Internet2 Update
SA3CC - 2 August 2023

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What is Internet2?

Not-for-profit computer networking consortium <u>led by members</u> from the research and education communities, industry, and government.

500+ members including:
- 251 institutions of higher education
- 9 partners and 76 members from industry
- 100 research and education networks or connector organizations
- 67 affiliate members

In general, Internet2:
- Provides the Internet2 Network - including an optical fiber footprint and cloud connectivity
- Operates international exchange points on the east coast of the United States; helps fund international links and connectivity
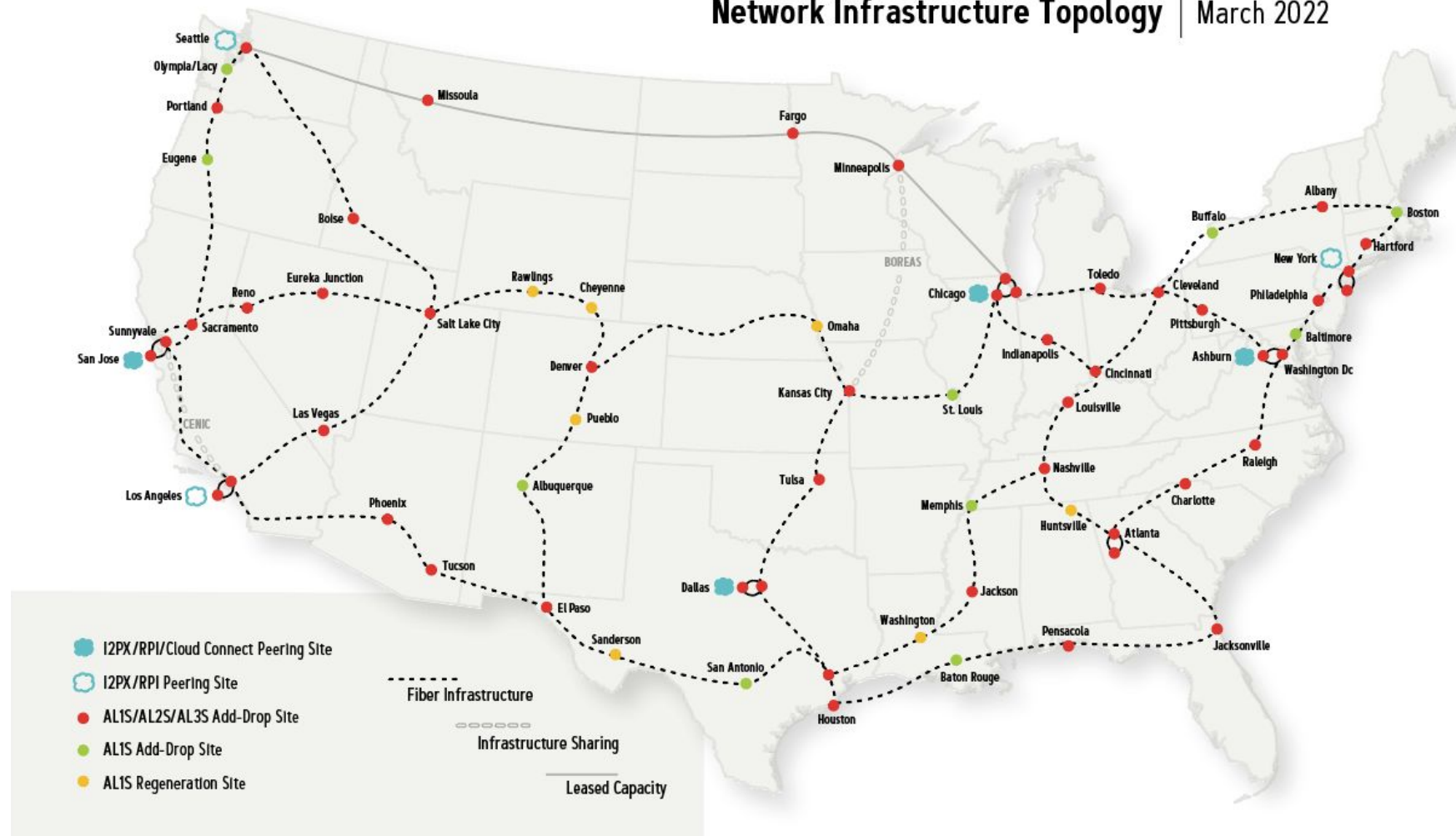- Provides trust and identity services
- Organizes community events
- Engages programmatically in key technology development activities and security topics

What is Internet2?

Network Infrastructure Topology | March 2022

What is Internet2?

- Fifth generation of the Internet2 backbone
- Ninety-four 400 Gbps Backbone links
- 27,600 Tbps of deployed capacity
- 1.6 Tbps available contiguously coast to coast
- Each link is on non-regenerated wave

