Internet2 Advanced Networking

Americas' Research Platform – Oct. 11, 2022

Christian Todorov, Network Services, Internet2

CELEBRATING 25 years 1996-2021

Agenda

- Next Generation Networking & 400G
- Network Performance Assurance
- Network Automation and Orchestration
- Cloud Connectivity

Internet2 Networking Overview and 400G

Next Generation Infrastructure

The NGI project has three phases:

- An upgrade of the underlying fiber, and the optical equipment to support 400G
- A complete replacement of the packet network and installation of a new Performance Assurance System (PAS)
- Implementation of Arroyo platform to support automation and orchestration of the new network and deliver new services to the community

NGI Principles

The Next Generation Infrastructure Program is a full set of activities to review and update the services, value and supporting technology of the Internet2 infrastructure portfolio (and relationships in the larger ecosystem)

- Includes the services and service models through which the community adopts Internet2 infrastructure services
- Includes new features, primarily driven by software, automation and systems virtualization to allow the infrastructure to be more readily integrated into the broader enterprise, campus, regional and cloud environment around us
- Greenfield approach was selected to ensure optimal hygiene and best value of delivered system

Data-Intensive Research

Enhanced Cloud Access

Software-Driven Infrastructure

Sustainable Economics

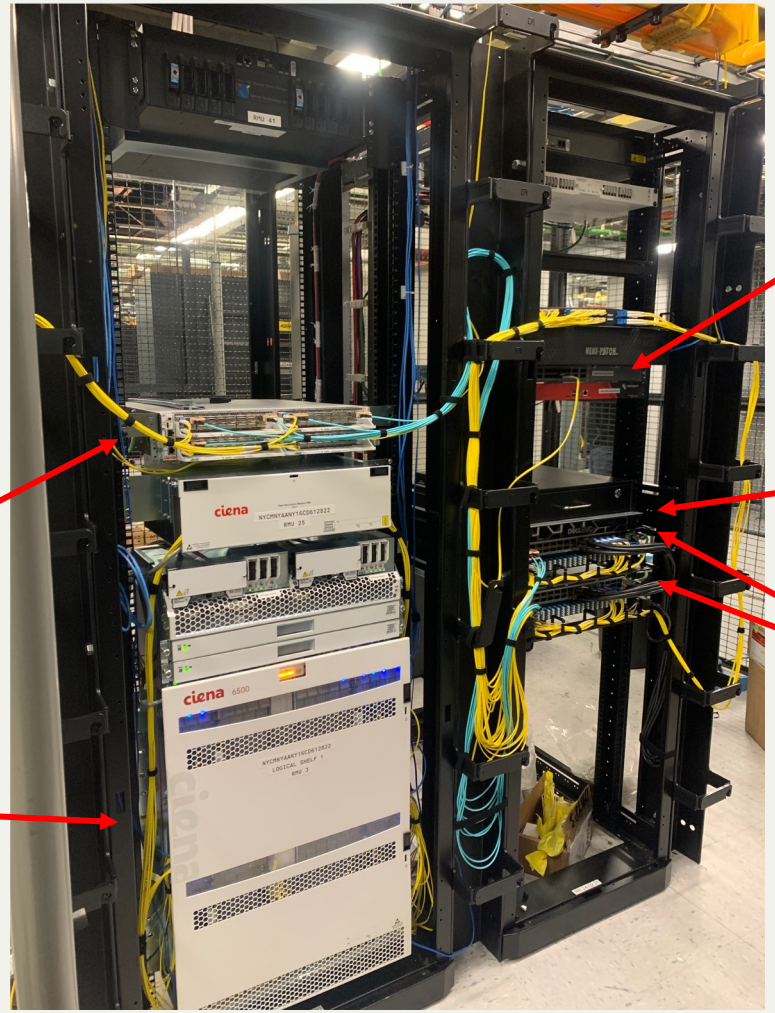
Infrastructure Sharing

The Internet2 Network

- Internet2 Network
  - 400G native networking – one of the first networks globally to deploy 400G at scale
  - 18,700 miles of dark fiber. Replaced ~ 80% I2-IRU nationwide LEAF fiber with new low-loss SMF-28 Ultra single mode fiber (through 2042)
  - 32Tbps of optical capacity per link
  - Assured supply chain for all networking vendors; equipment certifications:
    - 6500: JITIC, NIAP/CC, CMVP
    - Waveserver 5: NIAP/CC, CMVP
    - Cisco 8200: NIAP/CC, CMVP;
    - WS5 & 8200: JITIC - in process
  - 24x7x365 Production-level engineering and NOC support

