Internet2 Networks, Current and Future

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Internet2

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on HEP Networking, Grid and Digital Divide Issues
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Krakow, What a Wonderful City!

Agenda

- The Existing Internet2 Network (Abilene)
  - History
  - The Network
  - Peering with International Networks
- The New Challenge
- The new Internet2 Network
  - A Broader Design
  - Topology
  - New Capabilities
  - Connections and Peerings
  - Other Projects

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History

- With the end of NSFnet and beginning of privatization, the ability to support science applications was limited
- The vBNS days brought much better connectivity, especially to super computer centers
- Initial meetings of what was to become Internet2, a consortium of research universities, in 1996
  - There was a clear need to support the university research community
  - The Internet, even for “small” applications was not as robust as it is today
  - The university networking needs for science are not met today by the Internet protocols and likely will not be met in the near future

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The Internet2 Network Abilene

- First Internet2 network began in mid 1998 with first backbone (Abilene) at 2.5 Gbps (OC-48 SONET backbone)
  - Partnership with Qwest, Cisco, and Nortel
  - IP Network
- Backbone upgrade to 10 Gbps started I 2001 and completed in early 2003
  - Supported advanced services like IPv6 and Multicast
  - Focus on performance and reliability primarily for E-science applications

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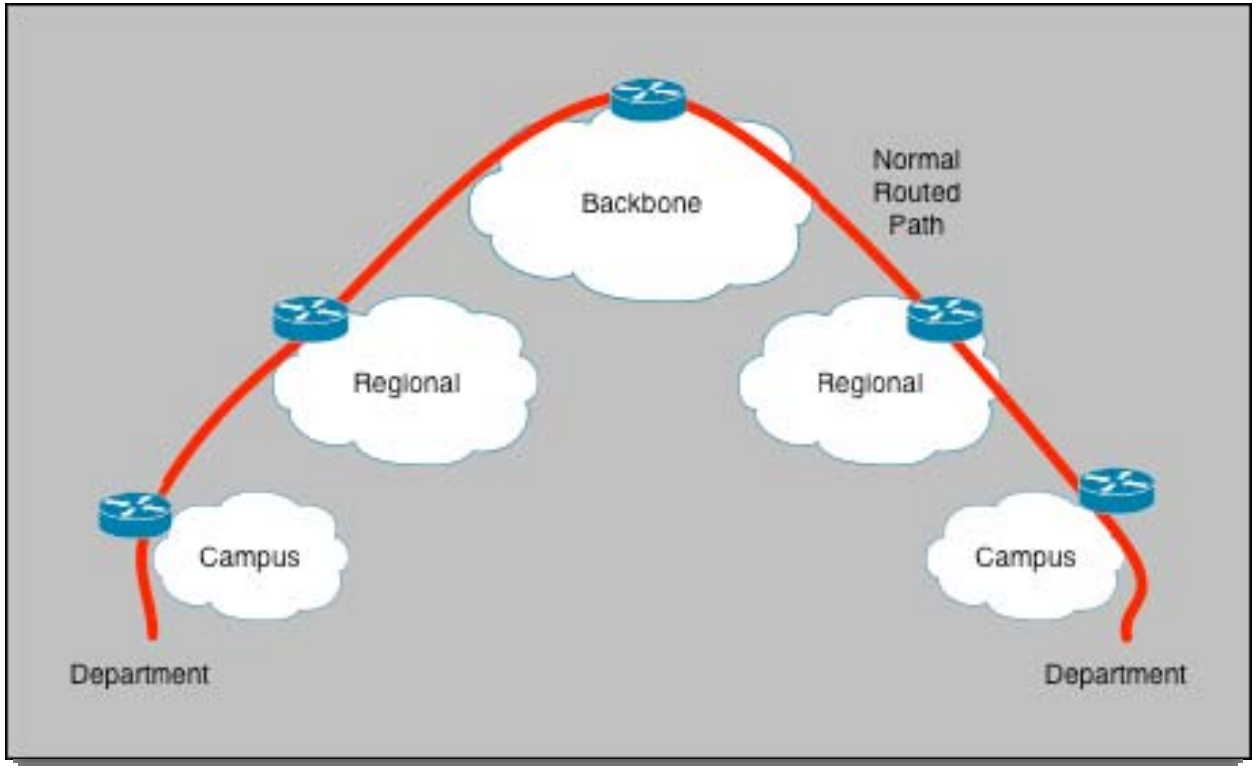
Current Internet2 Network (Abilene)

