# AutoGOLE / SENSE WG and Infrastructure

## Infrastructure and Services for Network and Domain Science Workflow Innovation

**5th NRP Workshop**
**March 21, 2024**
**UCSD, La Jolla, CA**

**National Research Platform International Extensions, Including the Global Research Platform**

Tom Lehman
Energy Sciences Network (ESnet)
Lawrence Berkeley National Laboratory

## National Research Platform International Extensions, Including the Global Research Platform

12:20 pm – 1:20 pm PT, VROOM, Atkinson Hall

- Introduction to Session (Joe Mambretti) (12:20 – 12:30, 10 min)
- NSF International Research Connections Program (Kevin Thompson) (12:30-12:40, 10 min)
- AutoGOLE/SENSE (Tom Lehman) (12:40-12:50,10 min)
- Asia Pacific Research Platform (Jeonghoon Moon) (12:50-1:00, 10 min)
- Ampath/AmLight (Julio Ibarra) (1:00-1:10, 10 min)
- CENI International Testbed (Gauravdeep Shami) (1:10-1:20) (10 min)
- GNA-DiS Overview (Harvey Newman) (1:15-1:25, 10 min)

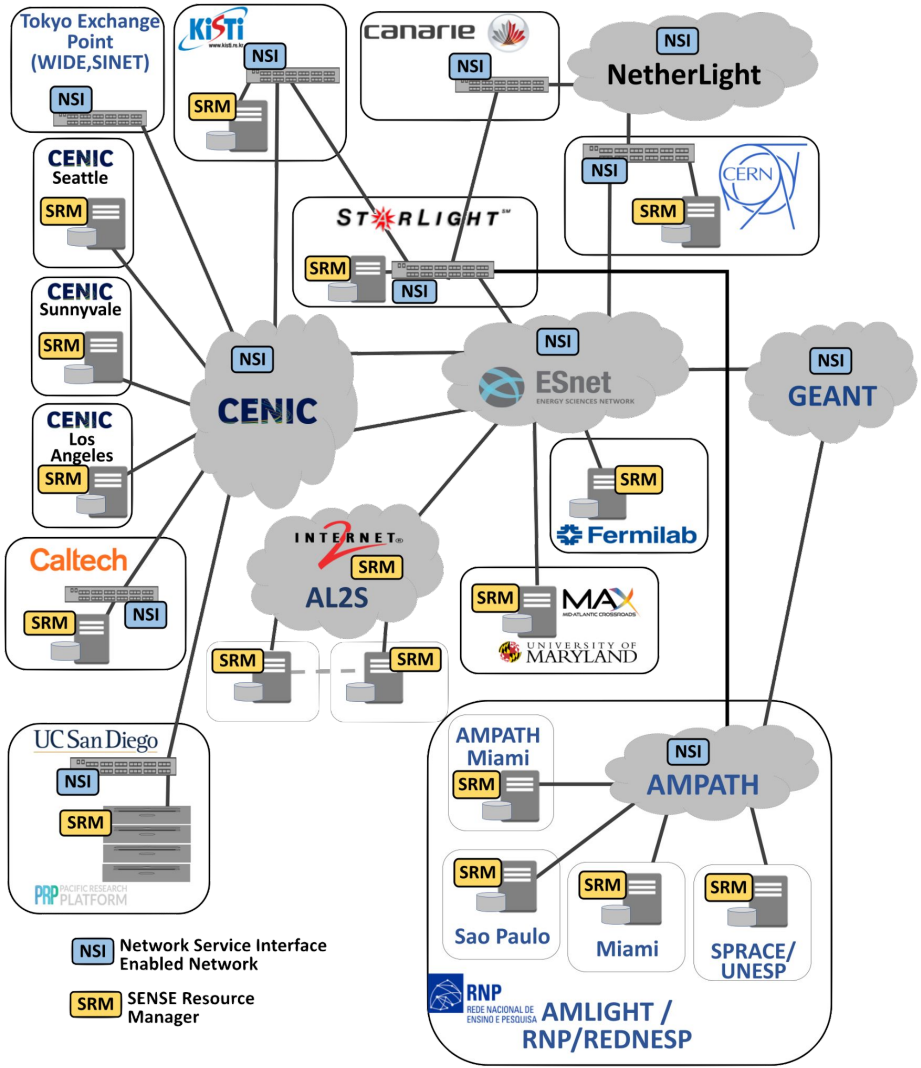
# AutoGOLE / SENSE Working Group

- Worldwide collaboration of open exchange points and R&E networks interconnected to deliver network services end-to-end in a fully automated way. NSI for network connections, SENSE for integration of End Systems and Domain Science Workflow facing APIs.
- Key Work areas:
  - **Control Plan Monitoring**: Prometheus/Grafana based
  - **Data Plane Verification and Troubleshooting Service**: Initial Deployment Underway
  - **AutoGOLE related software**: Ongoing enhancements to facilitate deployment and maintenance (Kubernetes, Docker based systems)
  - **Experiment, Research, Use Case support**: Support for multiple activities including NOTED, Gradient Graph, P4 Topologies, Named Data Networking (NDN), Data Transfer Systems integration and testing.
- Key Objective:
  - The AutoGOLE Infrastructure should be persistent and reliable enough to allow most of the time to be spent on experiments and research.
- WG information - https://www.gna-g.net/join-working-group/autogole-sen…/

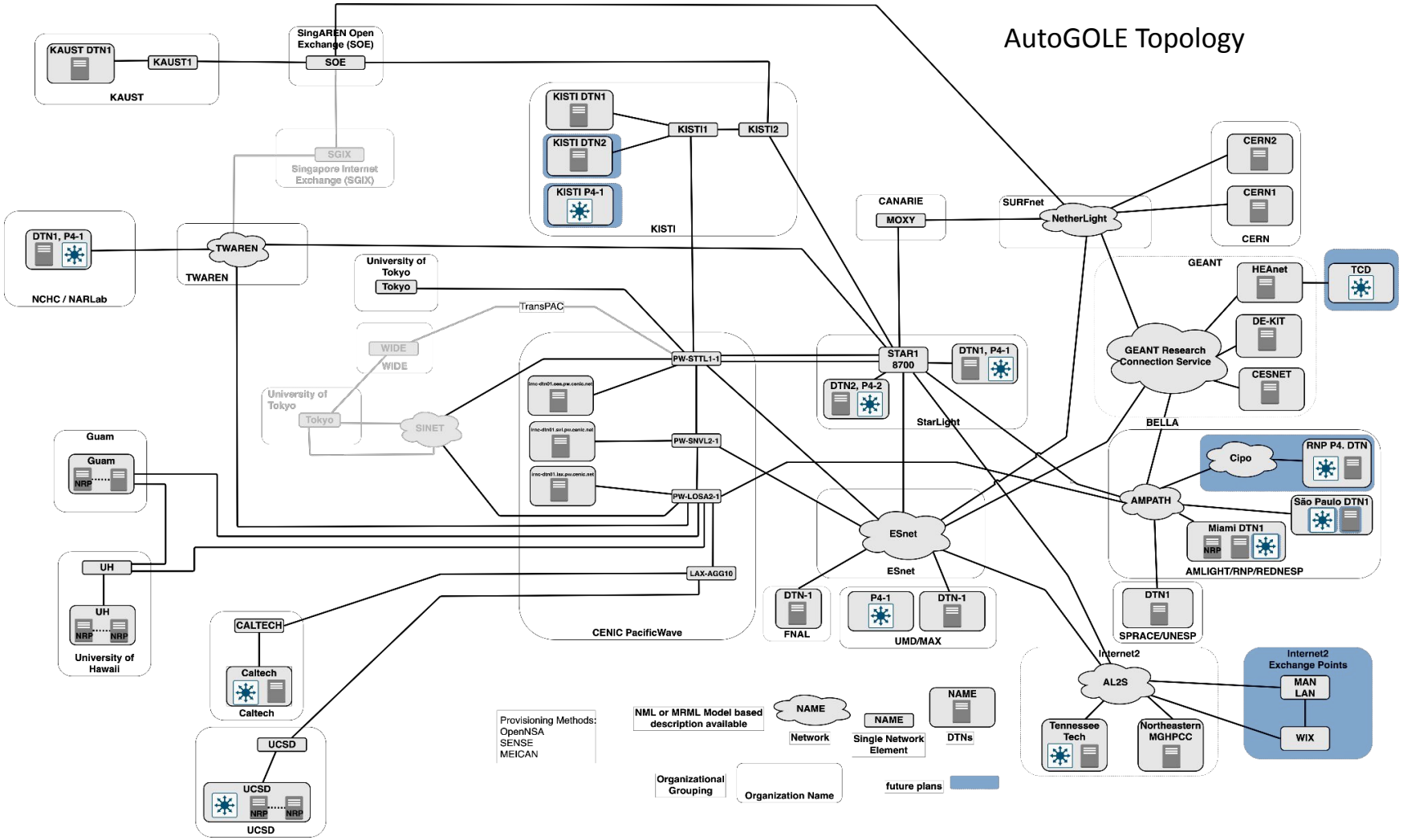
ESnet

# SENSE/AutoGole

- AutoGOLE, NSI, and SENSE working together provide the mechanisms for complete end-to-end services which includes the network and the attached End Systems (DTNs).
- Possible Provisioning Objectives: Layer 2 isolation, Guaranteed QoS, Managing Flows Path/Link usage



# AutoGOLE Topology



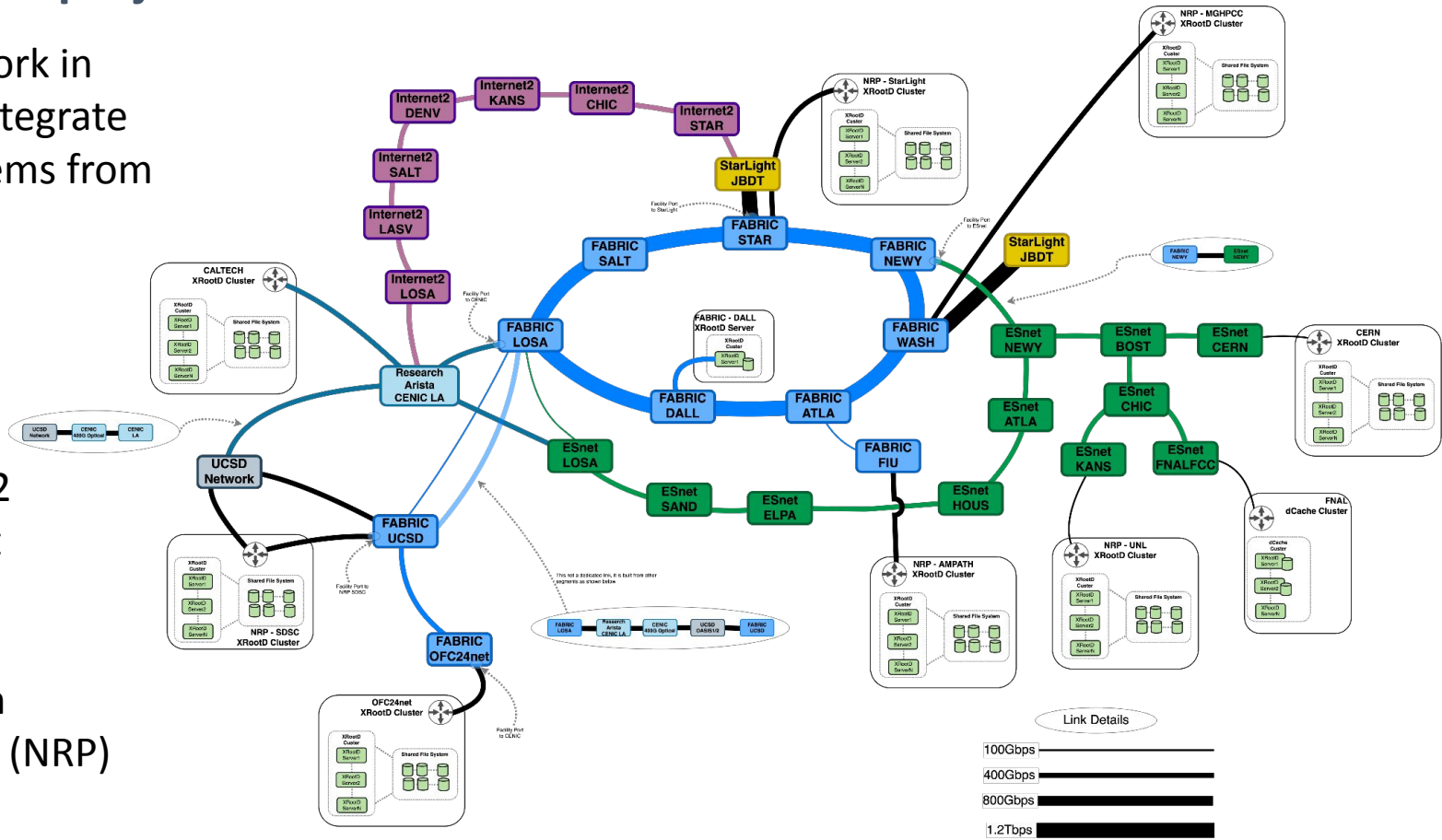
# SENSE/AutoGole

- The AutoGOLE infrastructure has a large global reach
- It has evolved to include a variety of network services from many different network providers/owners
- A key focus now is on integrating the edge resources such as:
  - National Research Platform (NRP) site
    - many distributed NRP Kubernetes based deployments
  - Domain Science Workflow Prototype/Development Systems
  - Others