JITIC: Joint Interoperability Test Command
NIAP/CC: National Information Assurance Partnership/Common Criteria
CMVP: Cryptographic Module Validation Program – Supported capability; no current demand for encryption

GREENFIELD TECHNOLOGY BUILDOUT



Secure Management Network
Terminal Server
Firewall / Switch

Performance Assurance Node
Dell R6515 Server
Mellanox ConnectX-5

NGI Packet Node
(2) Cisco 8201 – 24x400G & 12x100G

NGI Optical Platform
Ciena WaveServer 5
32-slot C6500 Open Line System

MASSIVE SCALE WITH SMALLER CARBON FOOTPRINT

	2010	NGI Online 2022	Impact
Total Annual Traffic	104 PB	2,785 PB	Increase of 26x
Backbone Link Capacity	250 Gbps	127,700 Gbps	Increase of 500x
Total Device Capacity	453 Gbps	810,000 Gbps	Increase of 1800x
Footprint Power Utilization	300,000 Watts	100,000 Watts	Decrease by 2/3x

Internet2 Networking Performance Assurance and Operational Transparency

Next Generation Infrastructure

The NGI Project Second Phase:

- An upgrade of the underlying fiber, and the optical equipment to support 400G
- A complete replacement of the packet network and installation of a new Performance Assurance System (PAS)
- Implementation of Arroyo platform to support automation and orchestration of the new network and deliver new services to the community

New Internet2 Performance Assurance Service

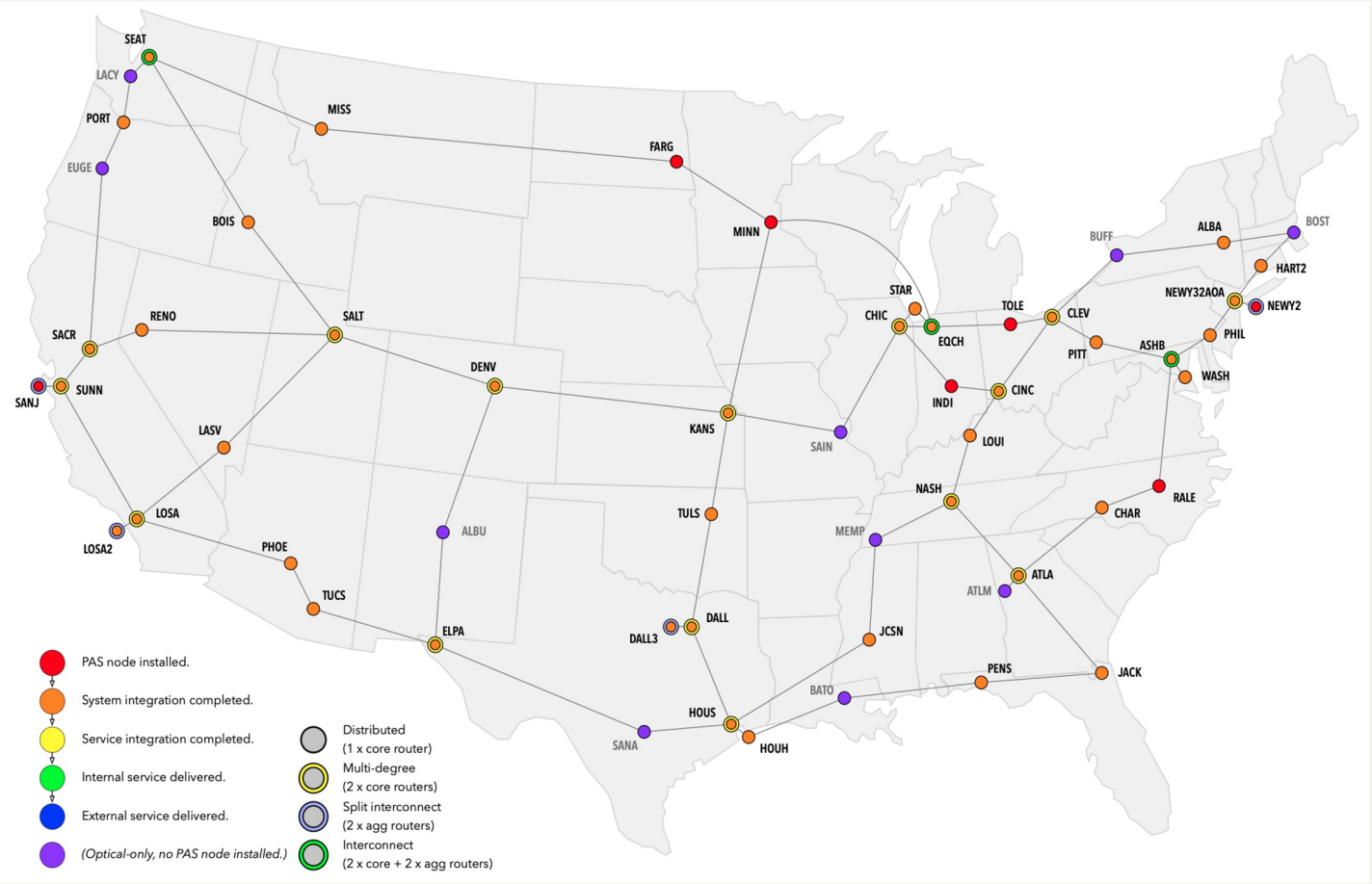
47 Node 2x100G dedicated perfSONAR nodes