National Architecture (Current)



Internet2 Connectors and Peers

- Connectors
  - 35 direct connections (OC-3c → 10 Gbps)
    - 3 10 Gbps (10 GE) connections
    - 7 OC-48c connections & 5 GE connectors
    - 24 connected at OC-12c (622 Mbps) or higher
  - 246 Primary Participants – research universities and labs
  - Cost recovery model
    - Regional to National
    - Campus to National
- Peerings
  - Connections through exchange points
  - 48 International agreements and 80+ International networks reachable through Abilene
  - Abilene supports transit for International peers
  - Peerings with other Federal Research and education networks in the US

See: http://abilene.internet2.edu/

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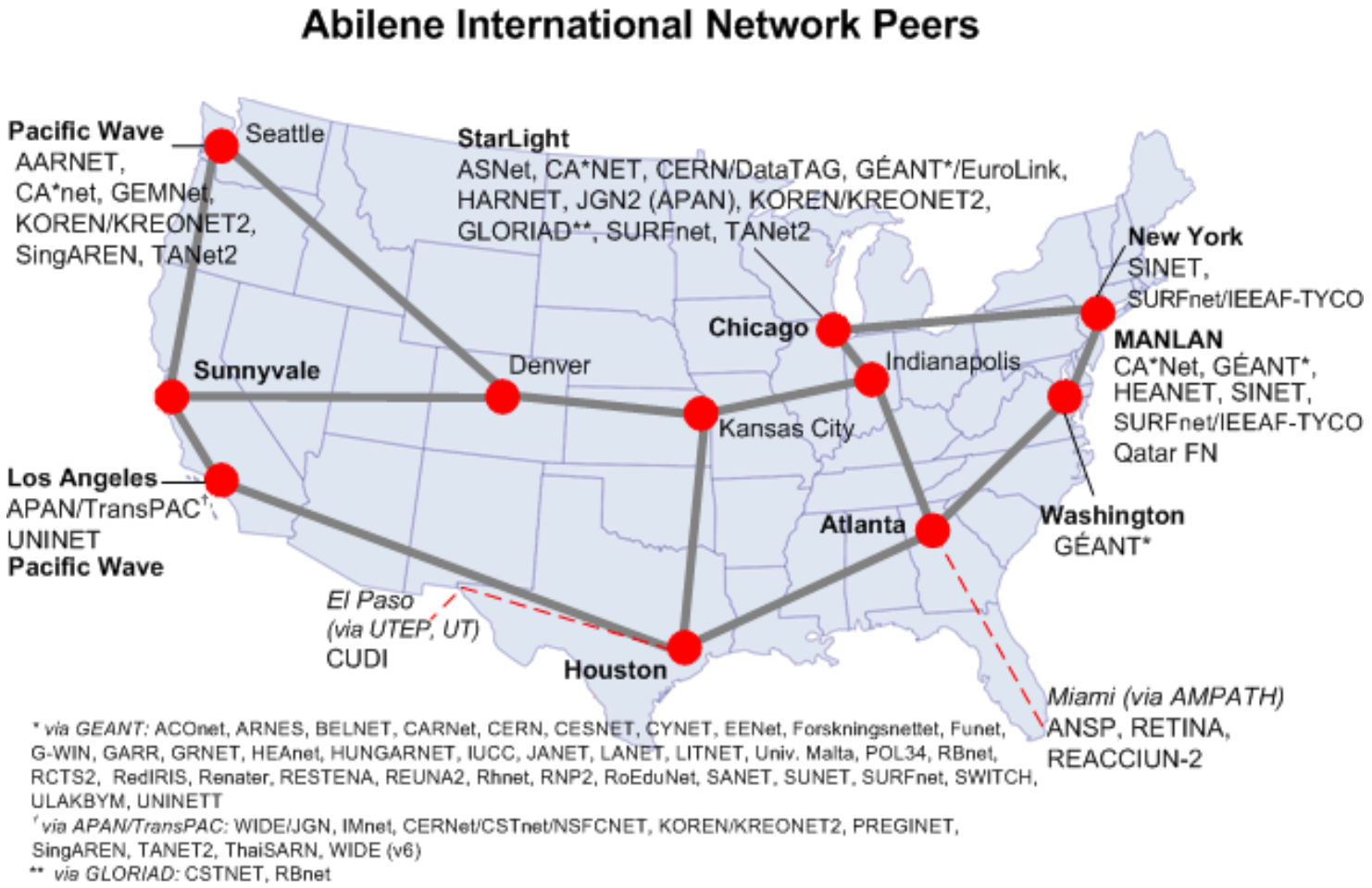
International Peers