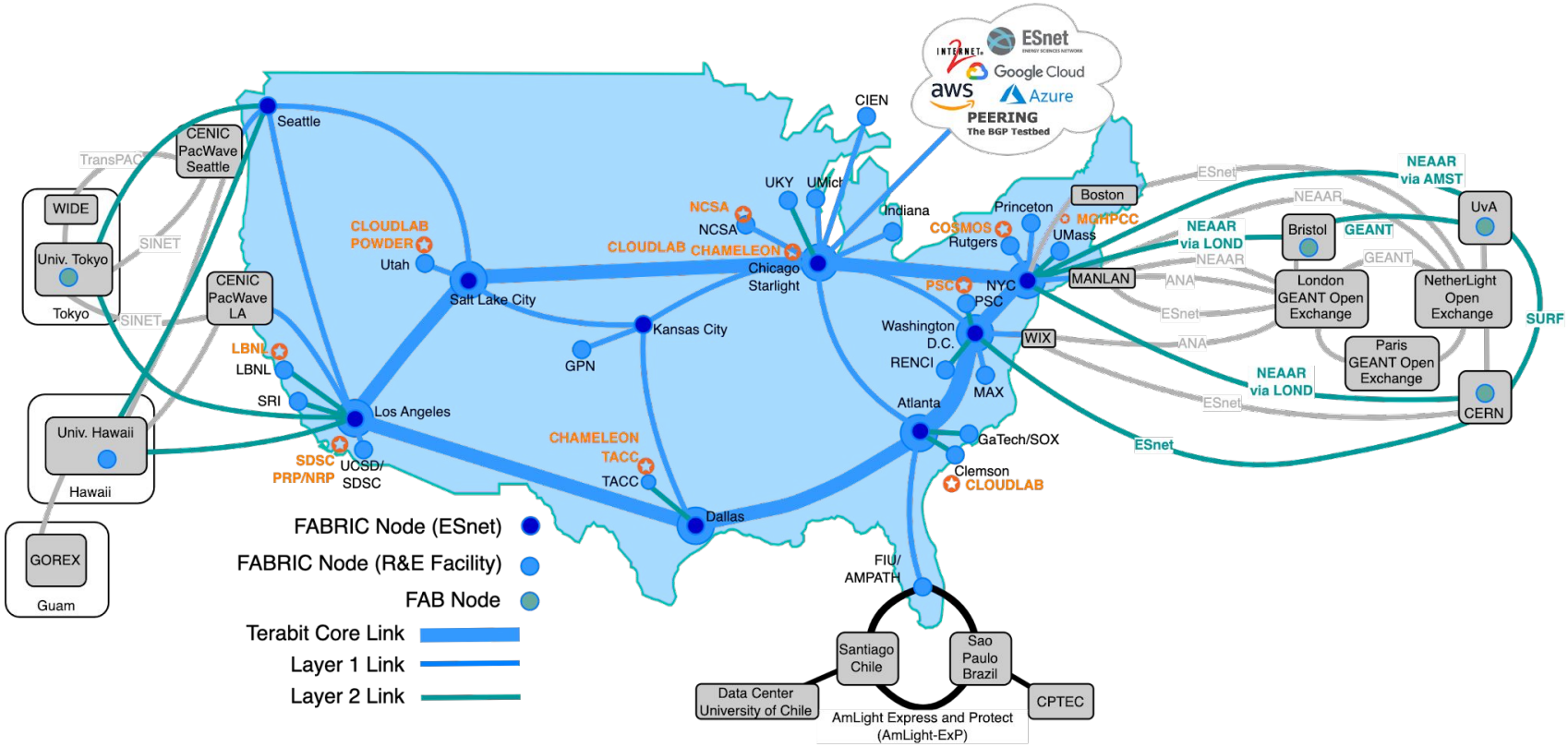
# Network Services and Edge Site Integration across multiple providers and projects

This shows work in progress to integrate services/systems from the following providers:

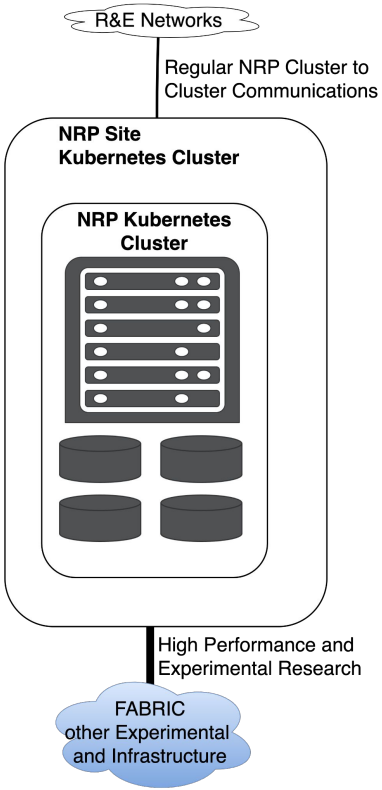
- CENIC
- UCSD
- ESnet
- Internet2
- StarLight
- FABRIC
- National Research Platform (NRP)



# FABRIC Topology



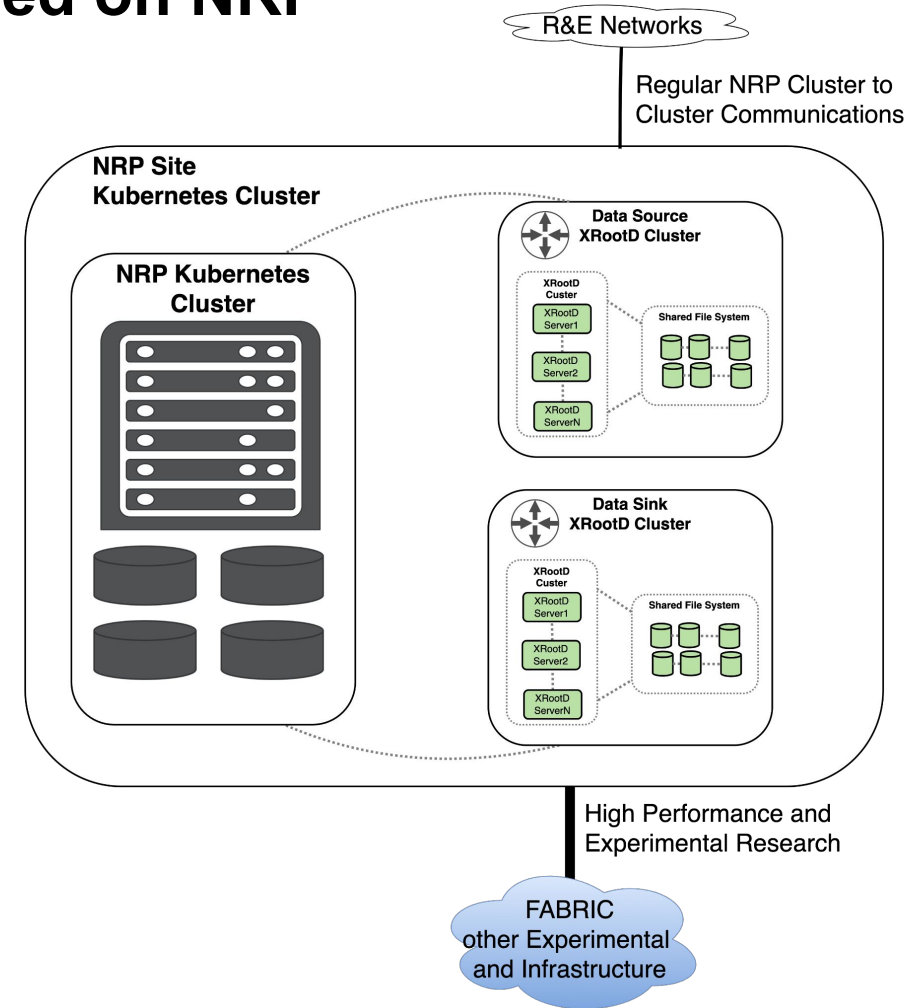
# NRP Connection to Advanced Network Services




- Connecting an NRP Cluster to any experimental infrastructure simply requires connecting one or more new dataplane connections to the experimental infrastructure.
- This can be easily accomplished using the Multus CNI container network interface (CNI) plugin for Kubernetes, which enables attaching multiple network interfaces to pods
- This new dataplane interface can then be used to attached to a wide variety of advanced network services.
- The standard NRP Kubernetes cluster connection to the R&E internet is use as normally for cluster to cluster traffic.

# XRootD Clusters Deployed on NRP

- Use NRP to build XRootD Source and Sink Cluster in same location
- Connect that Kubernetes pod to experiment research network infrastructure
- adjust the network services and topology as needed by research/test objectives

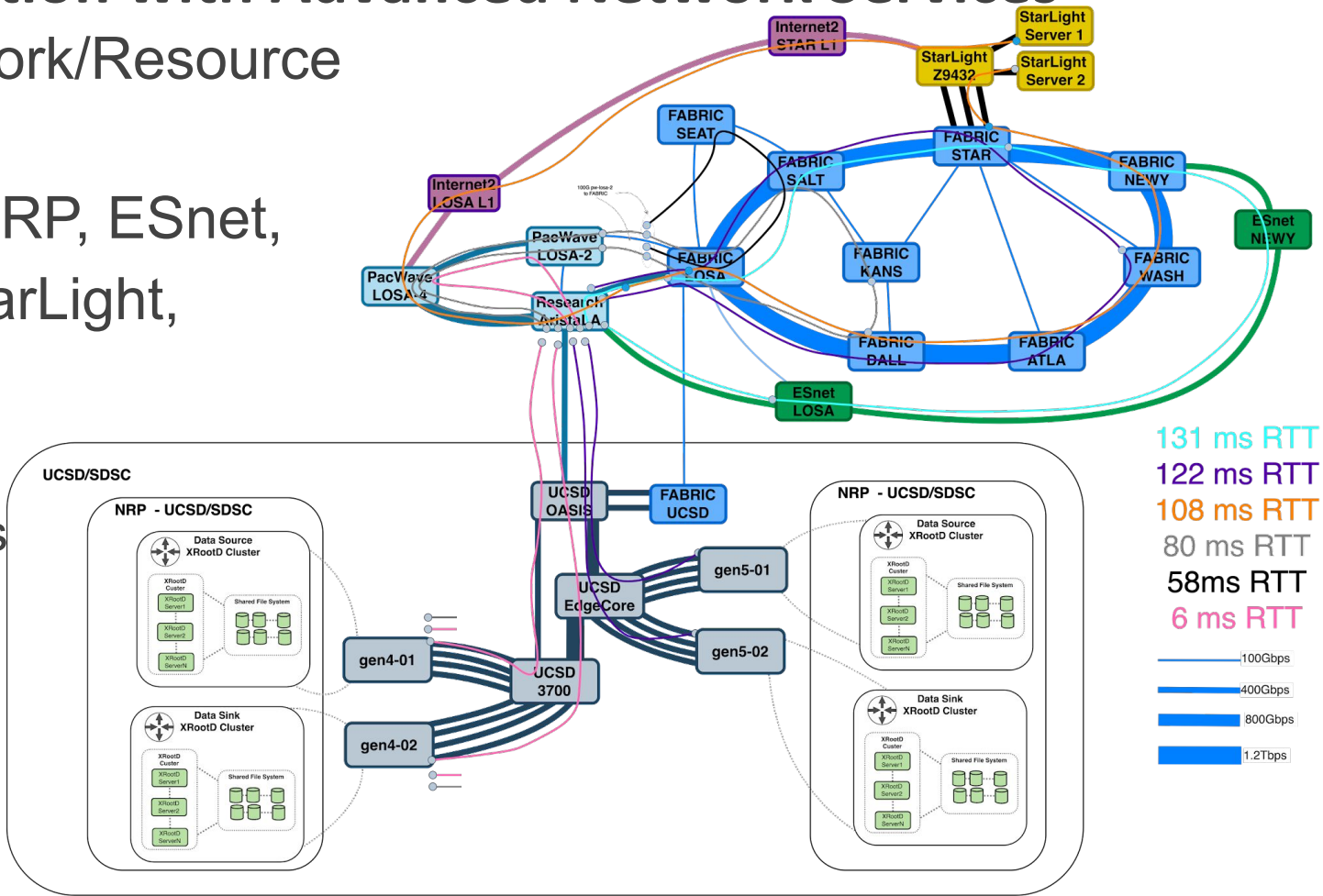


# NRP Integration with Advanced Network Services

Multiple Network/Resource Integration

- FABRIC, NRP, ESnet, CENIC, StarLight, Internet2

XRootD source and sink clusters in same location - variable RTTs



# Thanks!

# Extra Slides

# AutoGOLE / SENSE WG - Software

- GNA-G AutoGOLE/SENSE WG homepage
  - https://www.gna-g.net/join-working-group/autogole-sense
- Co-Chairs:
  - Tom Lehman (ESnet)
  - Marcos Felipe Schwarz (RNP)
  - Hans Trompert (SURF)
  - Buseung Cho (KISTI)
- AutoGOLE/SENSE Working Group mailing list
  - autogole@lists.gna-g.net
- Zoom meetings
  - every two weeks on Tuesdays, 10am ET

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# AutoGOLE / SENSE WG - Objectives and Vision