- 43 nodes installed and reachable
- 3 nodes pending installation

100G interface for internal PAS mesh and other 100G interface for ad hoc and external testing

Initial deployment projected to be complete by end of year

- Performance tuning:
  - Initial configuration in place
  - Final tuning is pending



Operational Transparency

Mission

Provide security-preserving operational transparency to the network operator, user and application developer communities to aid in application development and troubleshooting, and for network visibility and validation.

Moving Network Operations into the Light

- PAS Nodes:
  - Published, persistent link-based network health and performance tests, e.g., jitter, loss, latency, throughput, etc.
  - Policy-managed, user-controlled ad hoc tests across the backbone up to 100G
- Looking Glass:
  - Policy-restricted, Role Based Access Control and abstracted access to, and restricted output from Internet2 routers for curated “show” commands, enabling enhanced network visibility to network operators, researchers and application developers
- Published Maintenance Reporting and Live Status

Internet2 Networking Software Architecture

Next Generation Infrastructure

The NGI project moves to its third phase:

- An upgrade of the underlying fiber, and the optical equipment to support 400G
- A complete replacement of the packet network and installation of a new Performance Assurance System (PAS)
- Implementation of Arroyo platform to support automation and orchestration of the new network and deliver new services to the community

- Early efforts will focus on:
  - ✓ Deployment of NSO for network service modeling, automation, orchestration, and management
  - ✓ Development of NS Insight Console
  - Incorporating the ability to manage people and their roles across our ecosystem using IAM resources

Internet2 Insight Console -
Delivering the next generation of network-based services for the R&E Community

- Leverages the automation and orchestration capabilities of NGI
- Delivers on requirements from enterprise and researchers for ecosystem-wide solutions
- Incorporates the ability to manage people and things across our ecosystem through IAM, so important in a software-based world
- Addresses need to improve routing integrity within the R&E community