The Coming Challenge

- **“Grid applications will incorporate in excess of 100,000 processors within 5 years.”**
  - Dr. Larry Smarr, “On Vector” Workshop, UCSD Feb 2006
- **“The Global Information Grid will need to store and access exabytes of data on a real-time basis by 2010”**
  - Dr. Henry Dardy, Optical Fiber Conference, Los Angeles, CA USA, Mar 2006
- **“Each LHC experiment foresees a recorded raw data rate of 1 to several PetaBytes/year”**
  - Dr. Harvey Neuman (Cal Tech)
- **“US Bancorp backs up 100 TB financial data every night – now.”**
  - David Grabski (VP Information Tech. US Bancorp), Qwest High Performance Networking Summit, Denver, CO. USA, June 2006.
- **“The VLA facility is now able to generate 700 Gbps of astronomical data and will reach 3.2 Terabits per second by 2009.”**
  - Dr. Steven Durand, National Radio Astronomy Observatory, E-VLBI Workshop, MIT Haystack Observatory., September 2006.

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The Networking Challenge

- Example: Large Scale Distributed Clusters - 10,000 processor compute cluster
  - 4 Gbyte/processor memory, 1 GigE NIC
  - Burst capability = 10 Tbps
- Note: Parallel and distributed clusters are incorporating nodes faster than Moore's Law is reducing their size..
- Power requirements for single clusters will be too large to support in a single location - moved to geographically distributed clusters
- **How will they communicate?**
- These reflect some fundamental design decisions/assumptions of the existing (and original) internet architecture that may not be applicable today, especially for e-science applications
  - The GENI initiative (NSF) hopes to construct a Global Environment for Network Innovation looking to the future
  - Need to examine new architectures for e-science applications now

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The Dynamic Virtual Global Collaboratory

- Collaborating Virtual Organizations will become increasingly important
- Consider the emerging e-science paradigm…
  - Global science
    - For example, astrophysics, astronomy, earth sciences, climate modeling, etc.
  - Global shared resources
    - Large Hadron Collider, radio telescopes, polar research stations, computational resources, etc.
  - Global collaborating science teams
    - E-VLBI, HEP, Genomic Research, etc
- These “affinity groups” combine resources and people into a globally distributed virtual collaborating organizations to pursue a common discipline or objective.

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The New Internet2 Network

- Agreement with Qwest for the current Abilene Network ends in October of 2007
- The new Intenet2 network must be capable of supporting e-science applications
- Strategic Objectives
  - Ensure community control of the underlying (optical) network infrastructure
  - 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 lightpath 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