- Disaggregated Switching/Routing Platform Cisco 8201/8202 - 77 Routers, 47 Sites
- Cisco Network Services Orchestrator (NSO)
- Redundant/resilient routers, dual-connected cloud peers
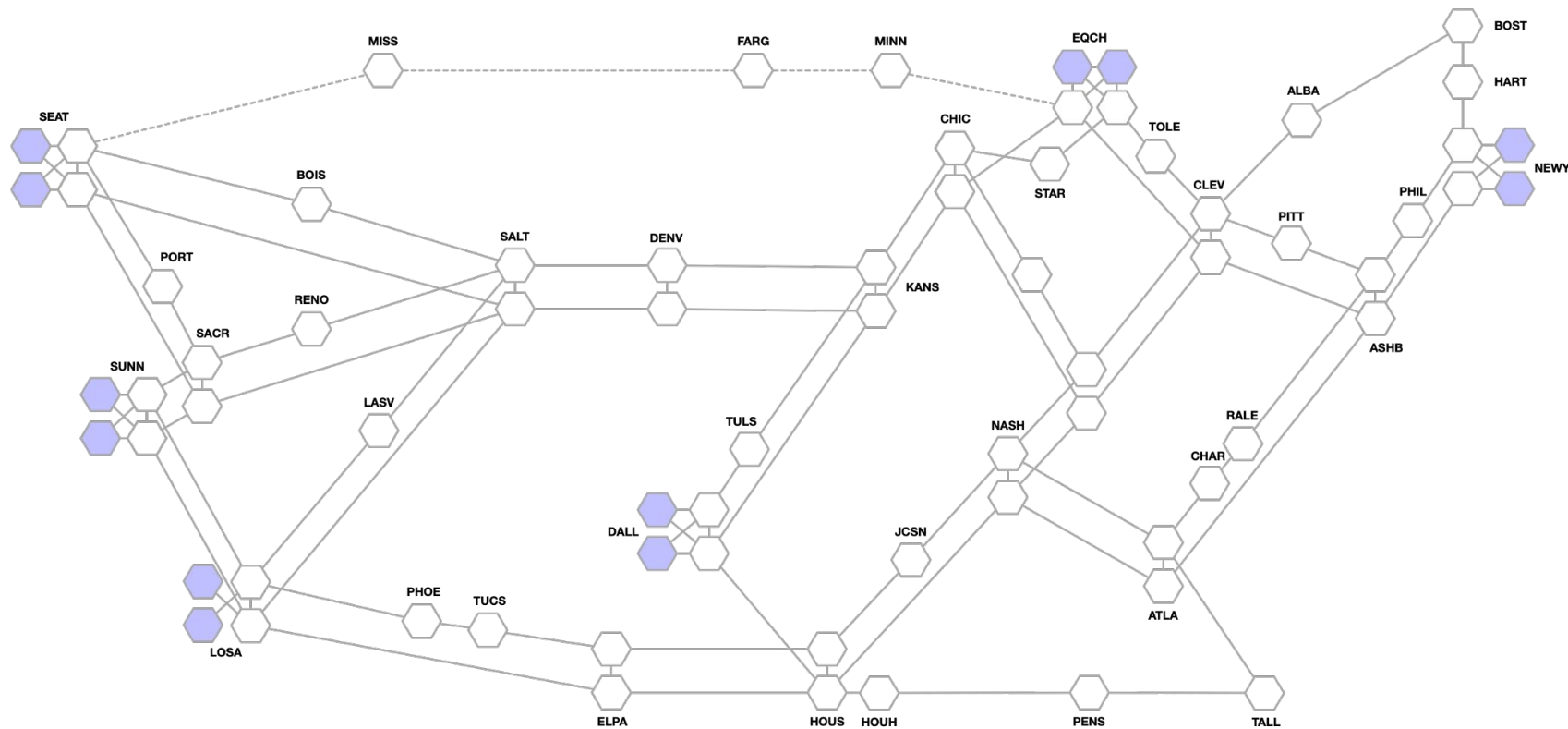
Approach Driven by Community Input

<u>Coordinate</u> with worldwide networks such that they function as systemic, best-in-class resources - ideally coupled with edge computing and storage systems

Provide <u>programmatic support</u> and infrastructure for:
- Grant funded programs. Specifically, experimental deployment of new capabilities using testbeds; which broaden impact and participation through data network-centric activities.
- <u>Data-intensive sciences</u> like LHC; other science and industry R&D program (high bandwidth)
- Cloud-centric applications supporting high-availability applications
- Integrated security, specifically routing integrity (MANRS, DDoS, RPKI-ROV)

Provide s<u>oftware, automation, and APIs</u> which allow for integration of network resources into a global, end-to-end fabric that flexibly allocates, balances and conserves the available network resources

Support regional caches/data lakes and access to network overlays with intelligent control & data planes (e.g. <u>FABRIC</u>, <u>Open Science Data Federation (OSDF)</u>)

Support <u>experiments</u> with fully programmable components (P4, PINS; SRv6; 5G) and operations platforms (NRP; global SENSE Testbed)

Some examples of things we are working on…

Engagement and Innovation	Collaborate Domestically (AP-REX) and Internationally (GREN, GNA-G)
SustainabilityX	Vendor Engagement, Lower Operating Costs Leverage Low Power Chassis, ZR+ Optics
Data Movement, Scalability	Build 400G+ for Infrastructure & Exchange Points High Scale at Edge / Cloud
Security	Promote Route Integrity (RPKI, ROAs)
Data Lakes, Caching, GPUs	Open Science Data Federation (OSDF) Testbeds
Programmability / Topology Visibility	Insight Console, APIs, Extensions supporting NSI, SENSE Enable core with SR-TE, BGP Classful Transport
Performance Assurance	Test Resources, Access to Platform
Programmatic Reporting (IRNC)	Flow Tools, Reporting