- Infrastructure which provides “end-to-end” network services in a fully automated manner
  - the network elements
  - the network stacks inside the attached end systems (DTNs)
- Leverages the open source software based on:
  - Network Service Interface (NSI): multidomain network provisioning
  - SENSE: end-system provisioning and realtime integration with network services
- Persistent Infrastructure, somewhere in between production and a testbed
  - Network Research, Experiments, Testing
  - Topologies and Services for Domain Science integration and research

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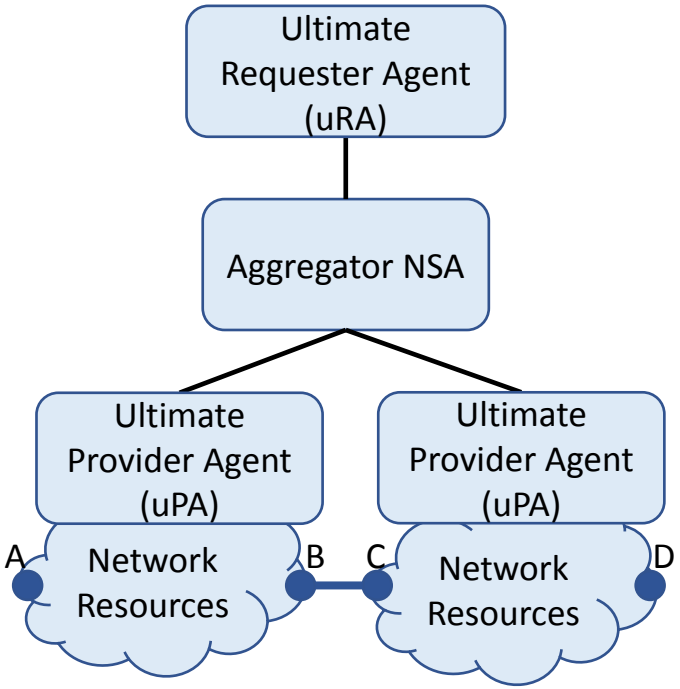
# OpenNSA

## NSI based Provider (uPA)




# Safnari

## NSI Aggregator

NSI Safnari

Usage | Connections

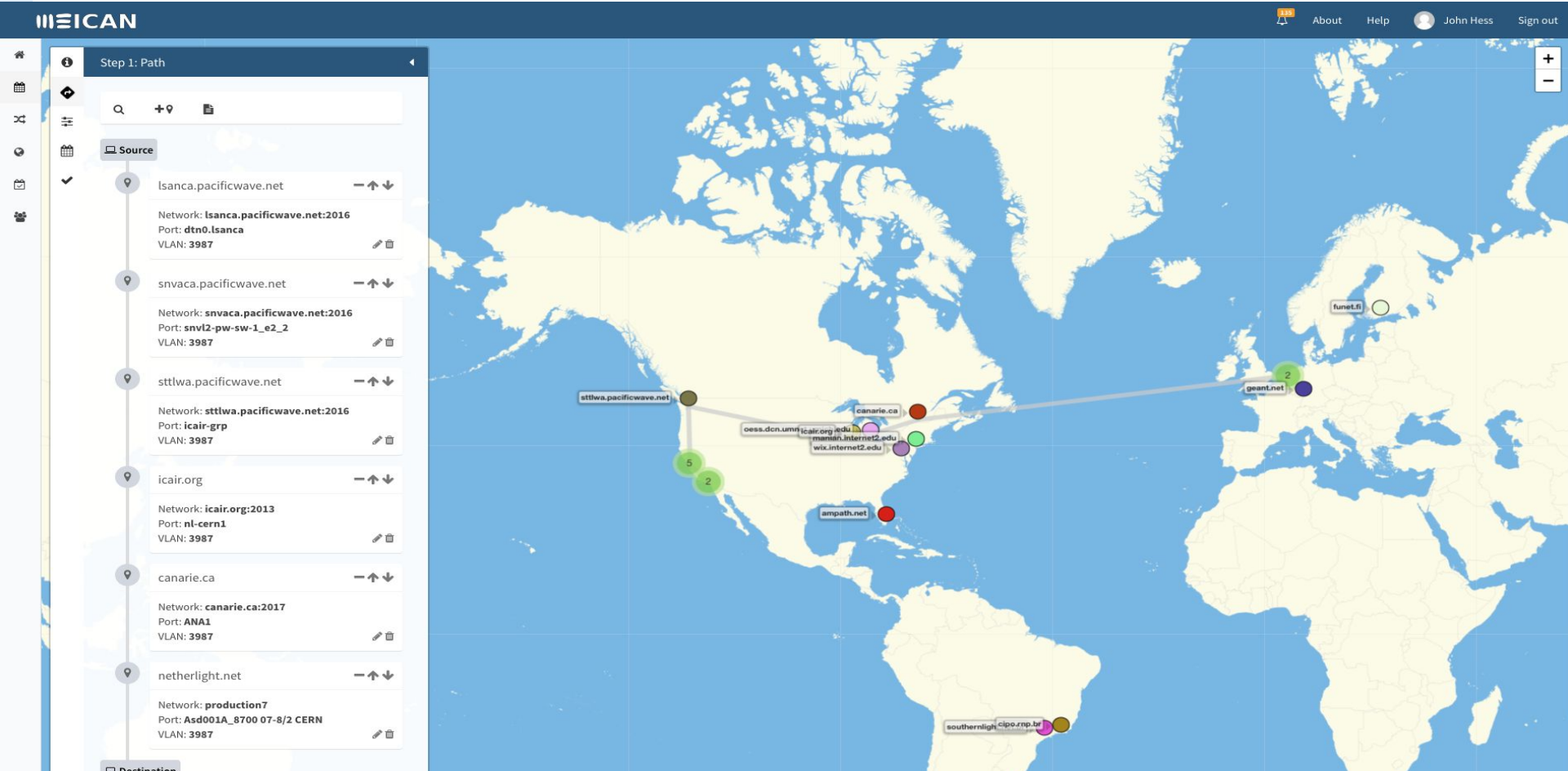
**Connection 6dfa8e66-cd18-4d57-bb3a-5b17c44c267f - CERN DTN - LA DTN with ERO - VLAN3988 - jhess**

**Start:** 2019-12-03T21:53:44.796Z
**End:** 2019-12-04T21:48:44.796Z
**Bandwidth:** 200
**Version:** 0
**Global id:** -
**Requester:** urn:ogf:network:cal.bears:2019:nsa:requester

**Source:** urn:ogf:network:lsanca.pacificwave.net:2016:topology:dtn0.lsanca?vlan=3988
**Destination:** urn:ogf:network:netherlight.net:2013:production7:cern-1?vlan=3988

| Child connection ID | NSA | Path | Status | Error? |
|---|---|---|---|---|
| LS-fa09b582ce | lsanca.pacificwave.net:2016:nsa | **From** lsanca.pacificwave.net:2016:topology:dtn0.lsanca?vlan=3988 **To** lsanca.pacificwave.net:2016:topology:losa2-pw-sw-1_e1_1?vlan=3988 | Released, Inactive | none |
| SN-740979f3c0 | snvaca.pacificwave.net:2016:nsa | **From** snvaca.pacificwave.net:2016:topology:snvl2-pw-sw-1_e7_2?vlan=3988 **To** snvaca.pacificwave.net:2016:topology:snvl2-pw-sw-1_e2_2?vlan=3988 | Released, Inactive | none |
| ST-64a9e1b353 | sttlwa.pacificwave.net:2016:nsa | **From** sttlwa.pacificwave.net:2016:topology:icas-sttlwa01-03_e1_1?vlan=3988 **To** sttlwa.pacificwave.net:2016:topology:icair-grp?vlan=3988 | Released, Inactive | none |
| IC-b47da37bc7 | icair.org:2013:nsa | **From** icair.org:2013:topology:pwave-grp?vlan=3988 **To** icair.org:2013:topology:nl-cern1?vlan=3988 | Released, Inactive | none |
| 19001CS08-ANA | canarie.ca:2017:nsa | **From** canarie.ca:2017:topology:CHCG1?vlan=3988 **To** canarie.ca:2017:topology:ANA1?vlan=3988 | Released, Inactive | none |
| 890861b8-c20f-4968-aa4e-a670ef50f7c6 | netherlight.net:2013:nsa:safnari | **From** netherlight.net:2013:production7:ana-1?vlan=3988 **To** netherlight.net:2013:production7:cern-1?vlan=3988 | Released, Inactive | none |

# MEICAN – NSI Visualization and Provisioning



# Integration of End-Site Resources and Science Workflows

- Automated provisioning and traffic engineering of paths across wide area networks and exchange points is important
- Added value for science applications includes integration of these services with:
  - End Site network, compute, and storage infrastructure
  - Science workflow agents and middleware

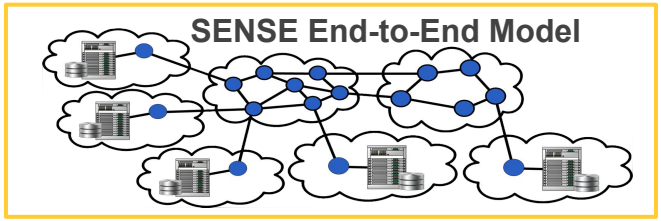
# SENSE Architecture

Intent Based APIs with Resource Discovery, Negotiation, Service Lifecycle Monitoring/Troubleshooting

Application Workflow Agent

SENSE Orchestrator

Model Driven SDN Control with Orchestration




Real-time system based on Resource Manager developed infrastructure and service models