- A dynamic system of deterministic lightpath capabilities using standardized advanced SONET protocols (GFP, VCAT, LCAS)
- 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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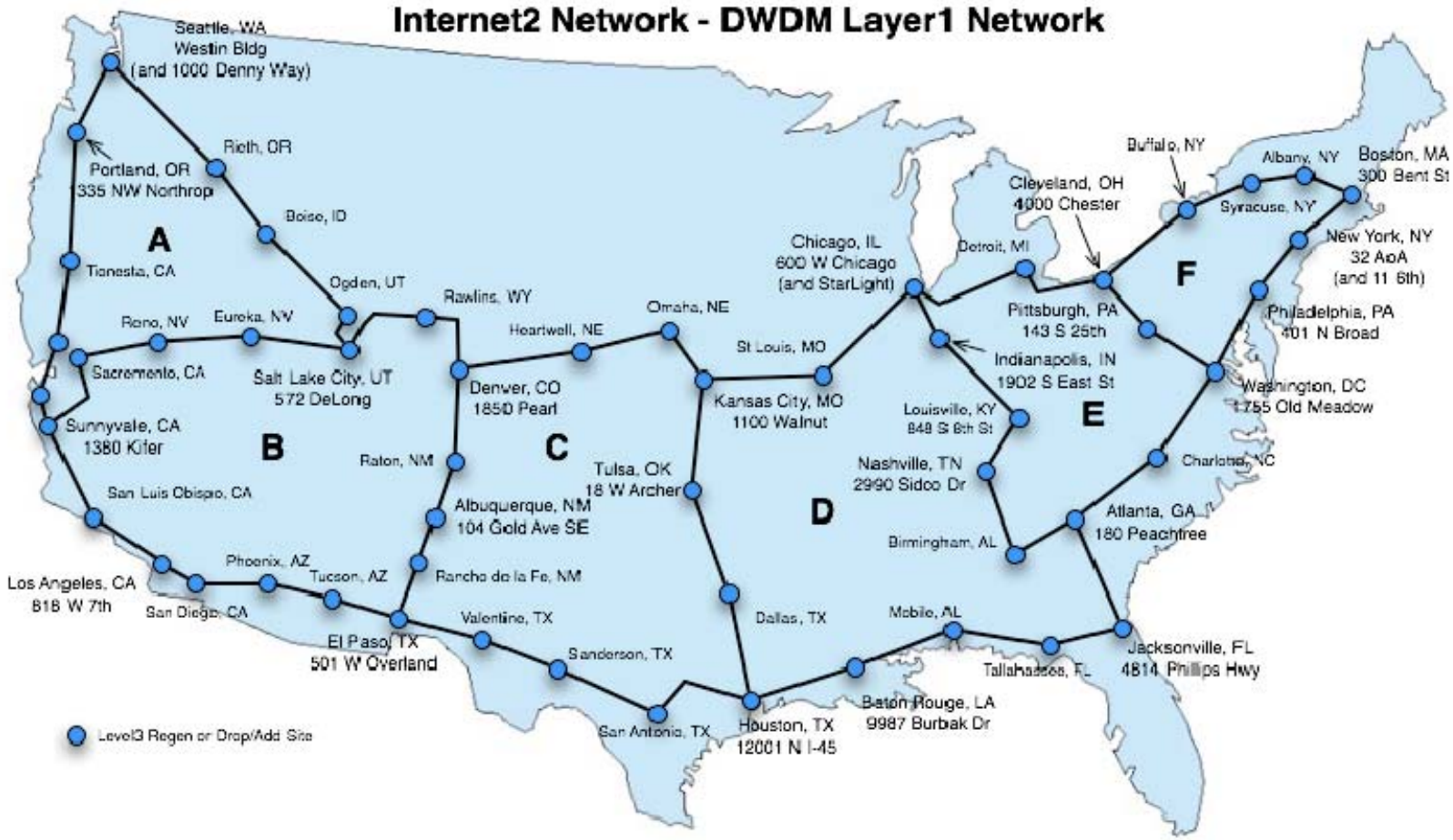
DWDM Topology



Internet2 ESnet Partnership

- 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 deterministic services
- Static and Dynamic services will be available to other partners