Backbone and Service Updates

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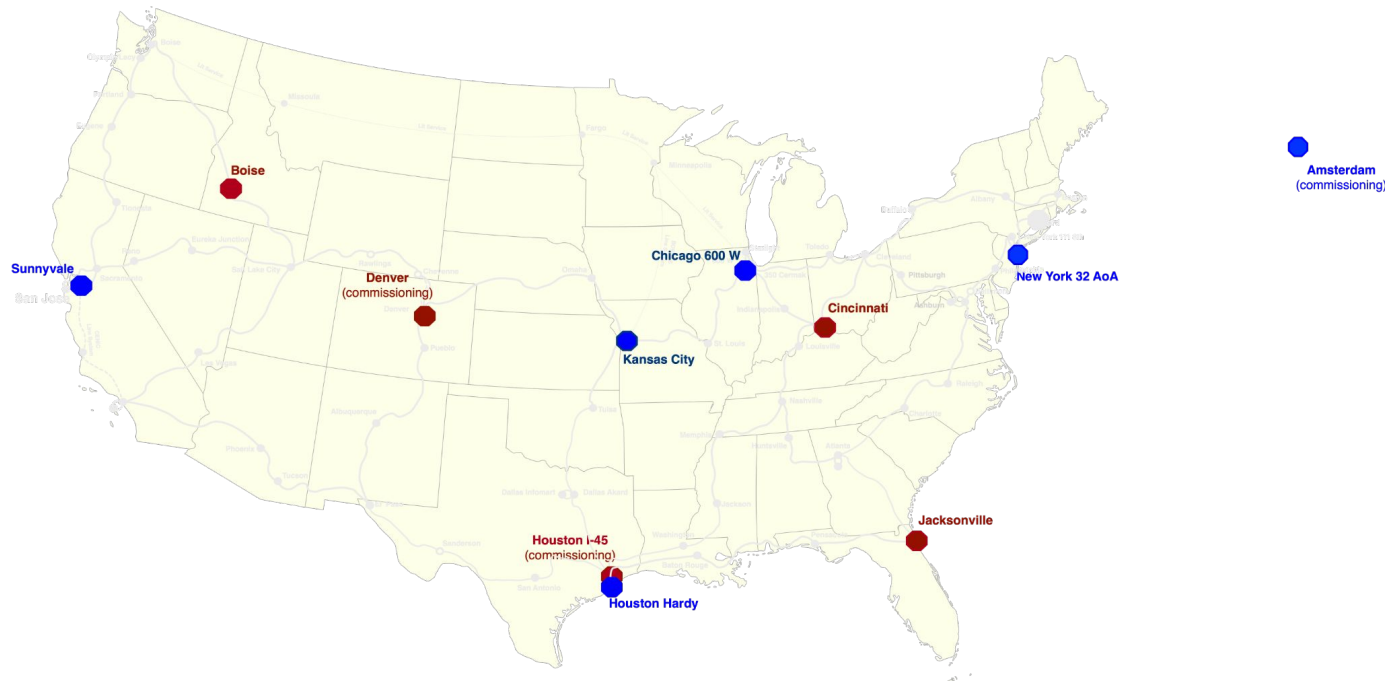- Redundant/resilient routers, dual-connected cloud peers