RM
UC San Diego
DTN

RM
ESnet
ENERGY SCIENCES NETWORK

RM
Fermilab
DTN

Datafication of cyberinfrastructure to enable intelligent services

RM
Caltech
DTN

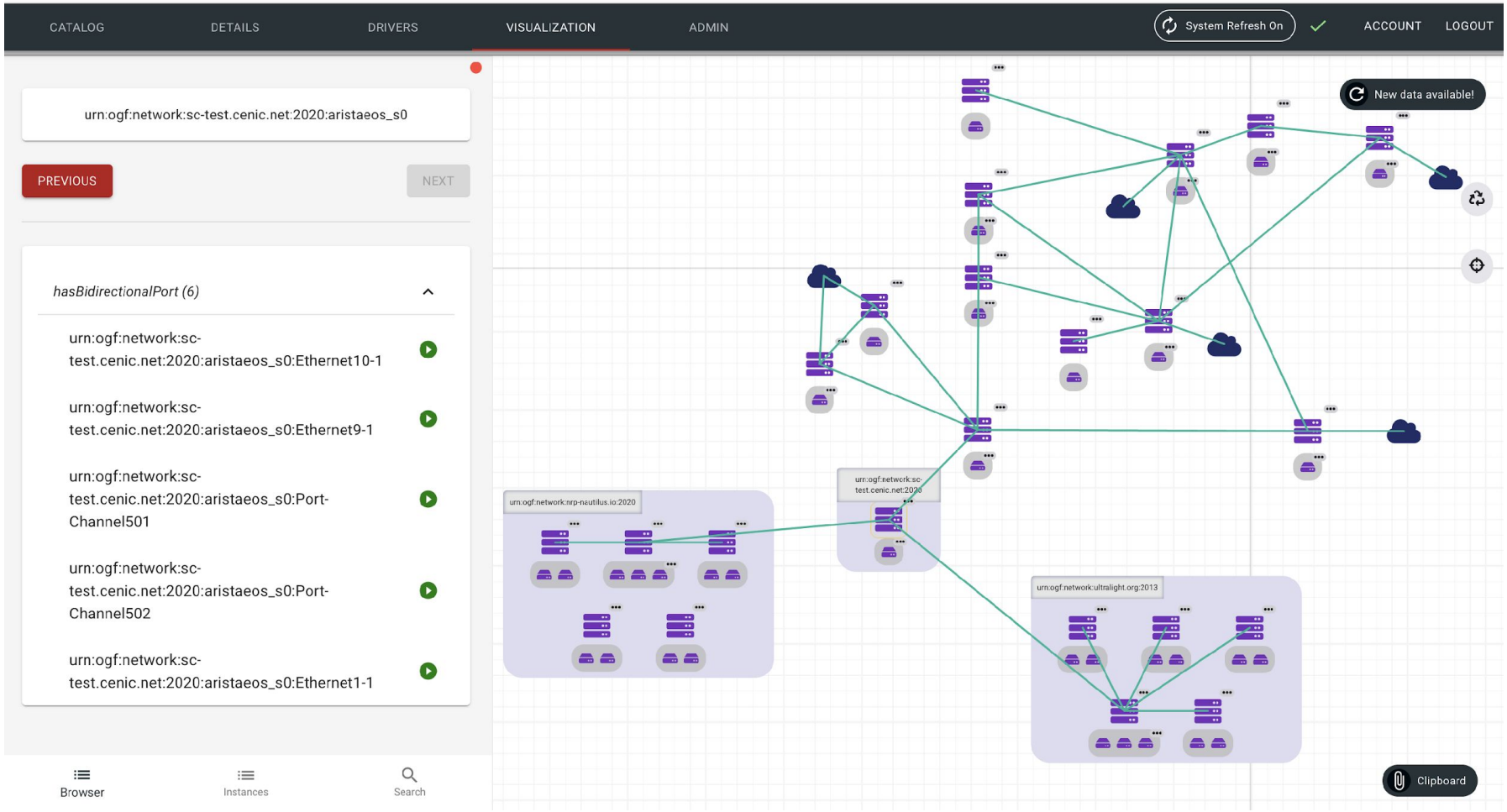
RM
CENIC

RM
INTERNET2

RM
UMD MAX
DTN

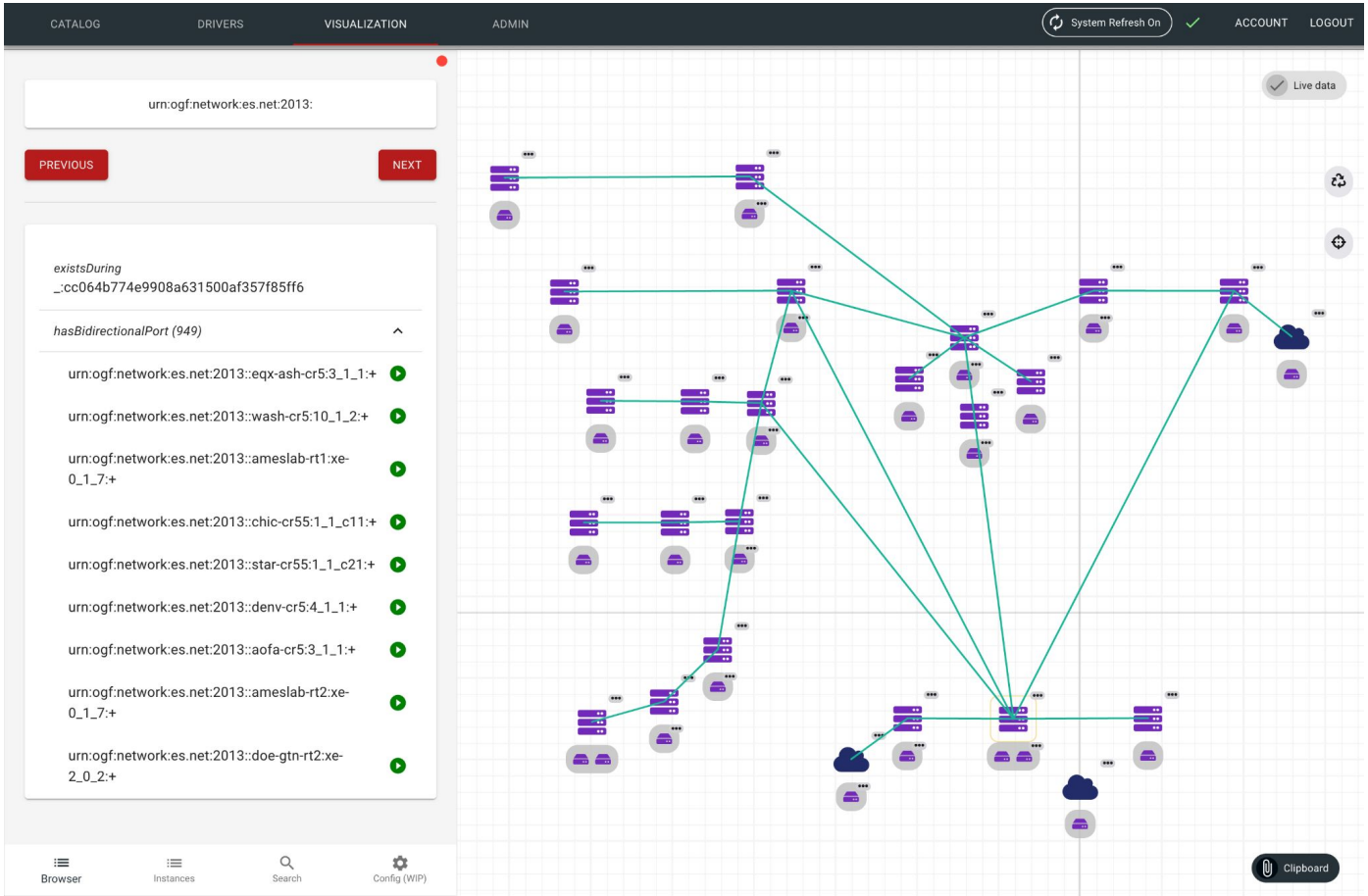
RM
SENSE Resource Manager

# SENSE - Model based Resource Descriptions

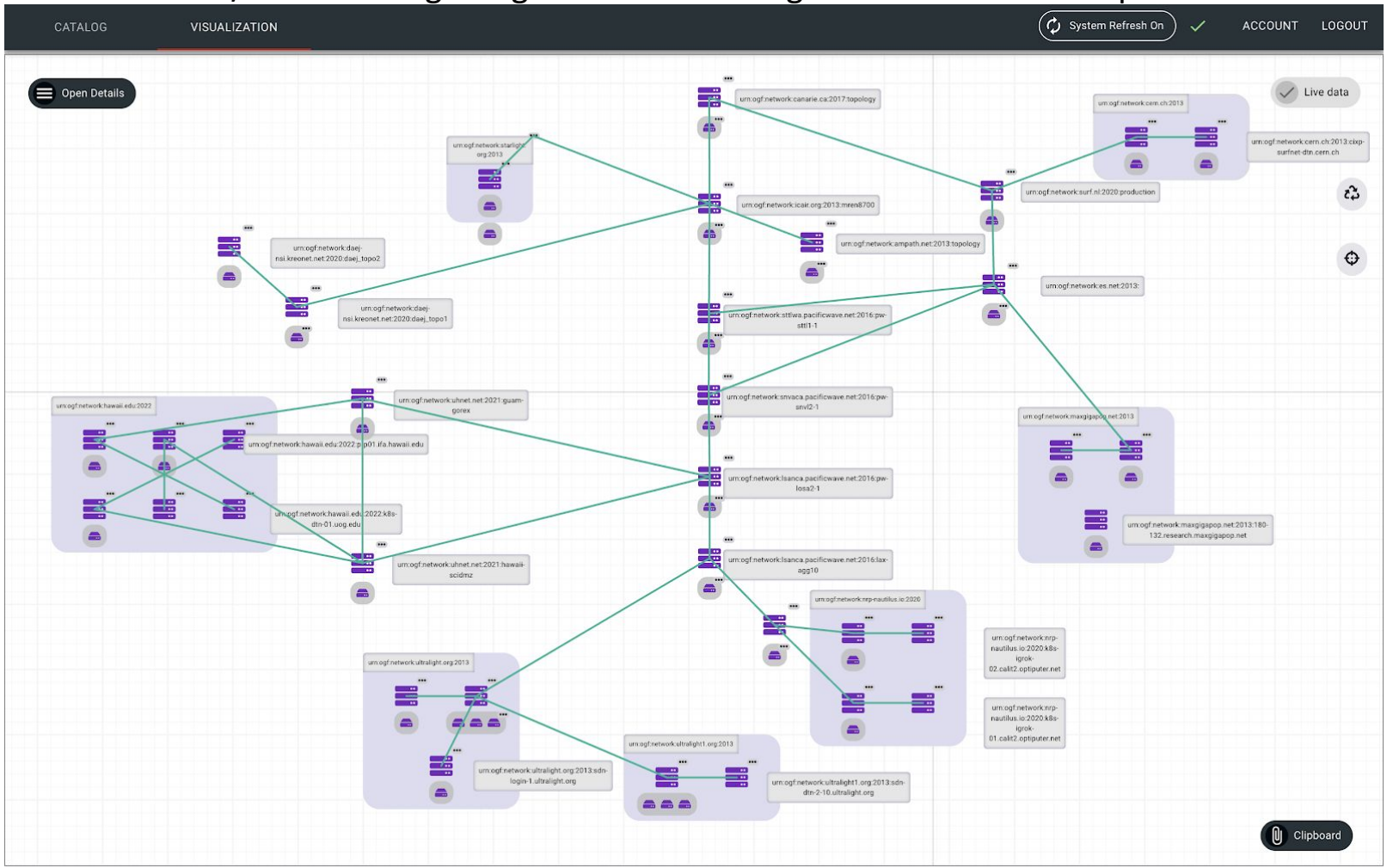


# SENSE Orchestrator View

- Based on real time collection of models from Resource Managers

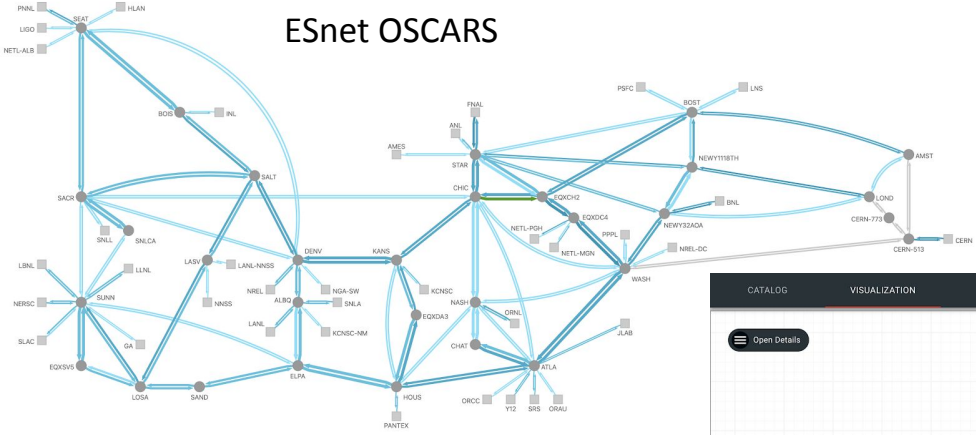


# AutoGOLE/SENSE - Integrating and Orchestrating services across multiple Infrastructures



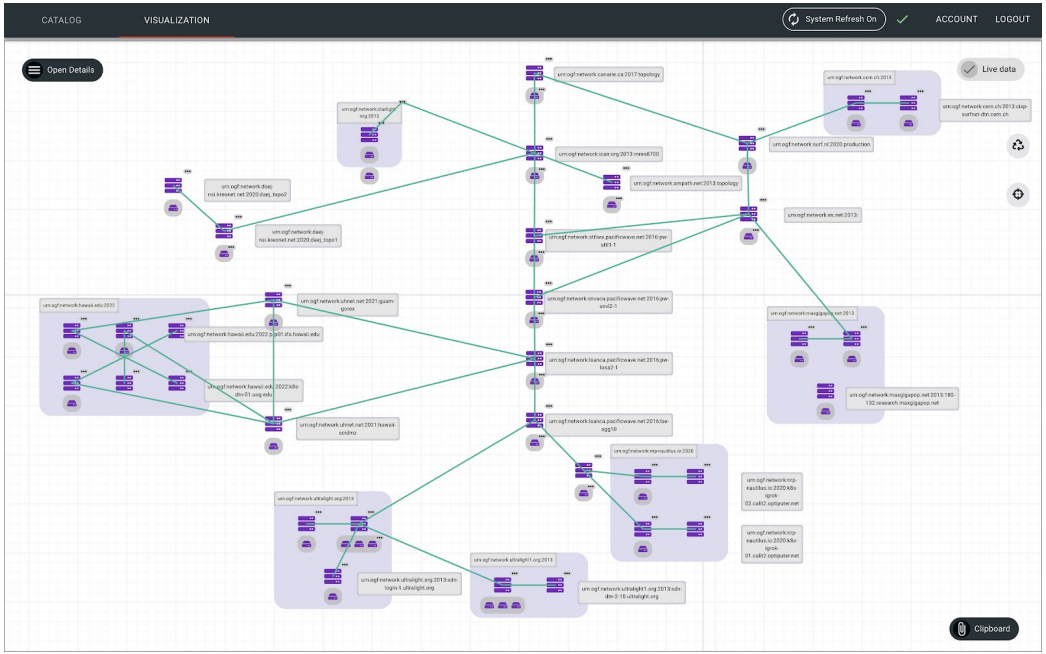
# AutoGOLE/SENSE - Integrating and Orchestrating services across multiple Infrastructures