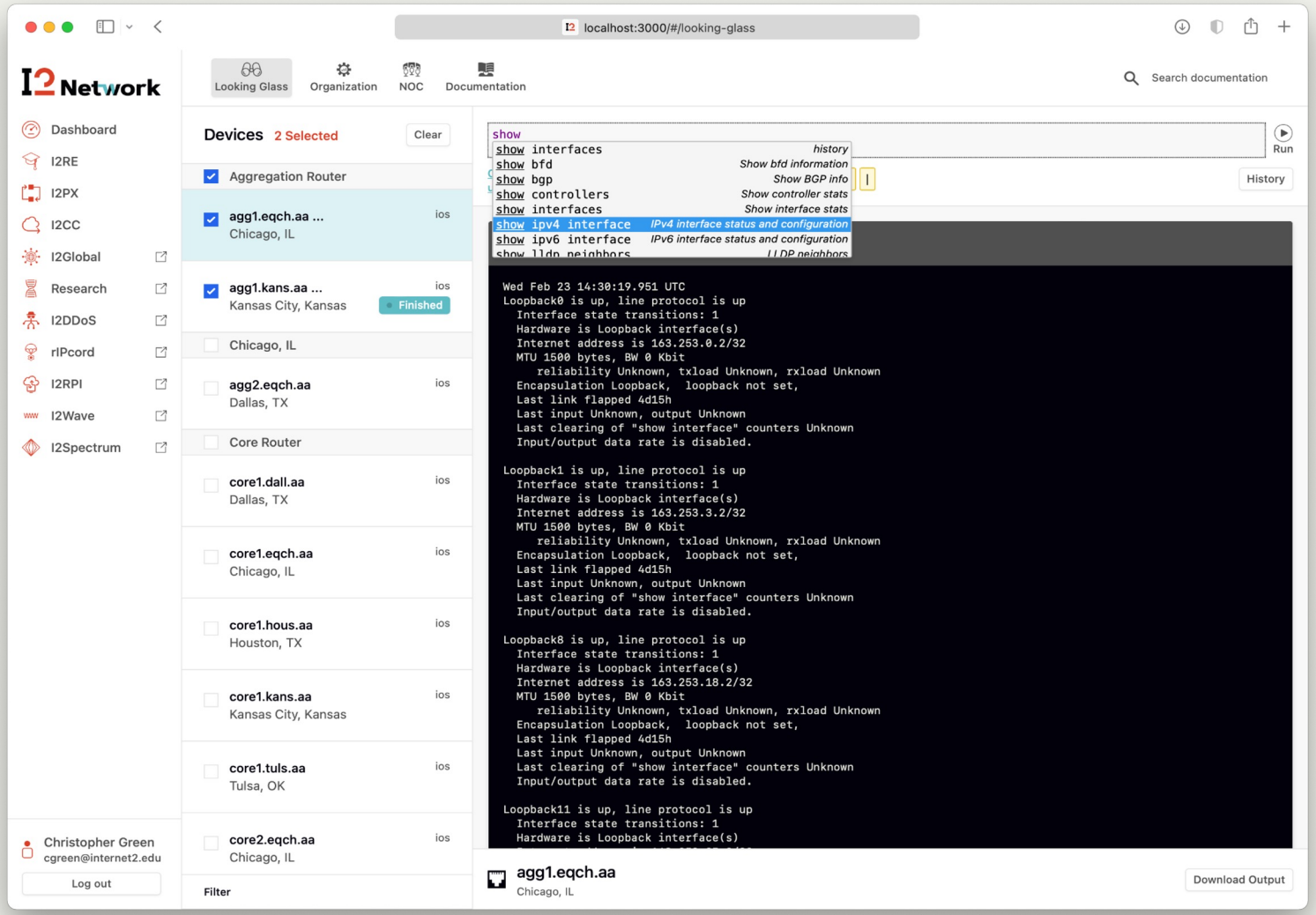
Three Phases of Insight Console Development

- Implementation of existing services
  - Looking Glass
  - Routing Portal
  - Cloud Connect Portal/Virtual Network Portal
  - Introduction of Role Based Access (IAM)

- Community input to Insight Console roadmap during Fall 2022 for implementation by end of 2023
  - e.g. What tools and services will be needed by the Members to meet their needs?