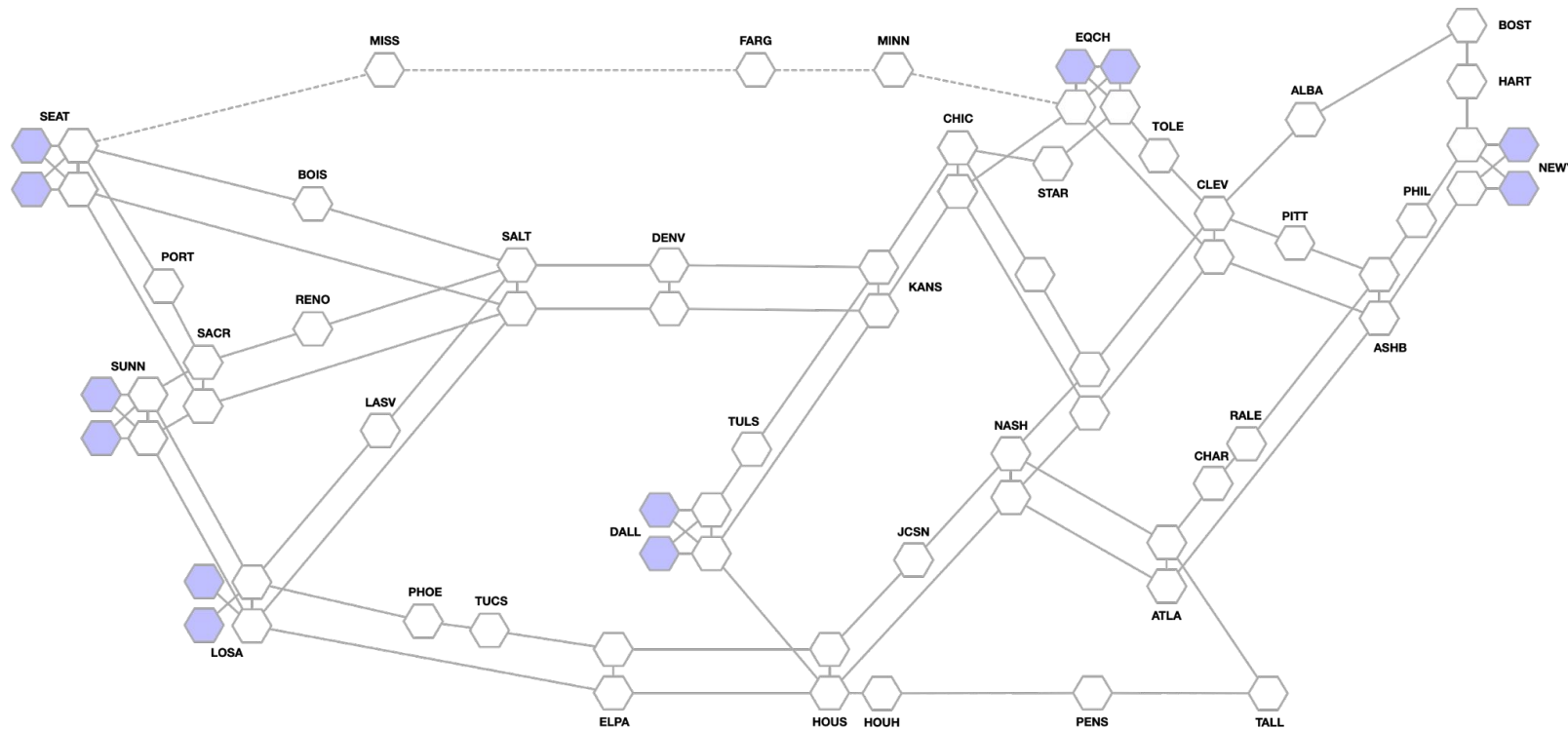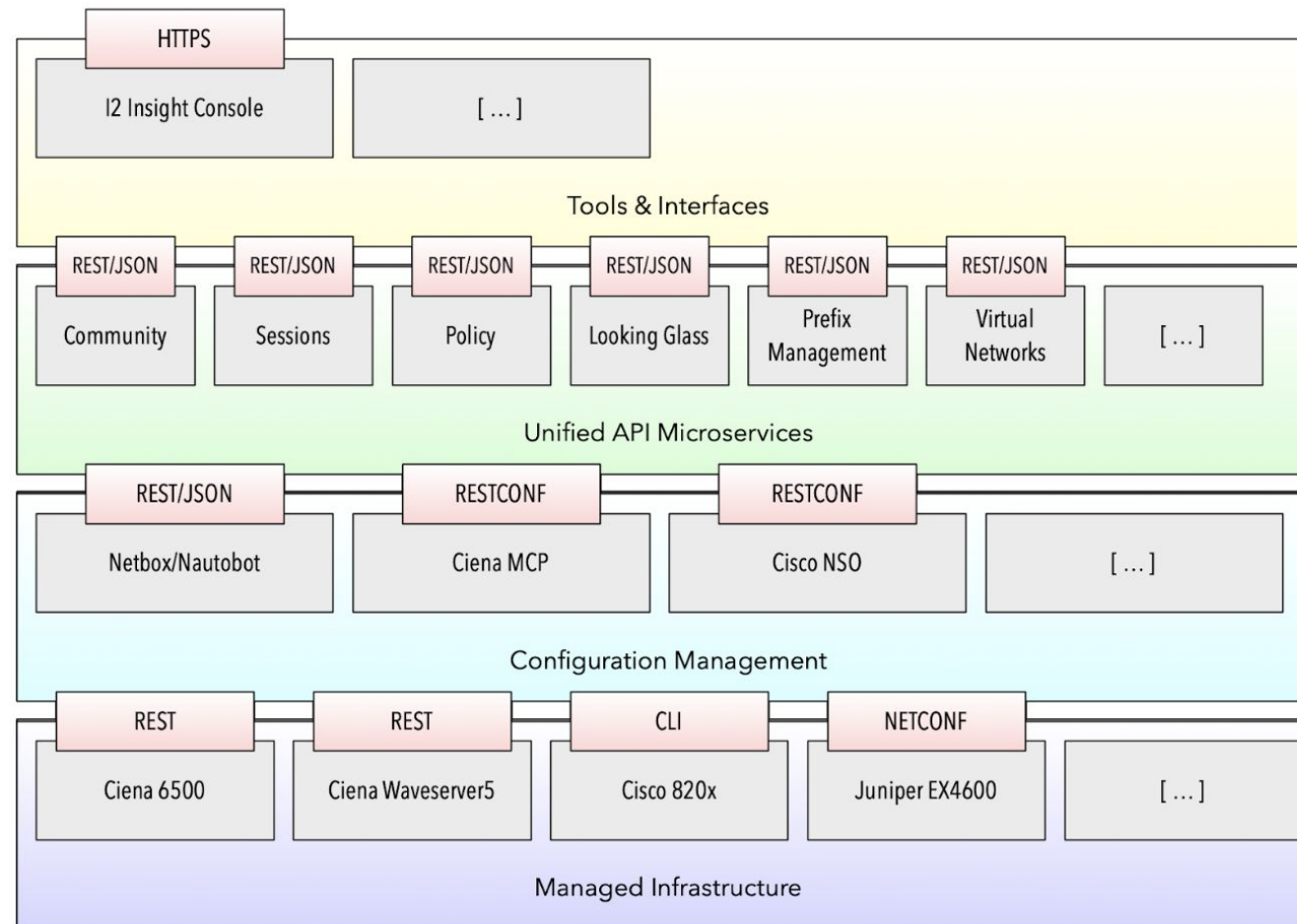
Backbone and Service Updates
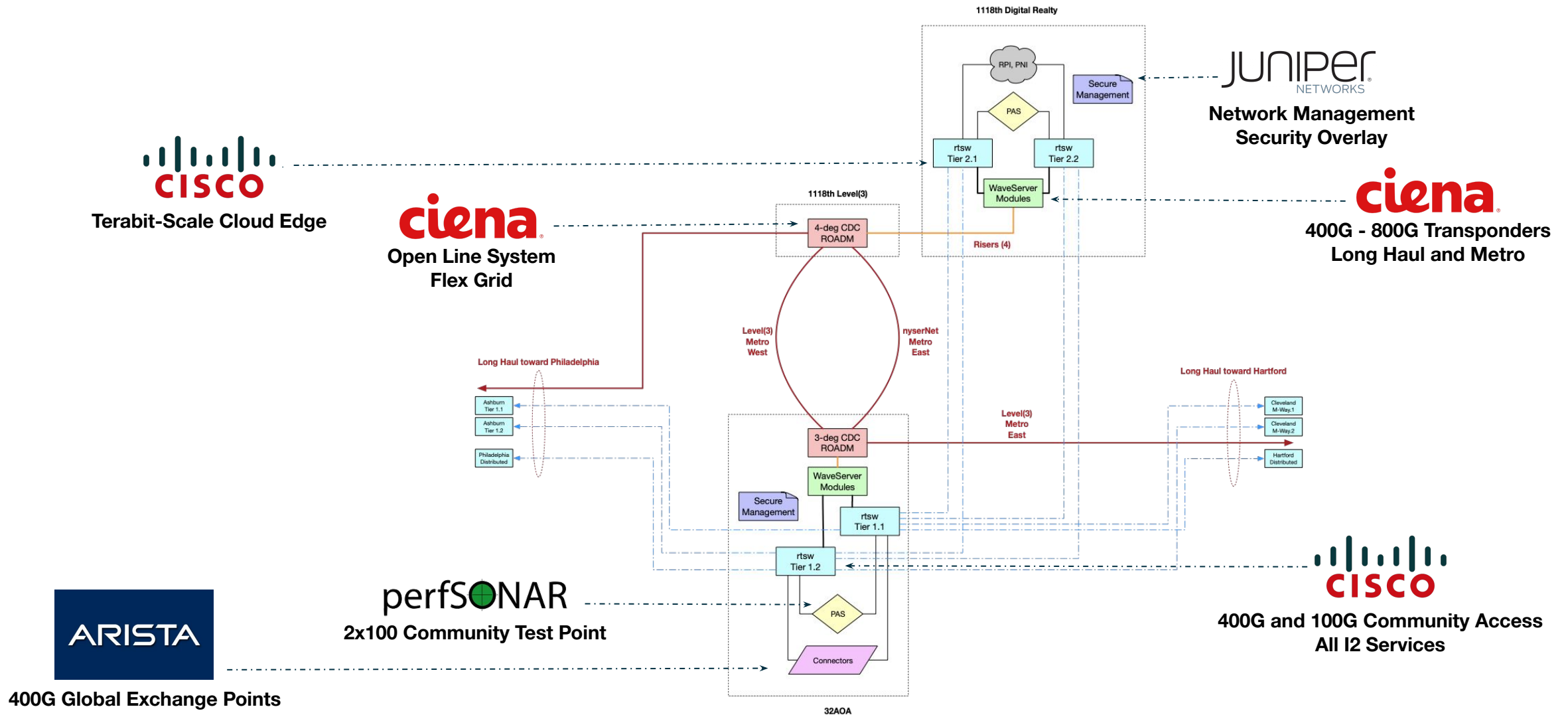
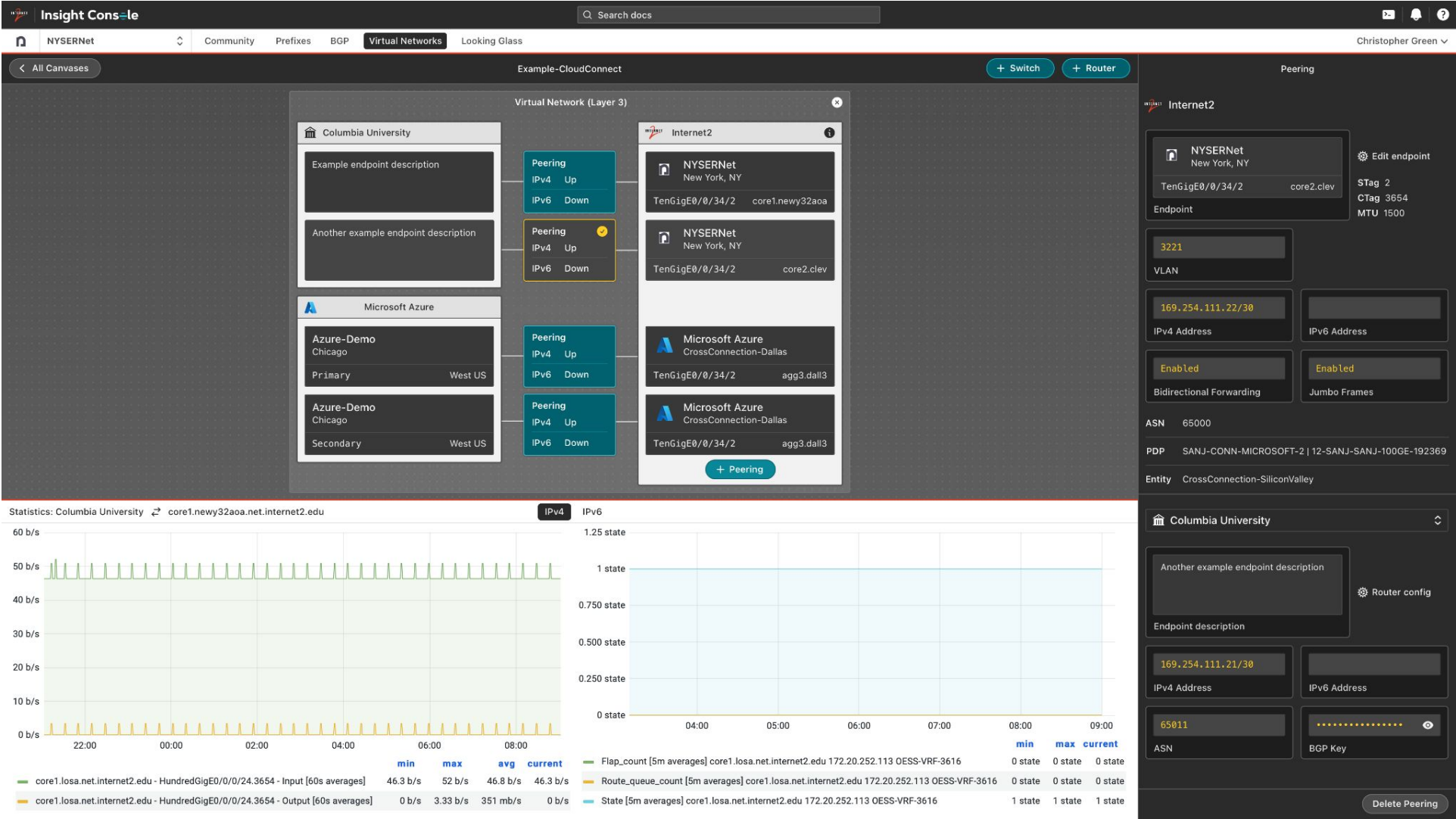# Backbone and Service Updates