ESnet OSCARS



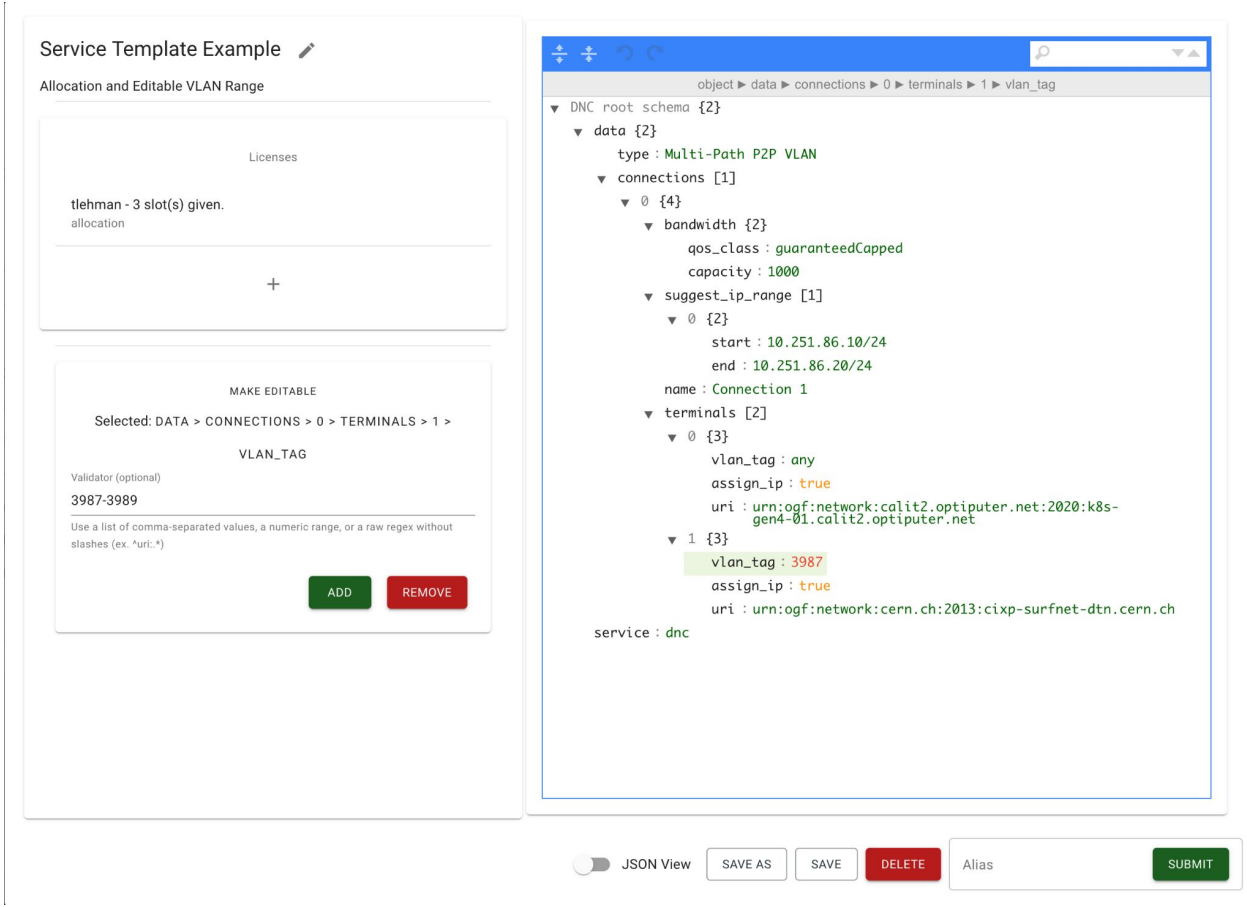

Internet2 AL2S


AutoGOLE/SENSE

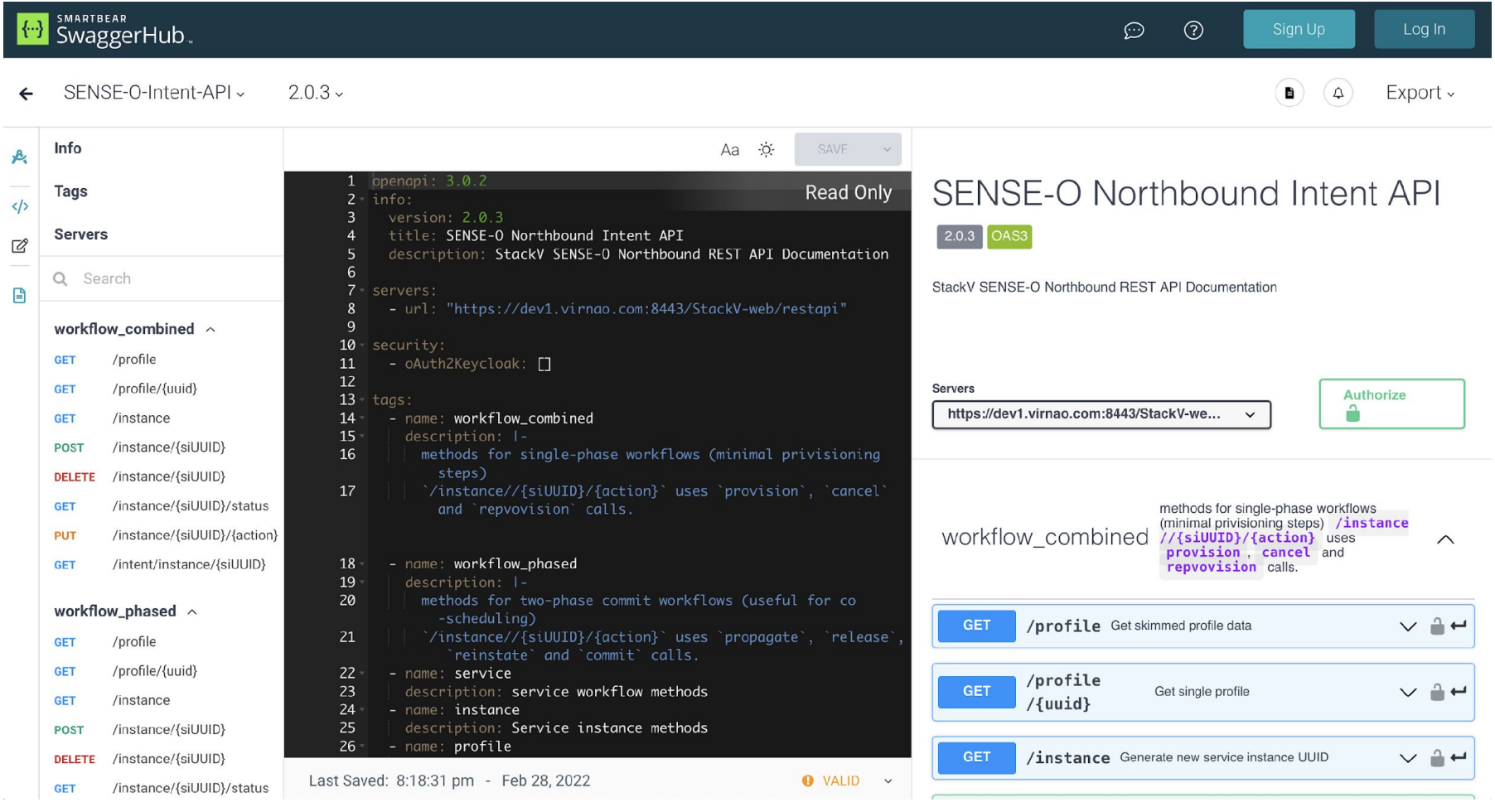


# SENSE Orchestrator - User Template

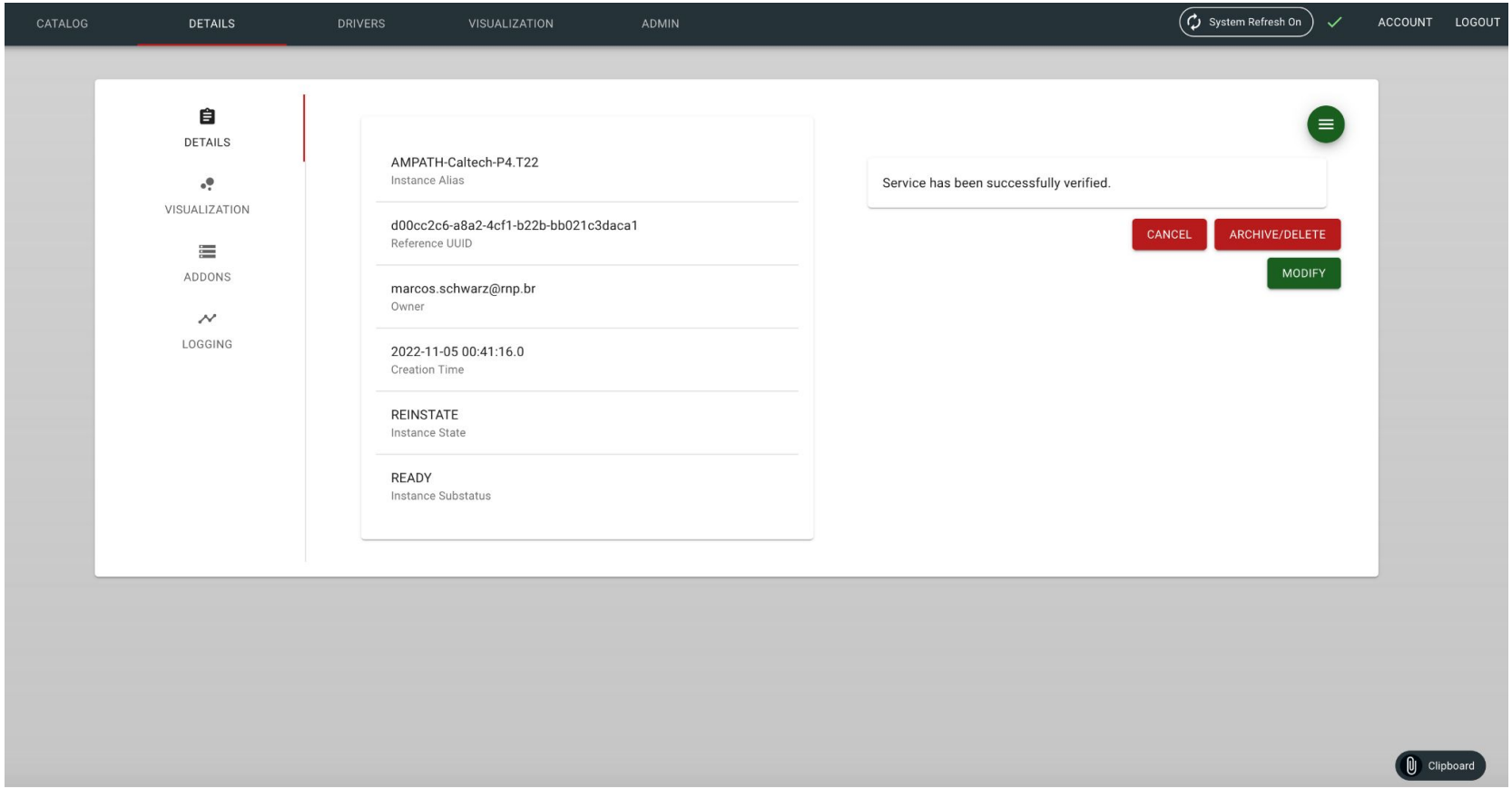
- Read-only with VLAN Range, Run Independently, 3 instance allocation