- Community input to a sustainability model for the Insight Console by 2024
  - e.g. What tools and services will be needed by the campuses & others to meet their needs ?

I2 INSIGHT CONSOLE AND API DEVELOPMENT

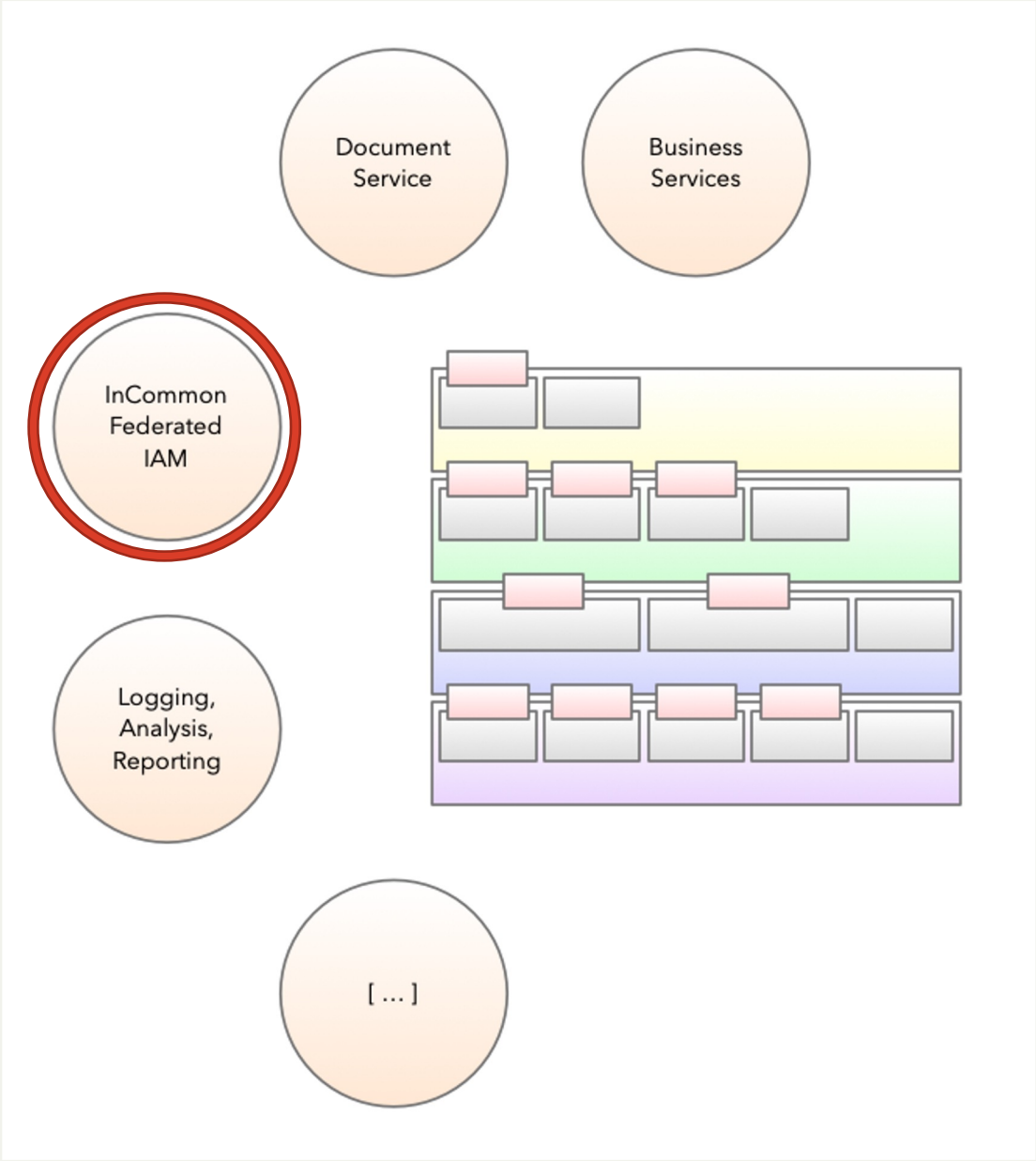


"Internet2 Insight"

- Access to many (or all) of our software-controlled services.
- Single unified front-end which may access external applications and APIs as needed.
- All console functions use an underlying API layer, which may be exposed in the future through other tools or directly to members who want to integrate their own tools.
- Will eventually encompass international provisioning.