Distributed Computing

- Participate in Open Science Data Federation (OSDF)
- Provides Distributed high-throughput computing (dHTC) in support of open science
- Internet2 operates 12 cache / compute nodes
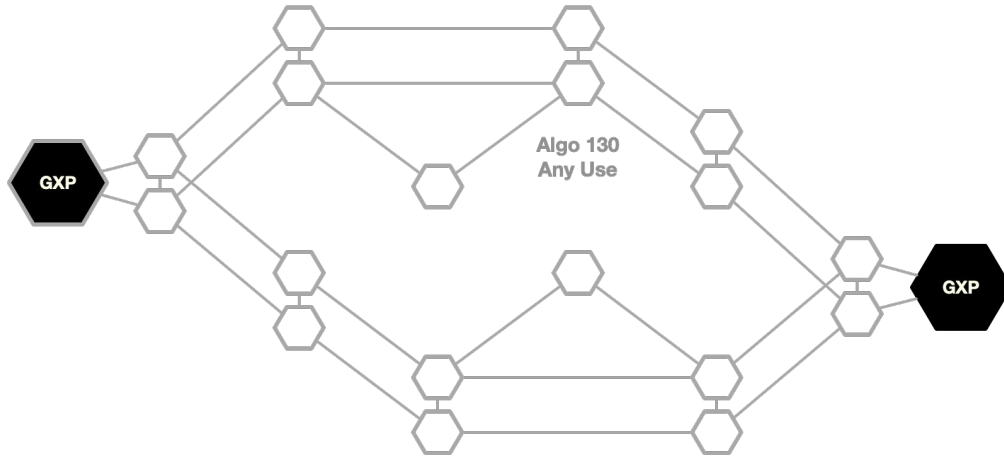- Filling key latency and location gaps