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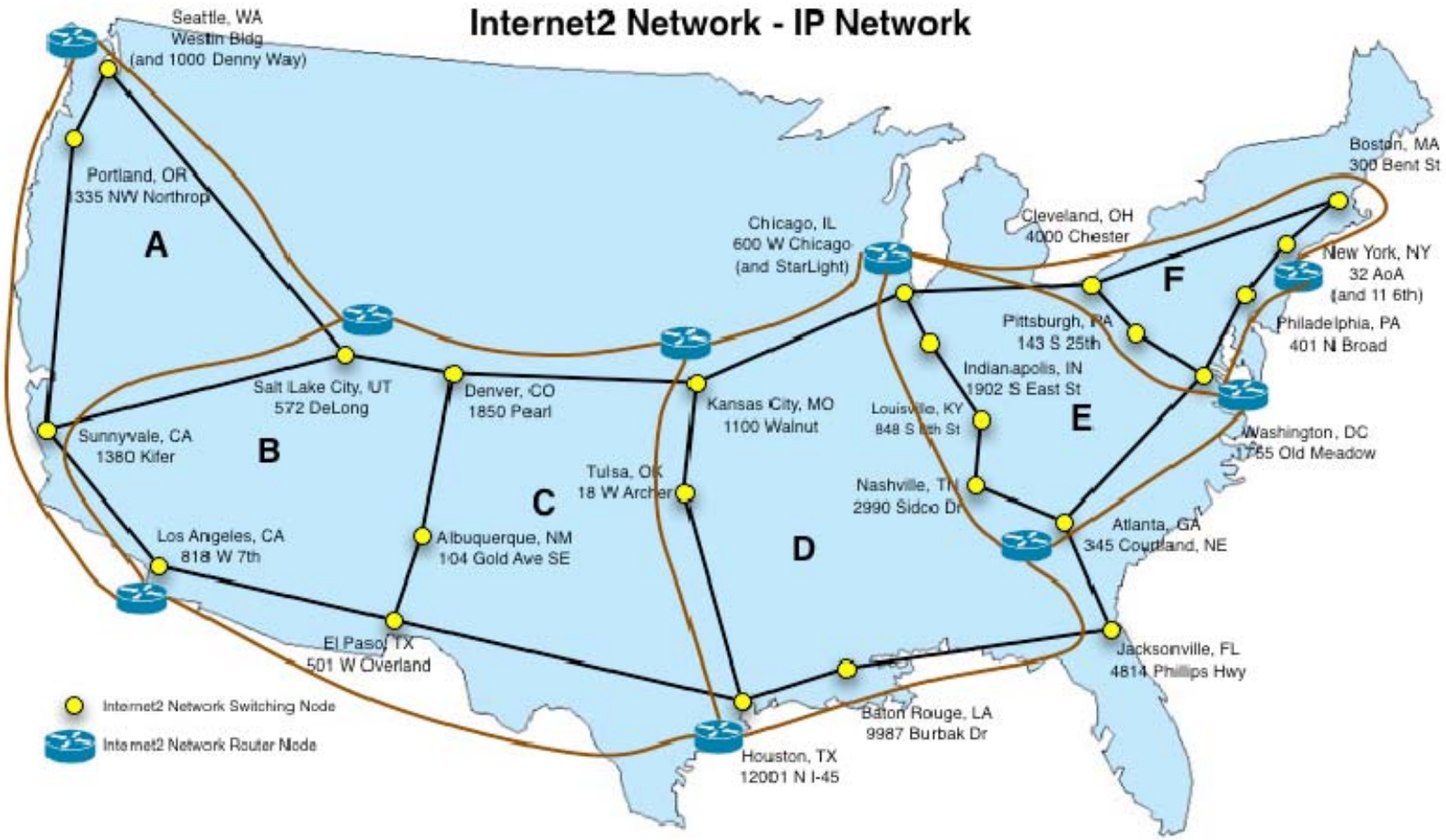
Internet2 Optical and IP Network



The New Internet2 Network - What's Different?

- Hybrid IP and Optical System utilizing Level3 fiber platform; equipment and fiber dedicated to Internet2, sparing and equipment maintenance by Level3, including an SLA for wave system
- Initially provisioned with ten times the capacity scalable to as many waves as needed, and to larger bandwidths per wave
- Dynamic provisioning of circuits and waves across the network within seconds
- Connections and Peerings through IP and circuits (lightpaths)!
  - The ability to create circuits between between researchers and facilities such as international radio telescopes and particle accelerators