Arroyo External Integrations

- **InCommon Federated IAM**:
  - Fundamental to our ability to support role-based end to end access to services
  - Foundational to determining who is authorized to access the services that will be developed by the community
  - A vital component in supporting security needs such as Zero Trust Network environments



AUTOMATION as APPLIED TO NGI

NSO service models heavily leveraged for service deployments
- Minimal, simple parameters needed to produce complex device configuration
- All changes are atomic across network

Layer 3 (BGP) service migrations successful with NSO
- Imported legacy network/DB data to produce NSO-generated service configurations
- Allowed migration of 1800 peerings in ~30 days (up to 150 / night)

Validation tooling under NSO determined success (quality assurance)
- BGP prefix acceptance/rejection monitoring before and after migrations
- Allows rapid validation & success of migrated services

Test Driven Development
- Rapid iteration of NSO service models with testing to deter regression
- Decrease time needed for new service deployments

Configuration Control / Monitoring
- Manual changes on devices are identified and flagged for reintegration into NSO models
- Ensures minimal drift

Time savings is not the entire picture

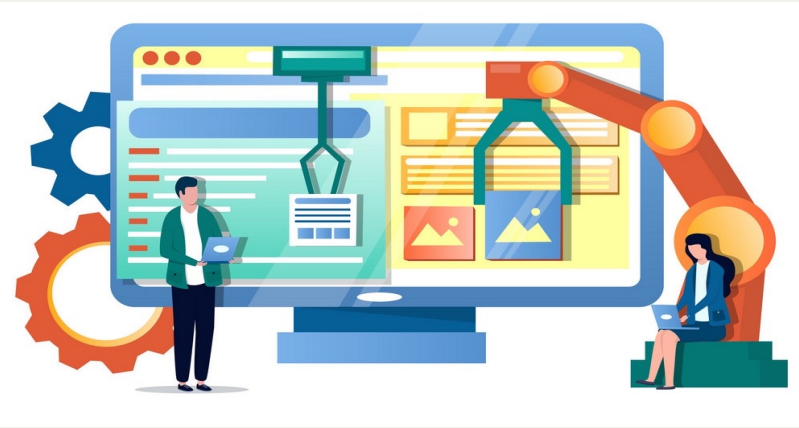
Consistency

Reduce engineer fatigue

Queue up changes in advance

Reliability (no fat fingering)

Tooling also provided validation input



Internet2 Networking Cloud Connectivity

Next Generation Infrastructure

Getting to the Cloud

Internet2 Peer Exchange
I2PX

Use of existing 3Tbps of peering capabilities to the major cloud providers for access to cloud SaaS services (e.g., Zoom or Office 365) – **shared** service

Internet2 Cloud Connect
I2CC

Enables connectors to use the Internet2 infrastructure to obtain up to 5Gbps of "direct-connect" **private** Layer 2 and Layer 3 access to Microsoft, Amazon and Google cloud platforms at no additional fee. Extending your data center to the cloud. (Cloud provider fees apply)