Backbone and Service Updates

Backbone and Service Updates

# Sidebar: Experimental Technologies Under Study

Flexible Algorithm (Flex-Algo)
- Custom Prefix-SID's → "Algo"
- Nodes can participate in any algorithm or multiple algorithms
- Algorithms propagated through IGP
- Algorithms deployed by provisioning system such as NSO
  - allows for **SRTE without controller**
- Example of disaggregated architecture with all nodes in same Algo

International and DIS Example:
constraining traffic, differentiating paths
- Constrain / move any-use traffic to certain paths (Algo 130)
- Provide dedicated links for specific uses (Algo 131)
- Provide N and S differentiation for backup (Algo 128+129)
- Traffic "color" (**BGP-CT or BGP-CAR**) or label can be assigned to particular Algo at ingress
- Theoretically, traffic can be dynamically drained off of certain segments for DIS burst use
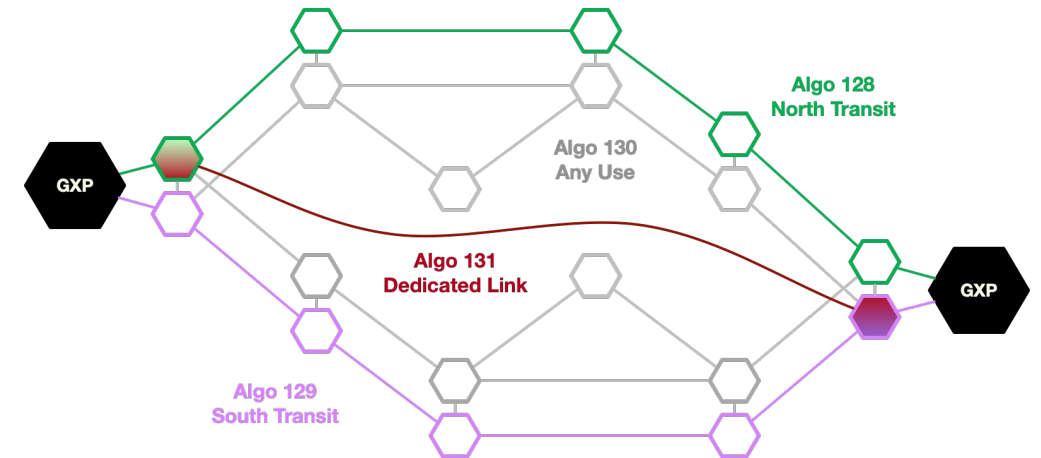
International-Related Areas of Effort

GXPs to 400G - The upgrade of Internet2-operated global exchange points (GXPs) to support 400 gigabit technologies and community-driven automation.

400G R&E transoceanic link - Implementation of the first 400 gigabit links to connect Europe and the UK to the continental United States.

AP-REX 2.0 - A series of related, partner driven activities intended to knit together exchange point operations, technologies, and features in the domestic United States.

   Common GXP features

    Experimental Links

    Internet2 Core Integration

    Software, Automation, and APIs

Programmability and data caching - Targeted implementation of P4 infrastructure and expansion of Open Science Data Federation (OSDF) cashes on both domestic and international footprints

These are best considered as a systemic approach toward support for data-intensive science!
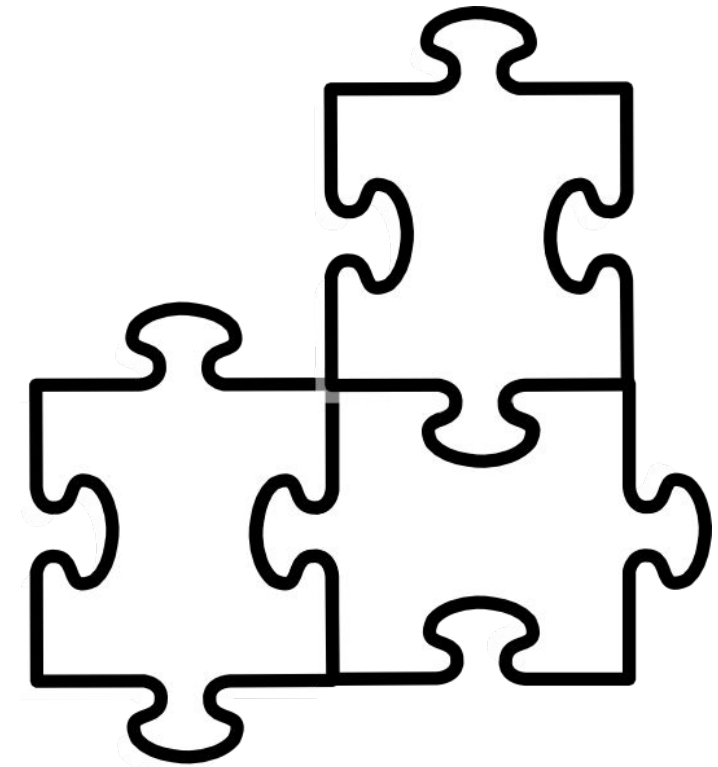
Expanding 400G to Global Exchange Points

Automating and Expanding Exchange Point Functionality; Match Community Development

- Hardware improvements to support 400G, including MAN/LAN and WIX
  - Arista DCS-7280PR3K-24 400G Switch
- 400 Gbps dedicated links between all three exchange point switches
  - ZR+ Optics
- Protocols
  - EVPN MPLS for L2 services (VXLAN Legacy)
  - SR MPLS for inter-node connectivity
- NSO Integration
- ISS Console Integration
  - Dashboard and Health Monitoring
  - Service provisioning

Boston (TBD)

400G

New York (MAN/LAN)

400G

Washington DC (WIX)