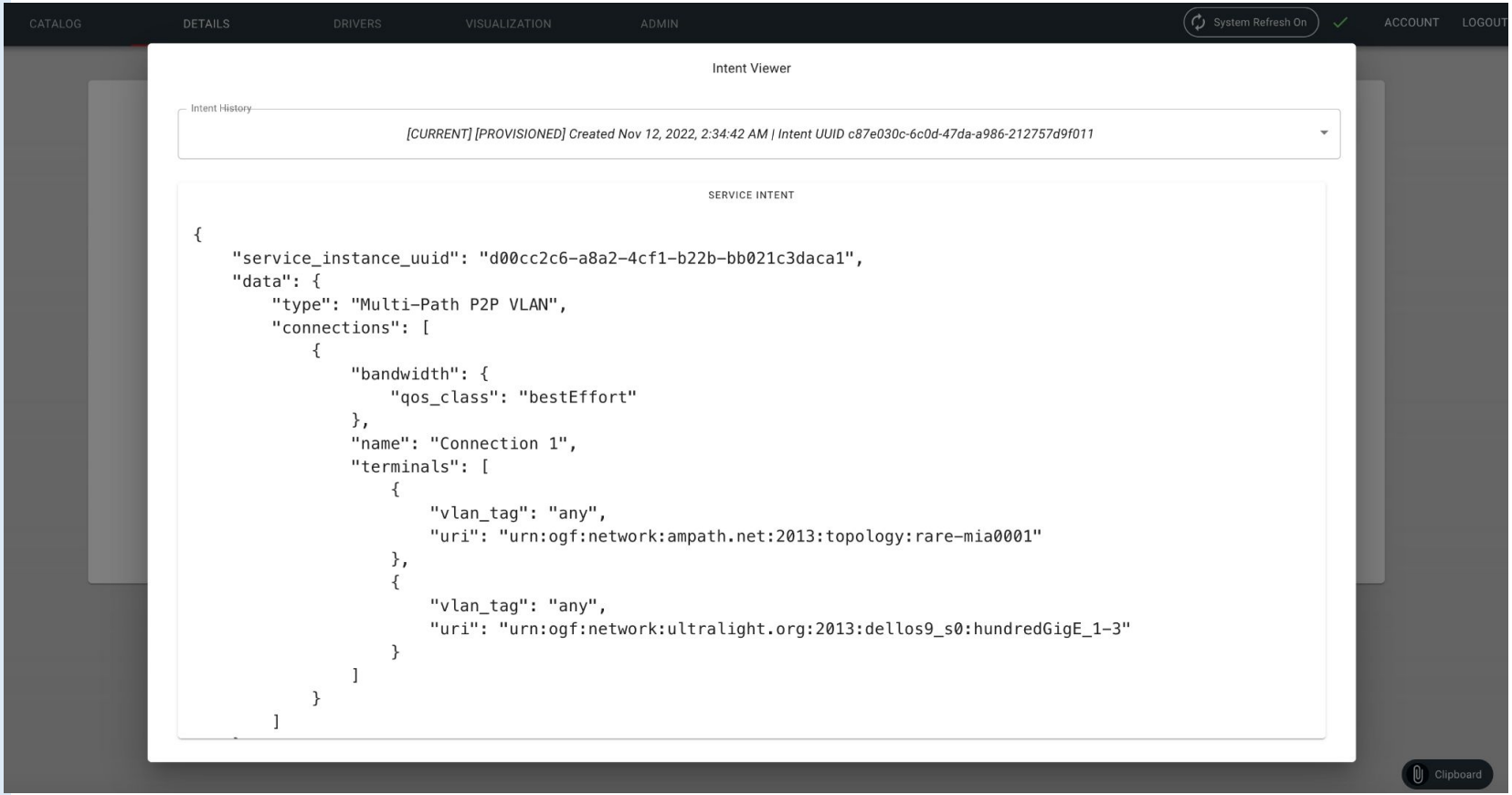
# SENSE - Northbound API



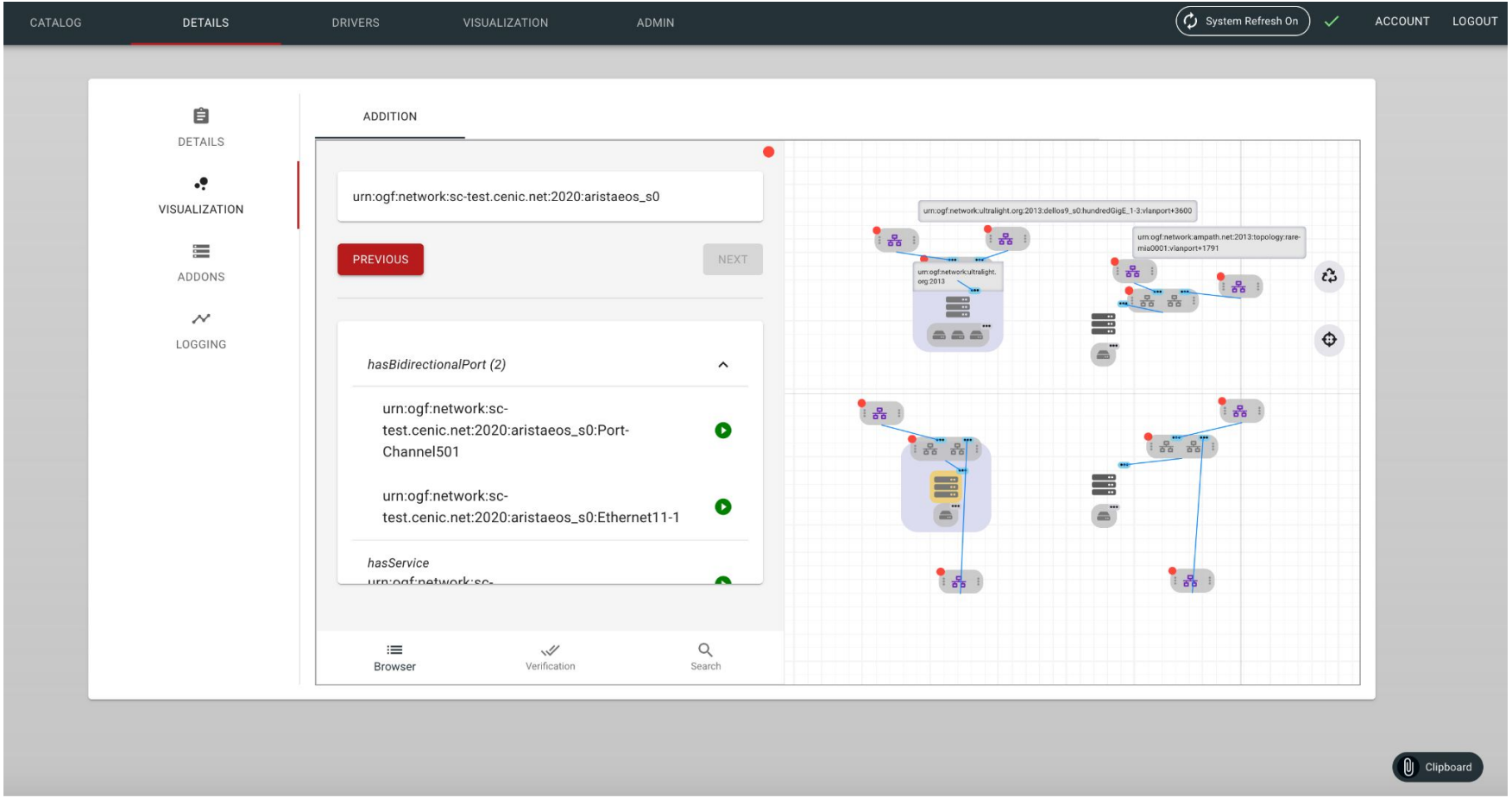
# SENSE/AutoGole Service Example



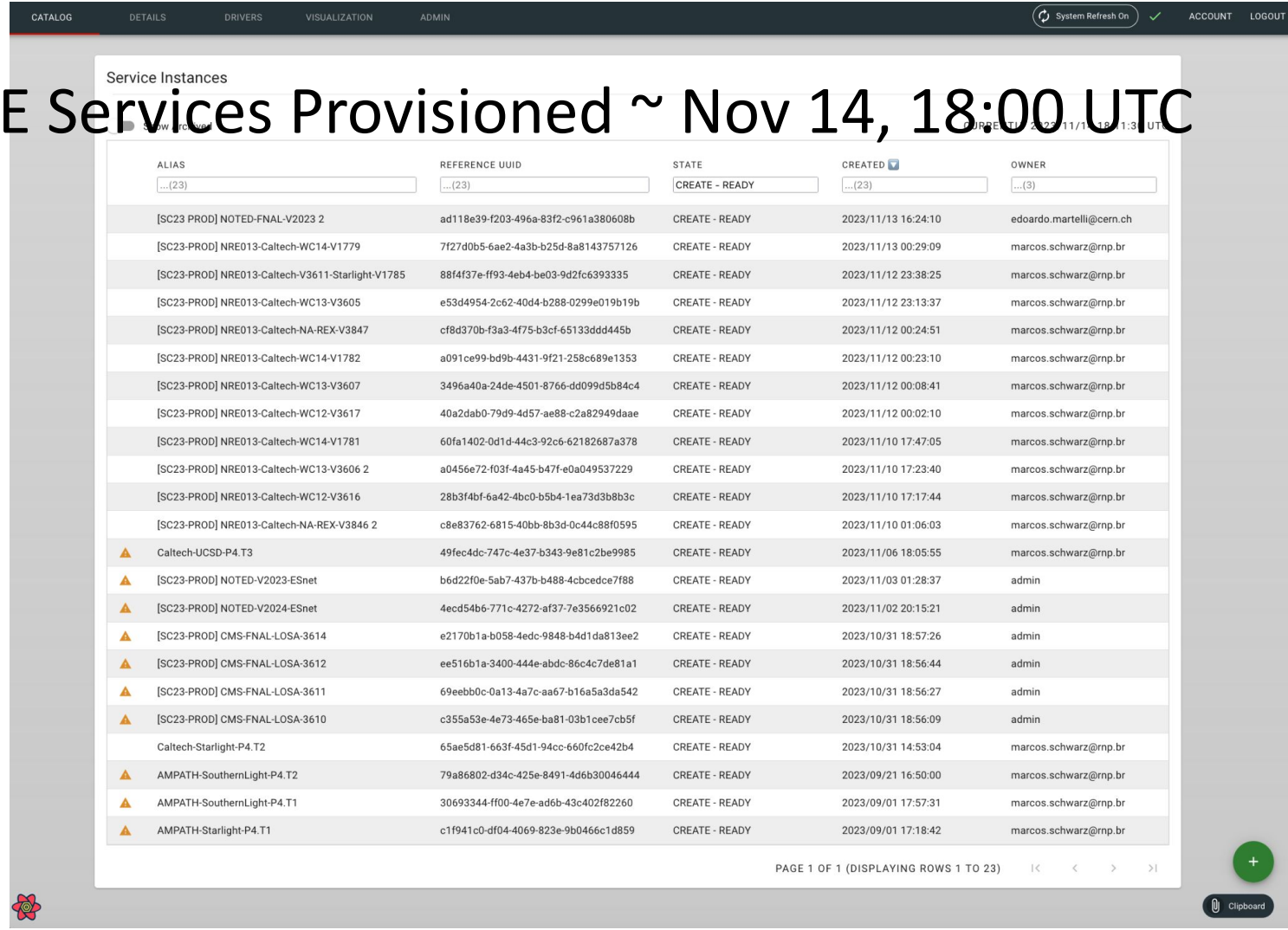
# SENSE/AutoGole Service Intent



# SENSE/AutoGole Service Visualization



# SC23 SENSE Services Provisioned ~ Nov 14, 18:00 UTC



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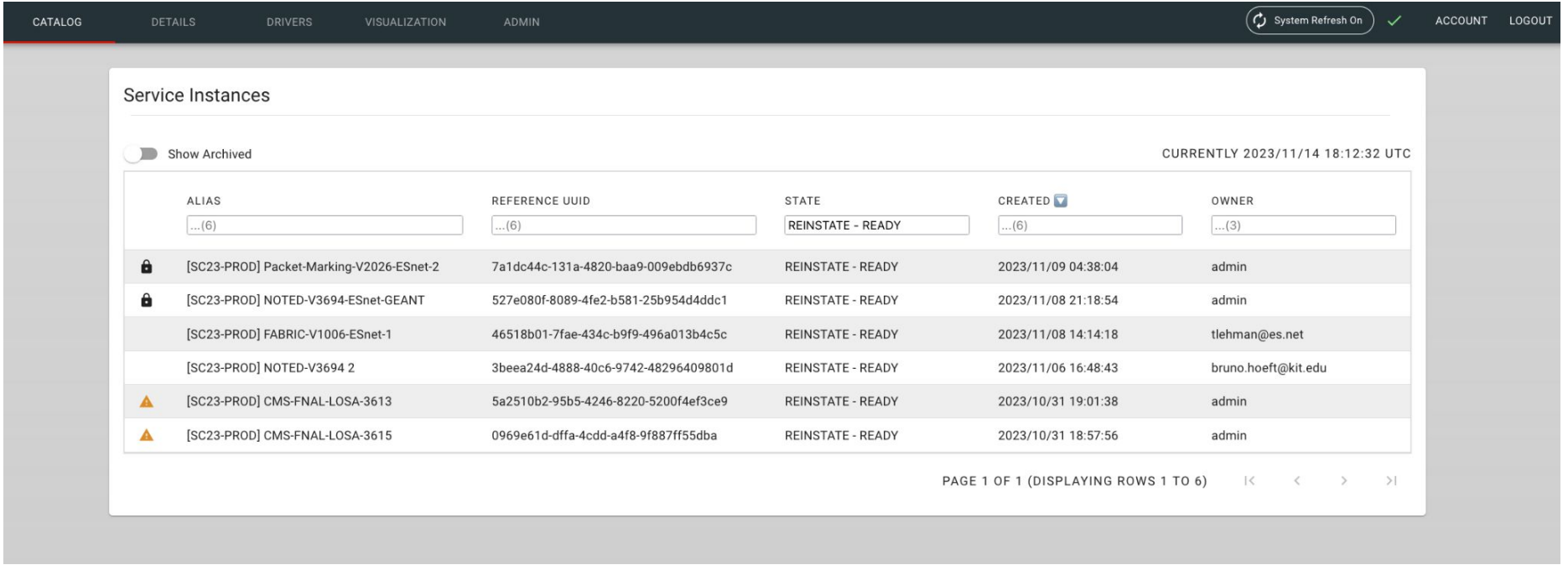
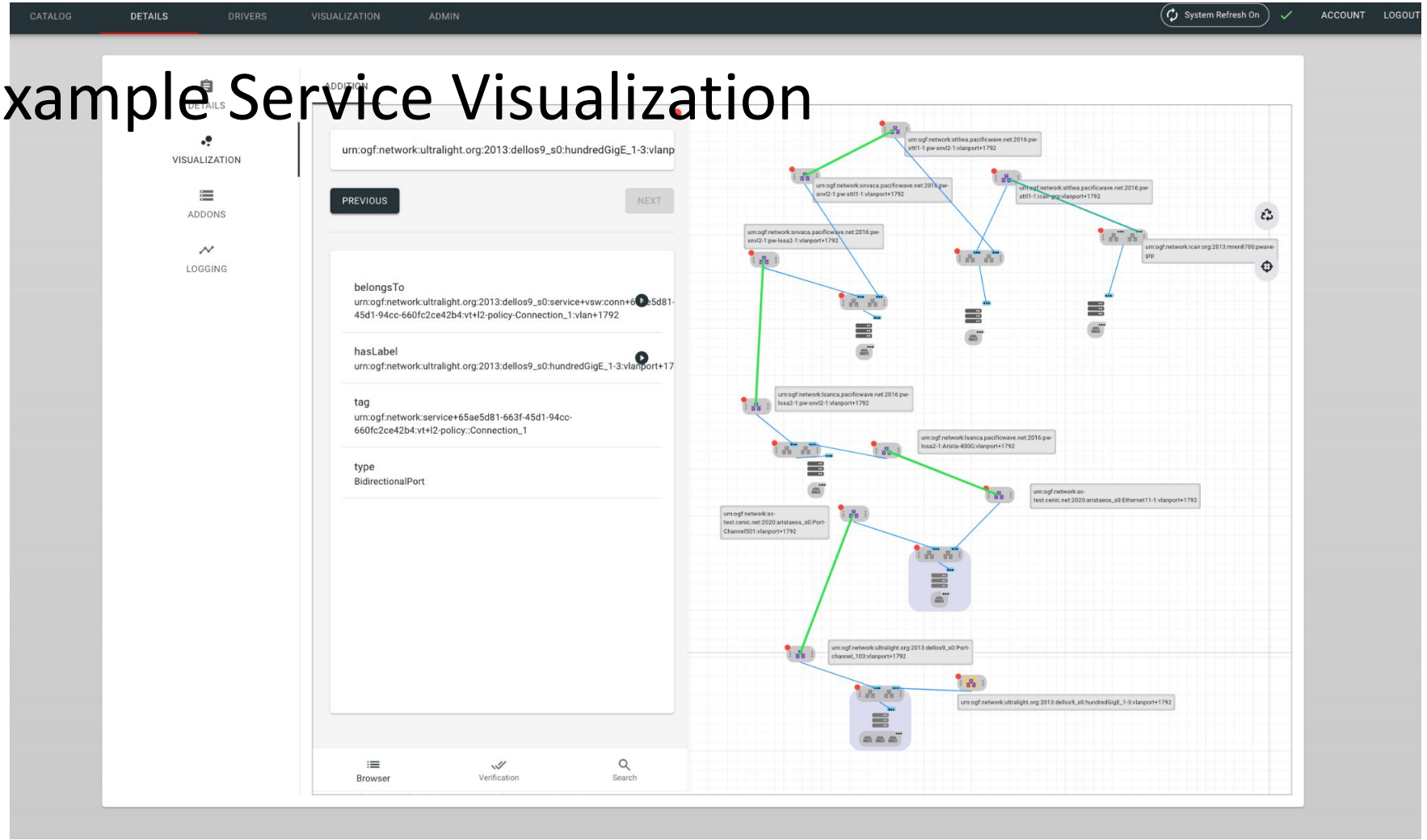
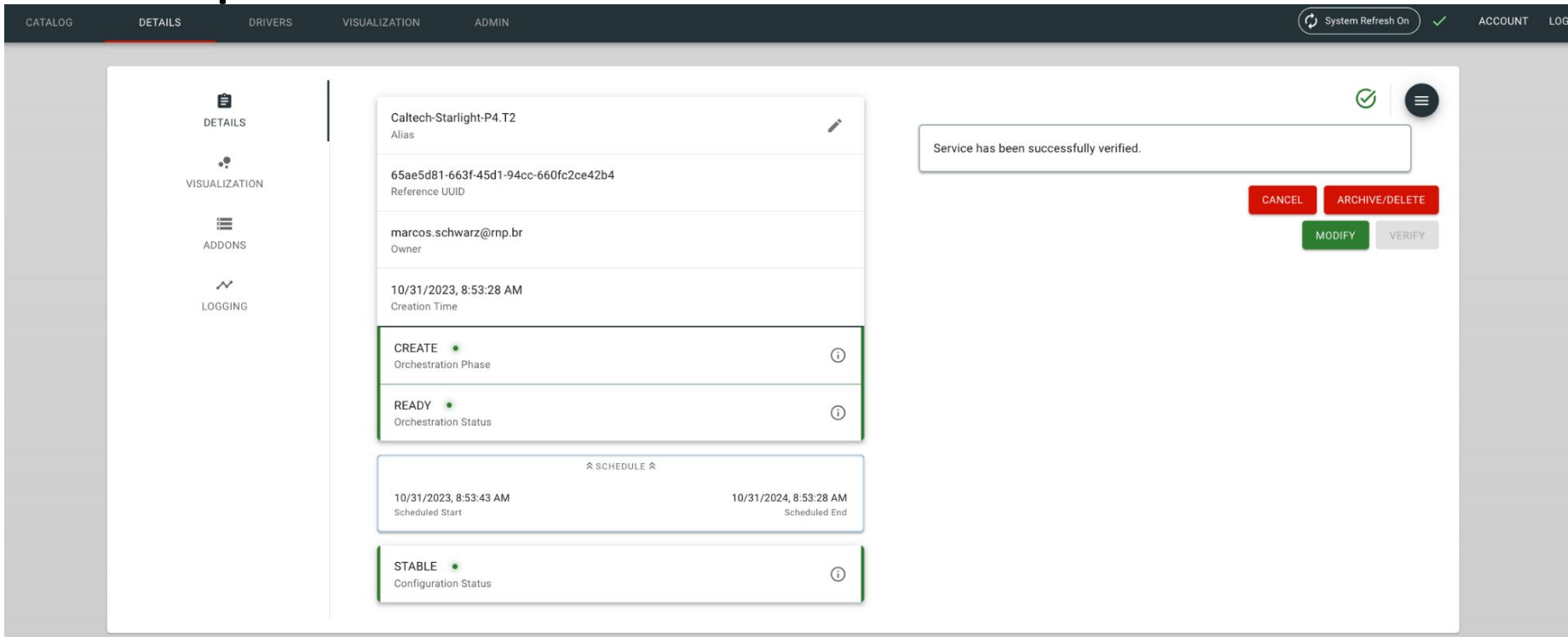