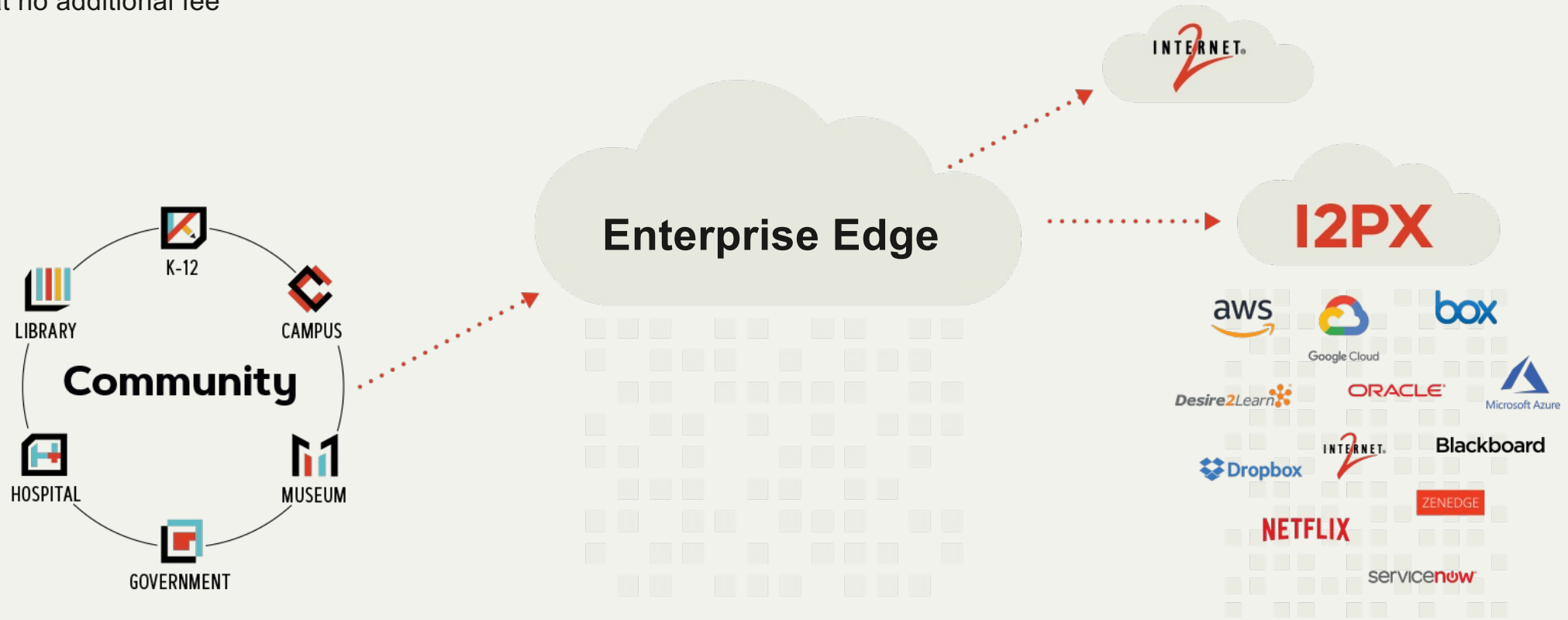
Internet2 Rapid Private Interconnect
I2RPI

Provides **private dedicated**10G interconnections at major peering points across the country at low annual rates. Leverages current Internet2 infrastructure to reach cloud providers, for dedicated access or improved resiliency. May be used to connect to any commercial provider located at the peering point