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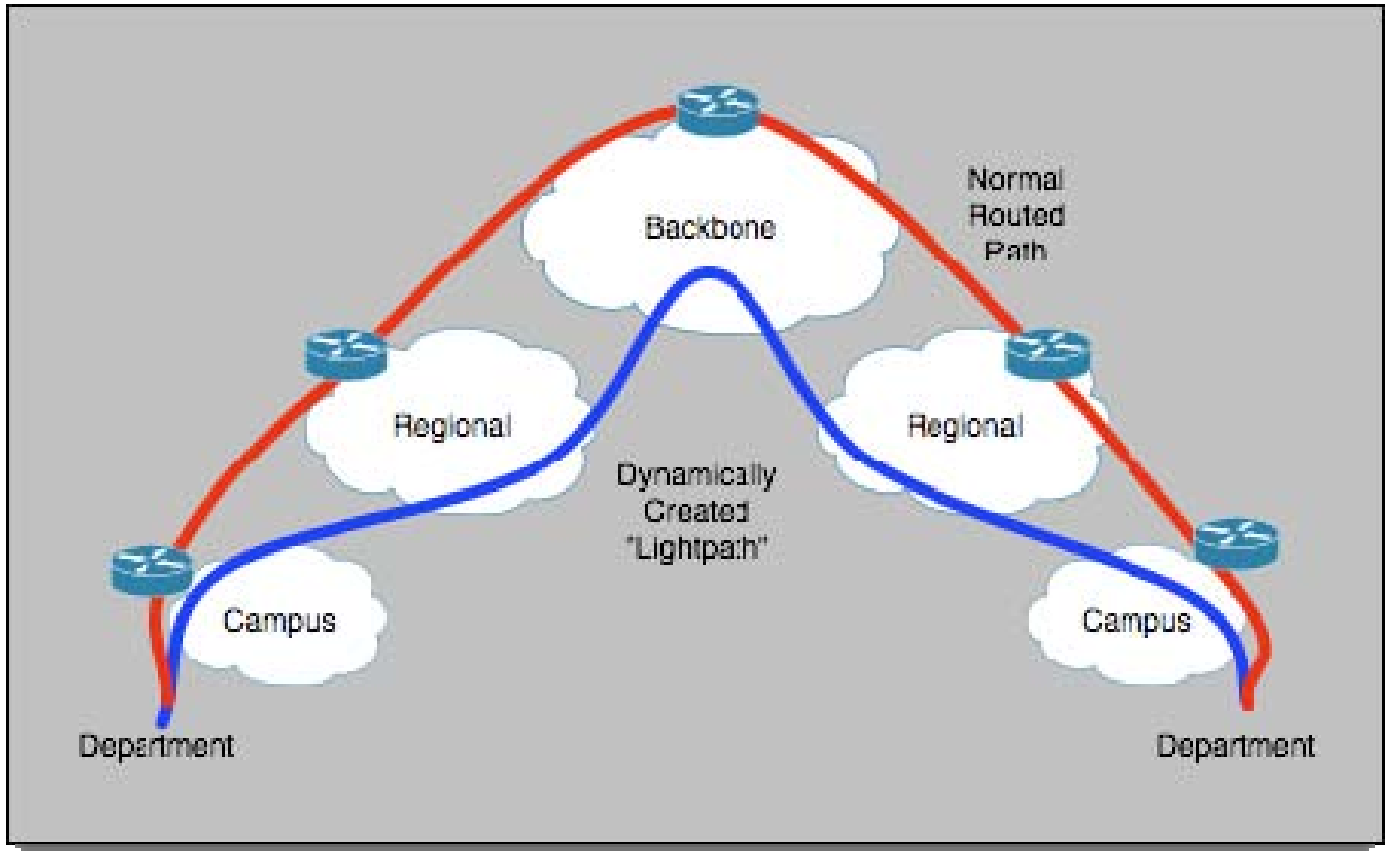
National Architecture (New)



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 (connections) through the optical nodes
  - Currently there are 4 NYC - Europe circuits for hybrid peerings
  - There is 1 NYC - Europe circuit for IP peering
- Currently examining the layer 1 analogy to Abilene as an International Transit Network (ITN)

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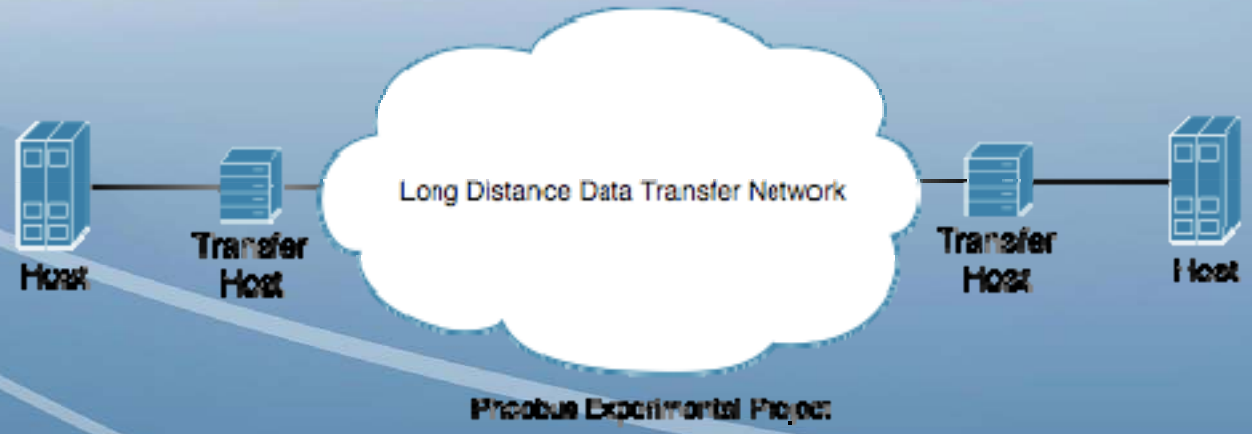
Example Projects on Internet2 Network

