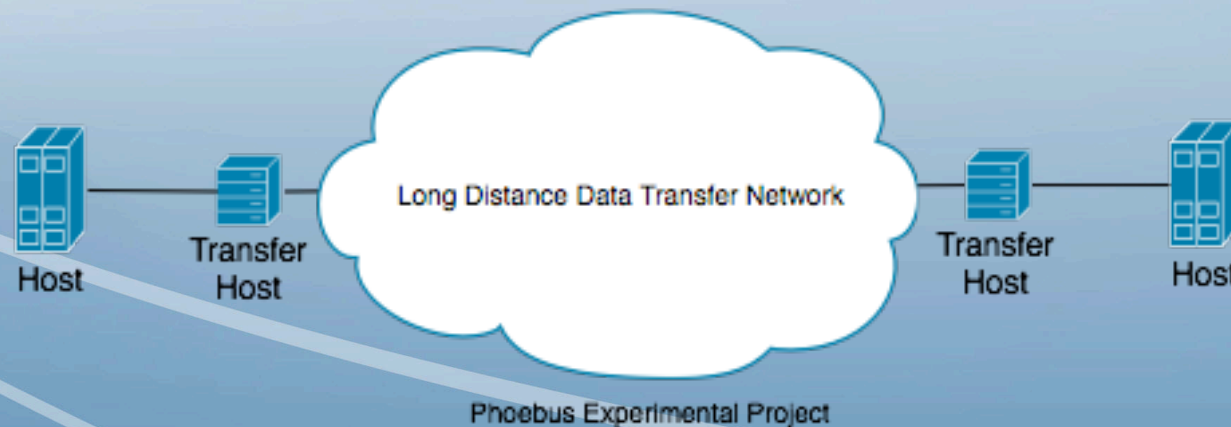
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Circuit Services

- 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)

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Example Projects on Internet2 Network

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

Host — Transfer Host — Long Distance Data Transfer Network — Transfer Host — Host

Phoebus Experimental Project
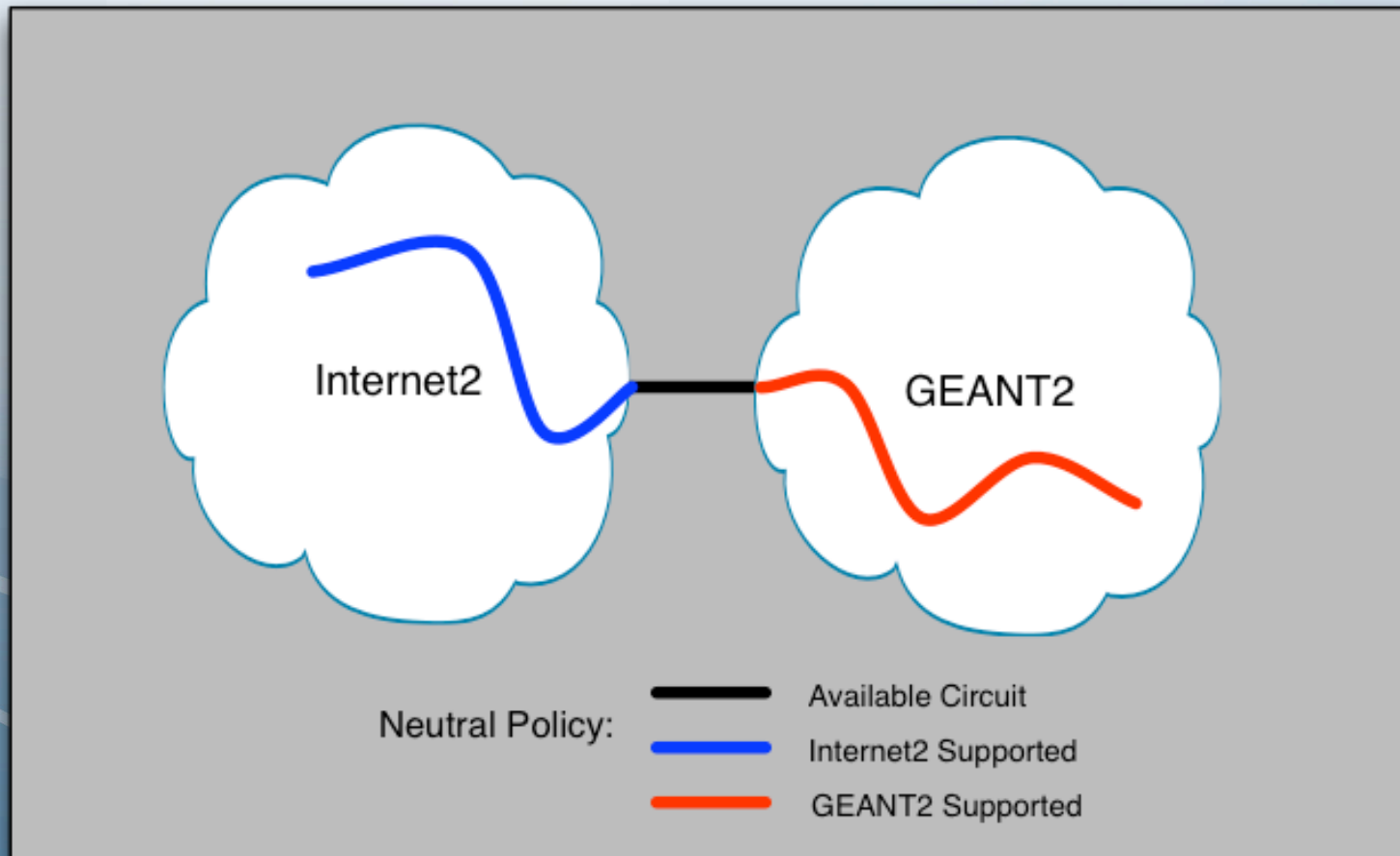
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Network Research Projects

- 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
  - Monitoring and Management
  - The following diagram illustrates the ideas

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Internet2/GEANT2 Service Trial

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Neutral Policy:

———	Available Circuit
———	Internet2 Supported
———	GEANT2 Supported

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www.internet2.edu