Myrtle Beach (Potential Future I2 GXP)
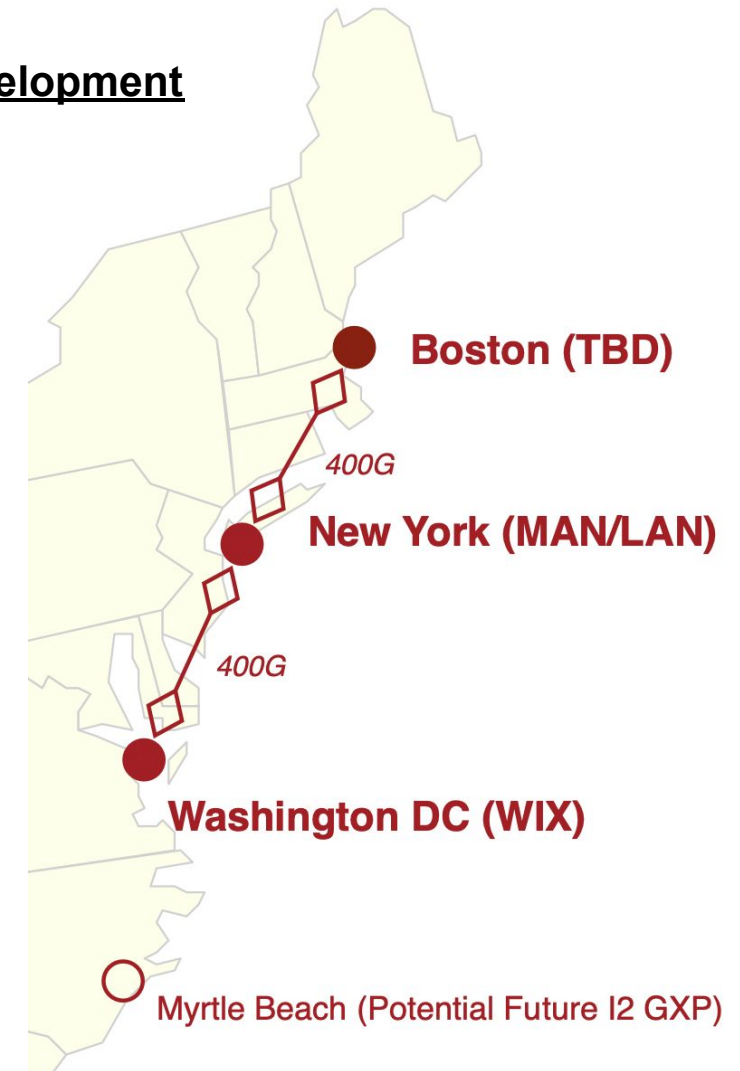
First 400G Transoceanic Links

400G Transatlantic Capacity Additions/Upgrades on Amitié cable

- 1 x 400G for Internet2/CANARIE
- 2 x 400G for ESnet
- **Expected no later than mid-October**
- Add Boston as open exchange point

- Exploring options on other cable systems, including Pacific Ocean
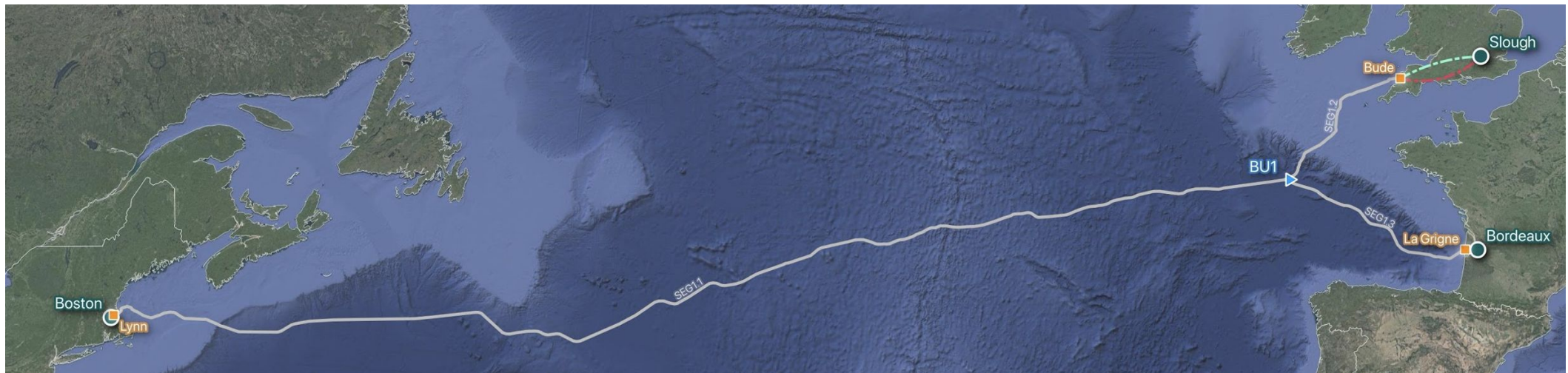
Supporting Community Transoceanic 400G Development

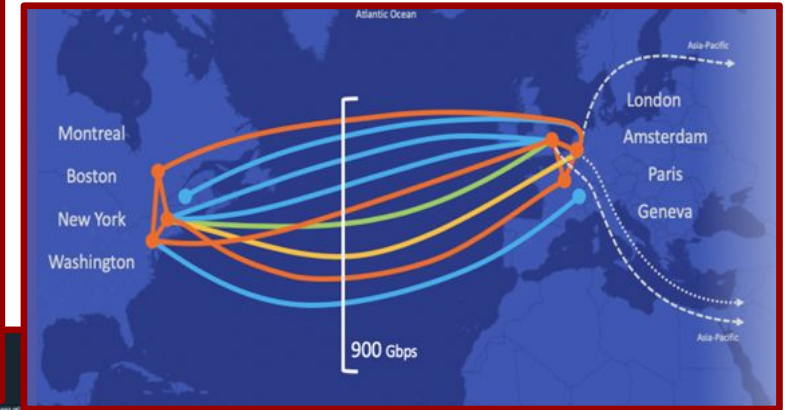**<u>Provide support to community for adding 400G diversity / triversity in all regions:</u>**

- Logistical
- Contractual
- Financial
- Staff Time
- Relationships with vendors

In tandem with...

- APOnet
- ANA
- FIU
- et al

AP-REX 2.0 Vision

- Create Domestic Consortium of Exchange Point and Link Operators

- Improve Coordination of Activities - GXPs may operate differently but we can all work together!