Designed to Deliver

Internet2 Peer Exchange
I2PX

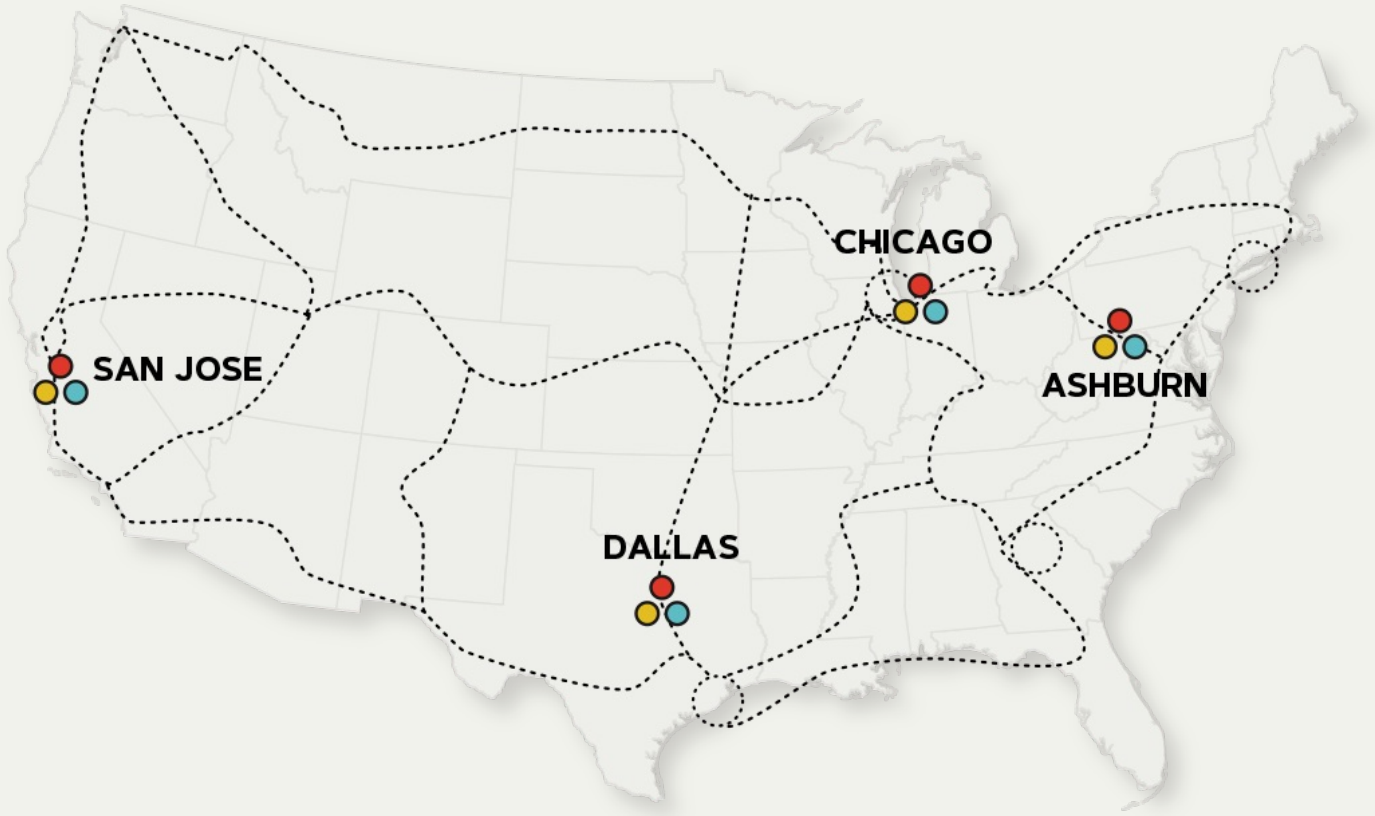
- Allows a connector to have high performing on-net shared access to cloud service providers, avoiding the commodity internet
- Designed from the ground up to focus on hosting cloud providers most valued by the Research and Education community
- Available to at no additional fee



Nationwide Connectivity

Internet2 Cloud Connect

I2CC



- **Microsoft ExpressRoute**
  2x1x100G in Ashburn + GovCloud
  2x1x10G in Chicago
  2x1x10G in Dallas
  2x1x100G in San Jose + GovCloud

- **Amazon Direct Connect**
  4x1x10G in Ashburn
  2x1x10G in Chicago
  2x1x10G in Dallas
  2x1x10G in San Jose

- **Google Cloud Interconnect**
  2x1x10G in Ashburn
  2x1x10G in Chicago
  2x1x10G in Dallas
  2x1x10G in San Jose

Nationwide Connectivity

Internet2 Rapid Private Interconnect

I2RPI

RPI can be used to provide private dedicated direct connects to any provider with some examples being 10G connections to SIP service providers, esports exchanges, or Oracle Cloud.

Thank you!

Questions:

Christian Todorov ctodorov@internet2.edu

2022
TECHNOLOGY
exchange
DENVER
DECEMBER 5-9
INTERNET2