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



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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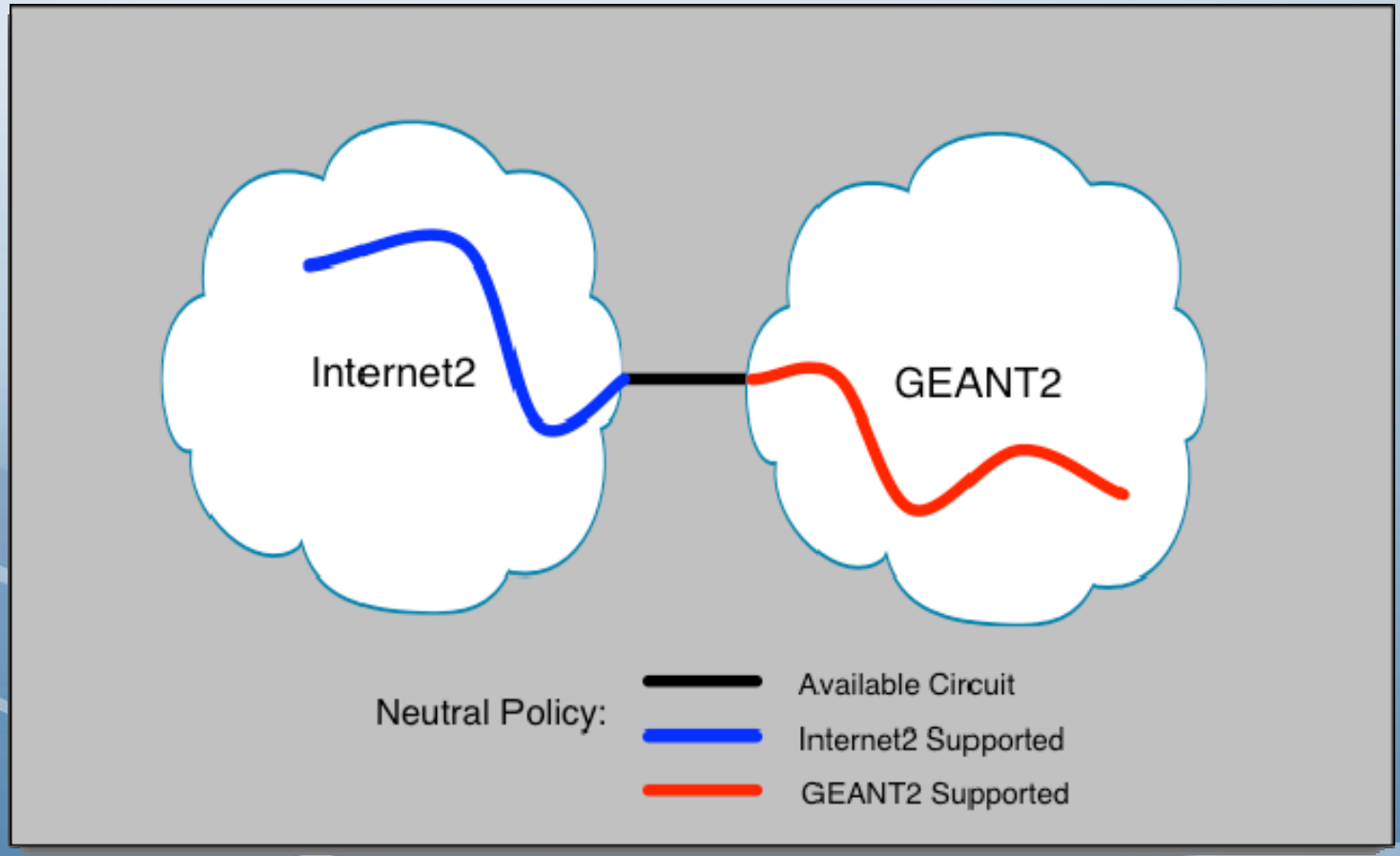
Internet2/GEANT2 Service Trial



www.internet2.edu