- Enable / optimize funding vehicles and grant opportunities for all parties

- Provide for efficient use of resources for transcontinental traffic, including:
  - Leverage common cores for routing production traffic to minimize operating costs
  - Provide dedicated links for experimental and meeting specific use (SC)

- Support research testbeds (e.g. FABRIC, BRIDGES)

- Encourage consistent set of operating principles and software features, such as:
  - NSI/AutoGOLE/SENSE
  - P4 and related instrumentation
  - Performance Assurance Services (PAS) test infrastructure (e.g. perfSONAR)
  - Measurement, monitoring, and reporting applications (e.g. NetSage, iGROK, stardust)

AP-REX 2.0 Vision

Midwestern Exchange Points
**Automation and Software Expertise**
(SDN, SDX, SDI…)
Transport Infrastructure
Research Programs
Technology Research
Strong Track Record of IRNC Awards

Automation and Software Expertise
(Stardust, AutoGOLE, etc)
Transport Infrastructure
Research Programs
Technology Research

East Coast Exchange Points
Atlantic Connectivity
Transport Infrastructure

Pacific Coast Exchange Points
Pacific Connectivity
Transport Infrastructure
Research Programs
Automation and Software Expertise
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Strong Track Record of IRNC Awards

East Coast Exchange Points
Atlantic Connectivity
Automation and Software Expertise
Transport Infrastructure

Europe and Asia-Pacific Connectivity
Research Programs
Automation and Software Expertise
Strong Track Record of IRNC Awards

Gulf Coast Exchange Points
South America, Africa, and
Caribbean Connectivity
Research Programs
Automation and Software Expertise

MOXY
STARLIGHT
ESnet
PACWAVE
IU International Networks
MAN/LAN WIX BOSTON
AMLIGHT

# Initial AP-REX 2.0 Transport Architecture Concepts

Leverage Internet2 NGI Core Network for Routine GXP Transit Traffic
- Routine traffic; commodity purposes
- Persistent production quality transport
- Path selection coming in future Cisco IOS-XR releases
  (along the lines of FLEX-ALGO)
- Potential support for multiple traffic classes to be developed
  (along the lines of BGP-CT, traffic-marking)
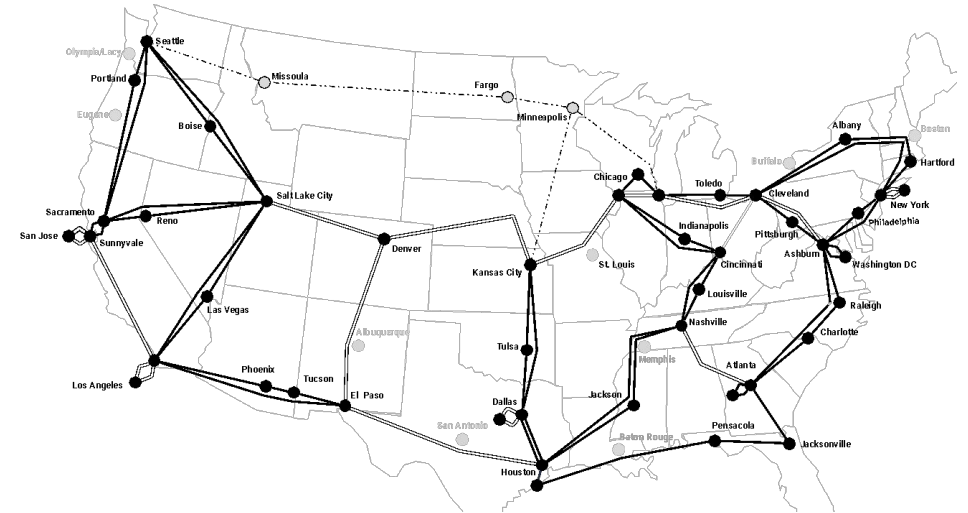
Leverage Dedicated Waves for Programmatic Experimentation
- Example: Supercomputing, Data Mover Challenge
- Part of AP-REX Consortium Efforts, some potentially funded grants
- Persistent but movable
- 400 Gbps Native
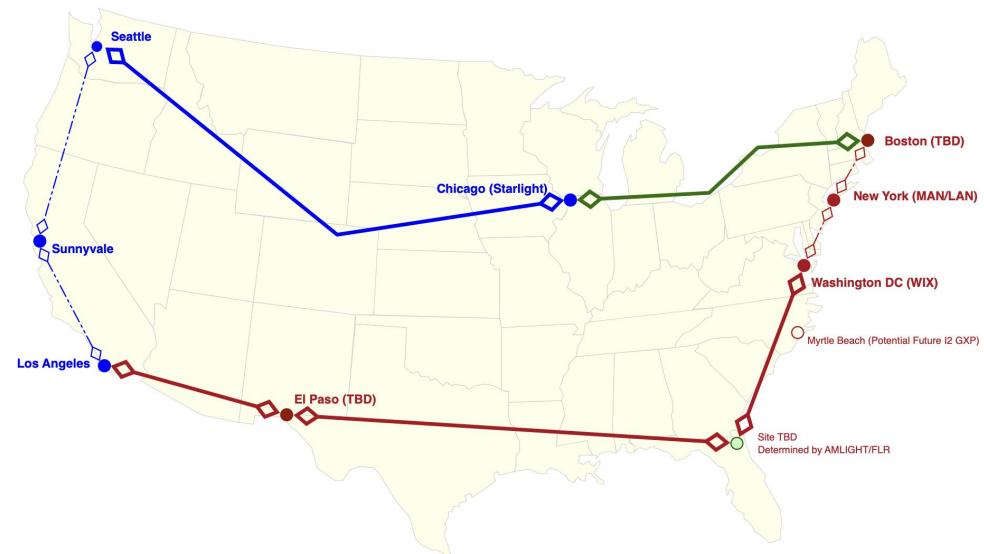
WHAT'S NEXT

Complete Deployment of New 400G Links and GXPs (Q2 and Q3 of 2023)

Deliver Insight Console, APIs, and NSI-functionality to new Software Stack (Q4 of 2023)

Experiment with Expanded Core Network Functionality to Support Data-Intensive Use Cases (2023+2024)

Expand AP-REX Domestic US Consortium for Global Exchange Point Coordination
    MOUs, Roadmaps, Initial Work (2023)
    Expand Footprint, Add Features, Iterate (2024+)

Begin to merge improvements in core network technologies and software stack developments into general use (2024+)