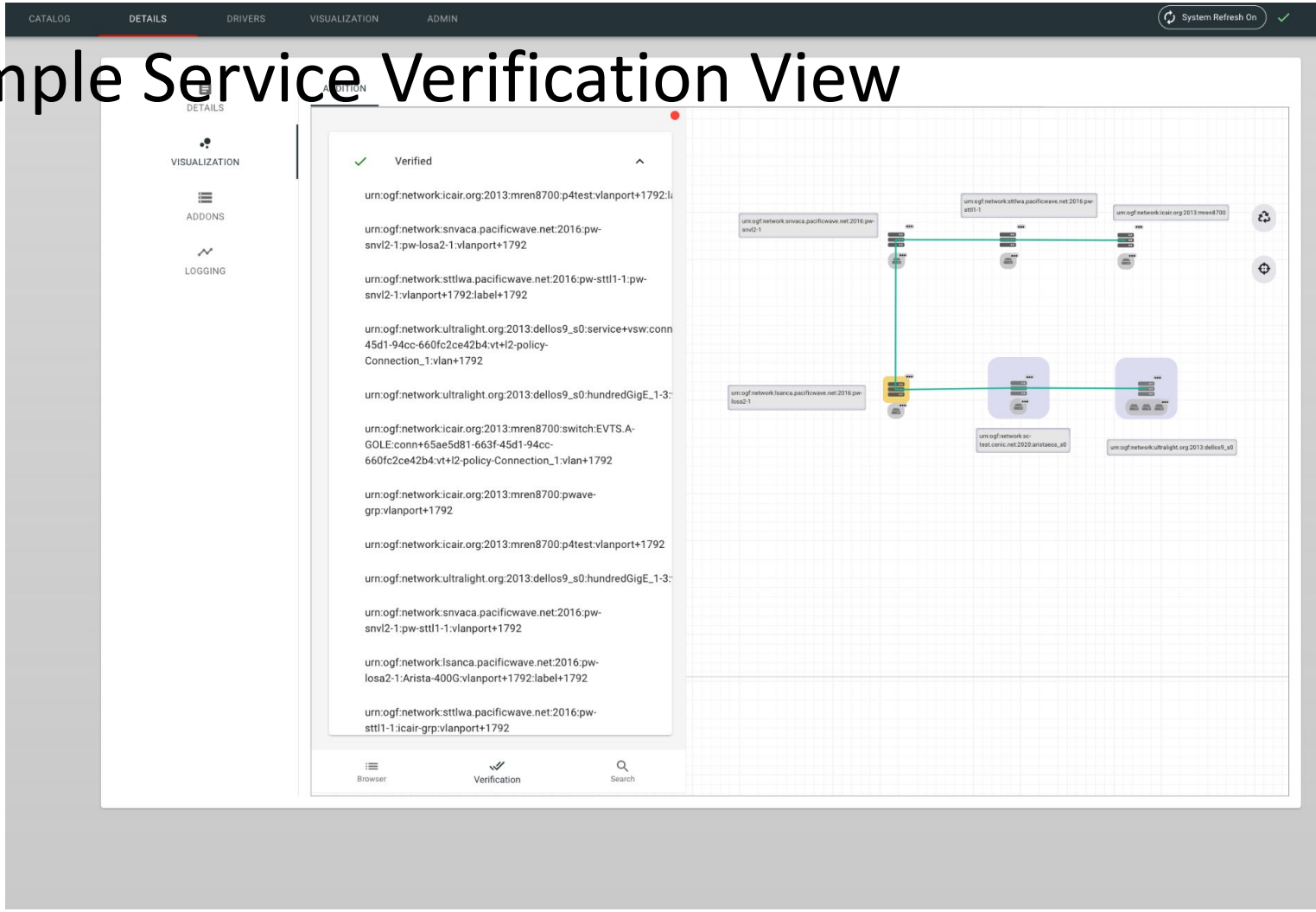
# Example Service Visualization



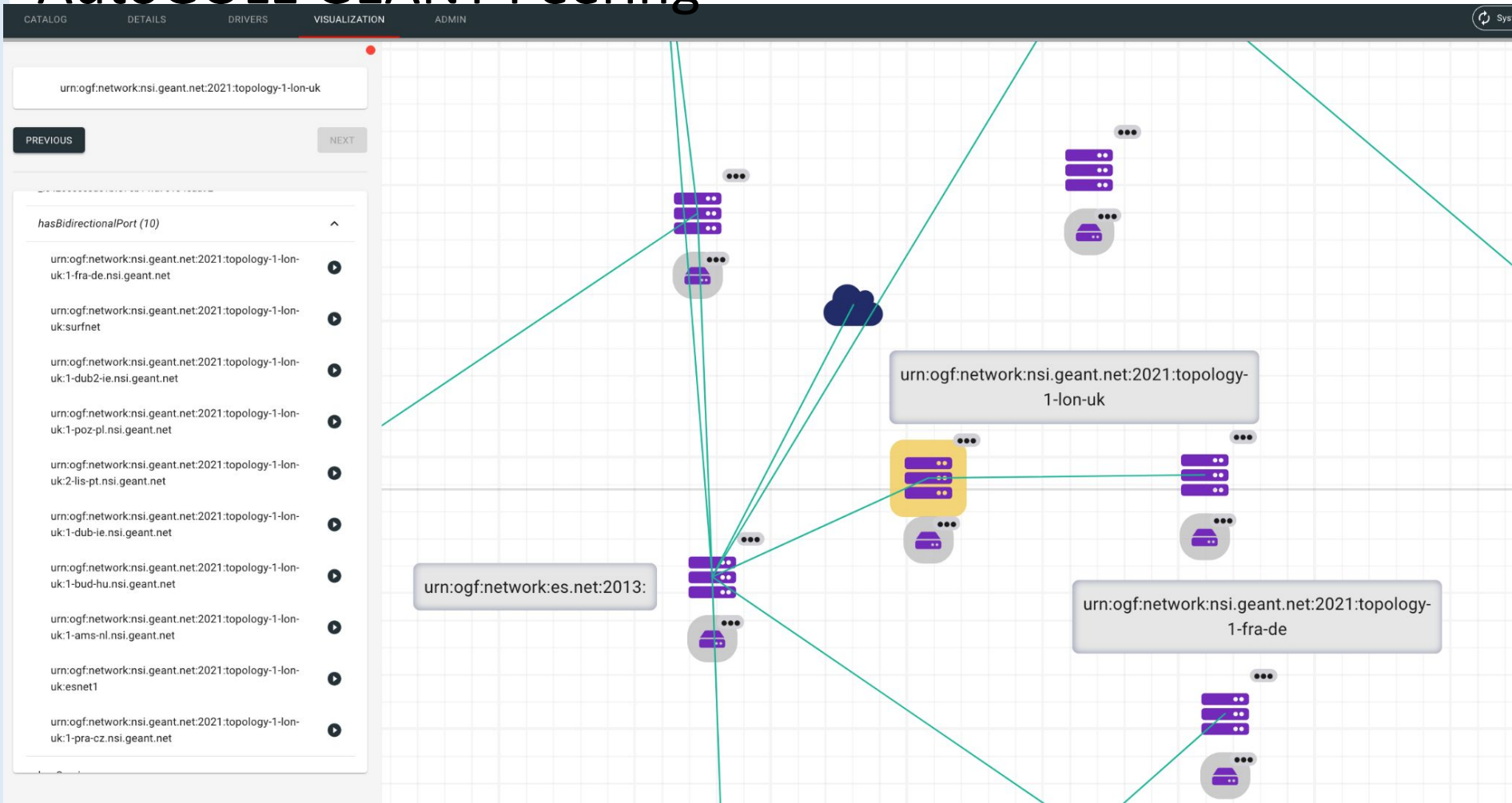
# Example Service Detailed View



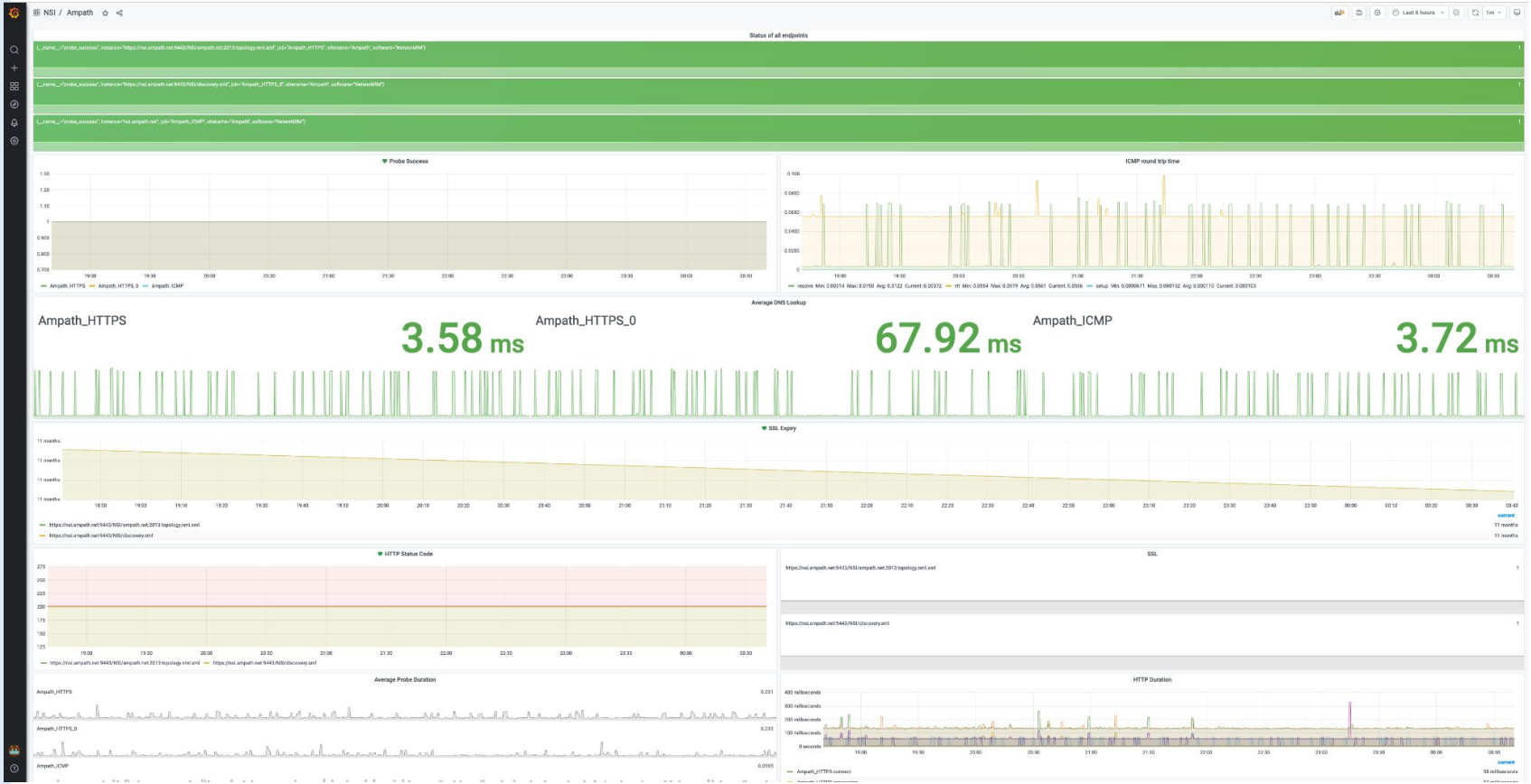
# Example Service Verification View



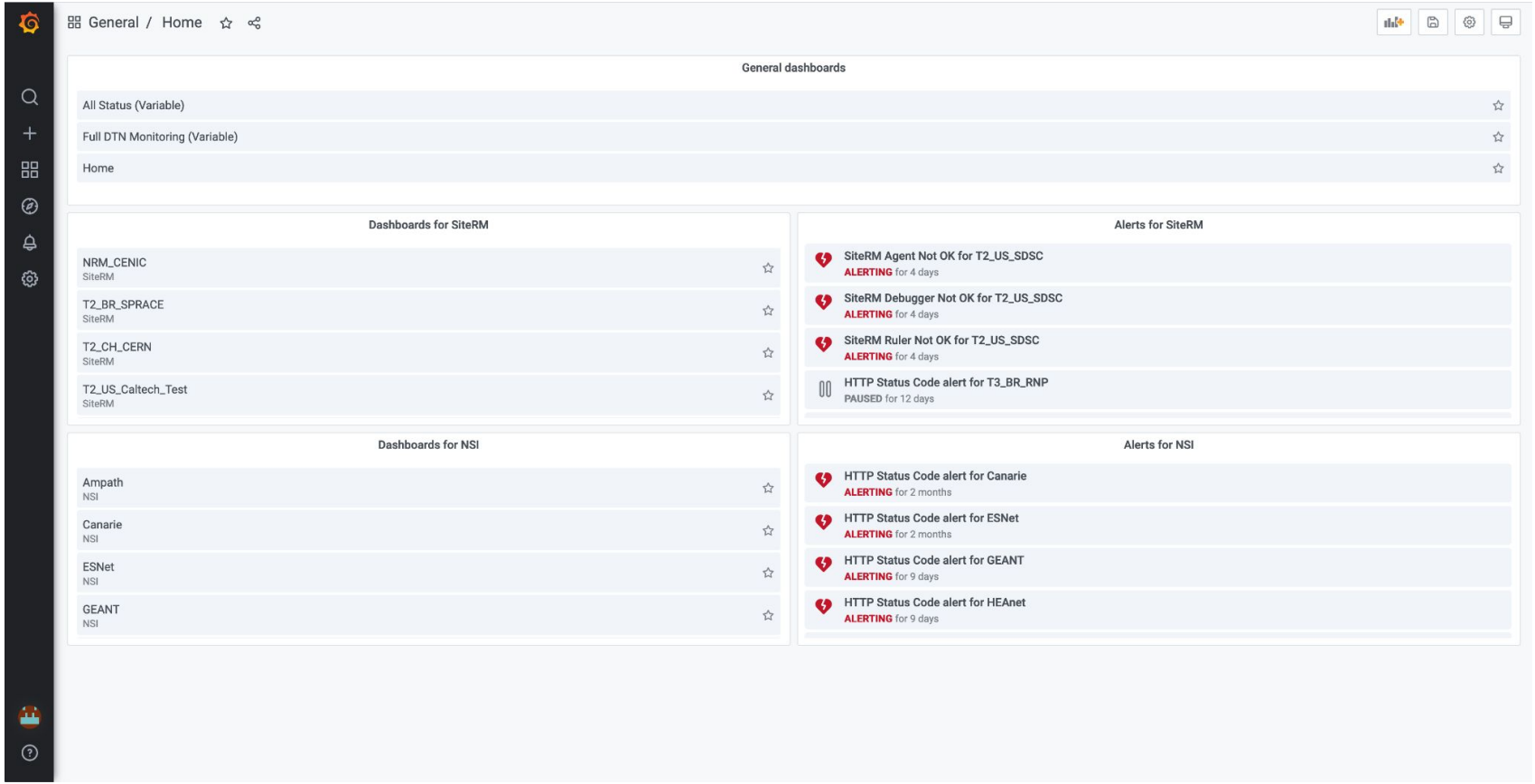
# AutoGOLE GEANT Peering



# SENSE/AutoGole Control Plane Monitoring

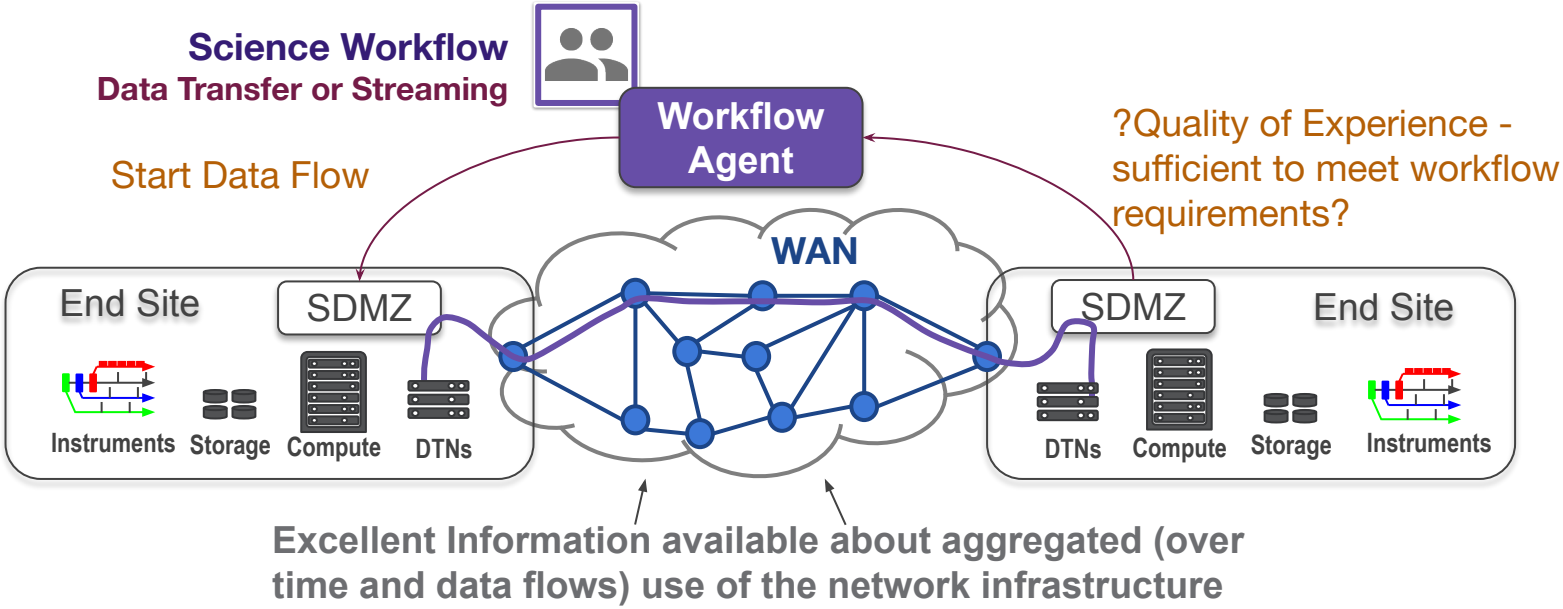


# SENSE/AutoGole Control Plane Monitoring



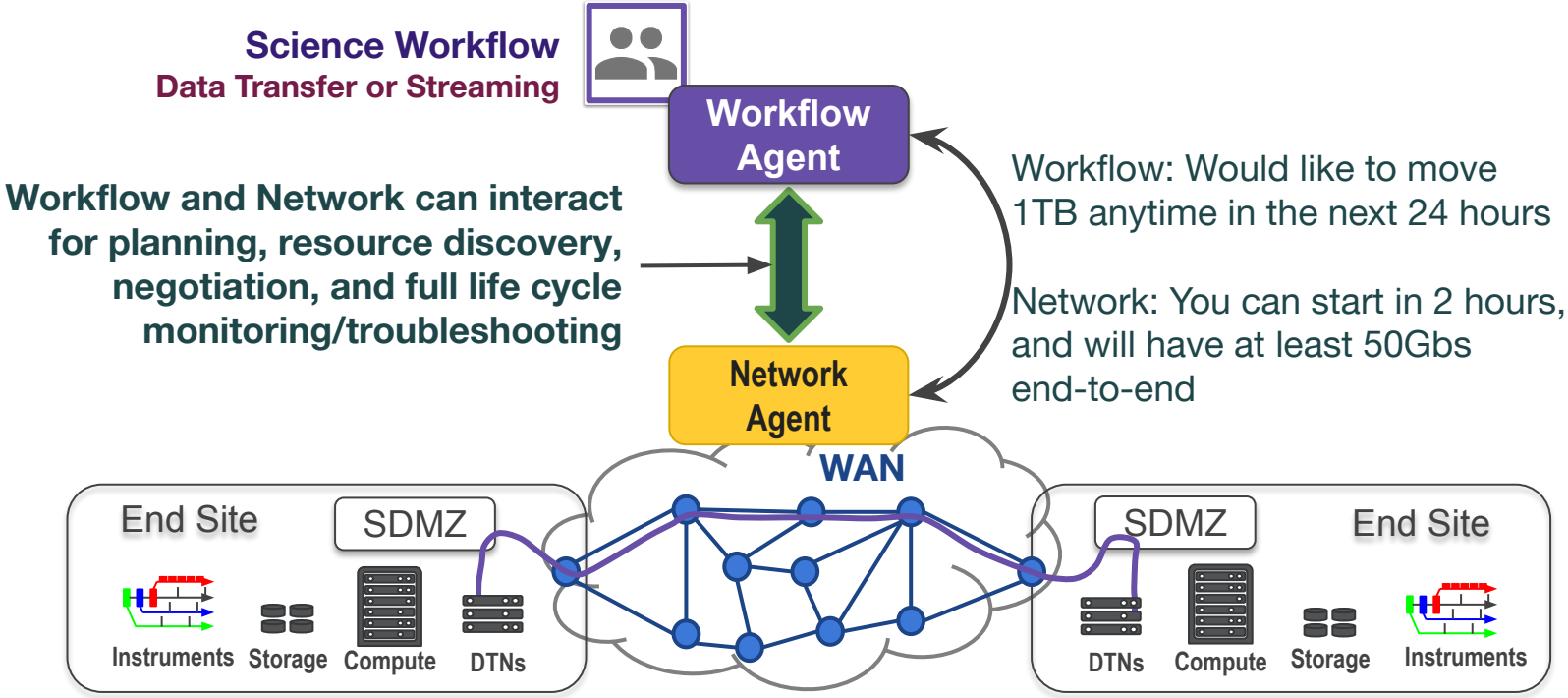
# Enable Science Workflow and Network Interaction with Deterministic "Quality of Experience"

- **No realtime per flow data available for planning or monitoring**
- **No "deterministic" network services available**
- **Start data flow, and hope for the best**



# Elevate Network to First Class Resource

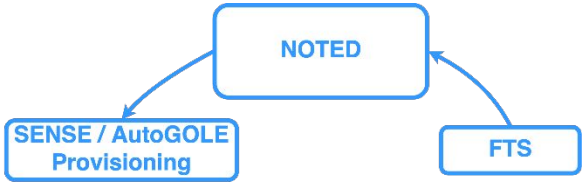
## API driven Automation and Orchestration

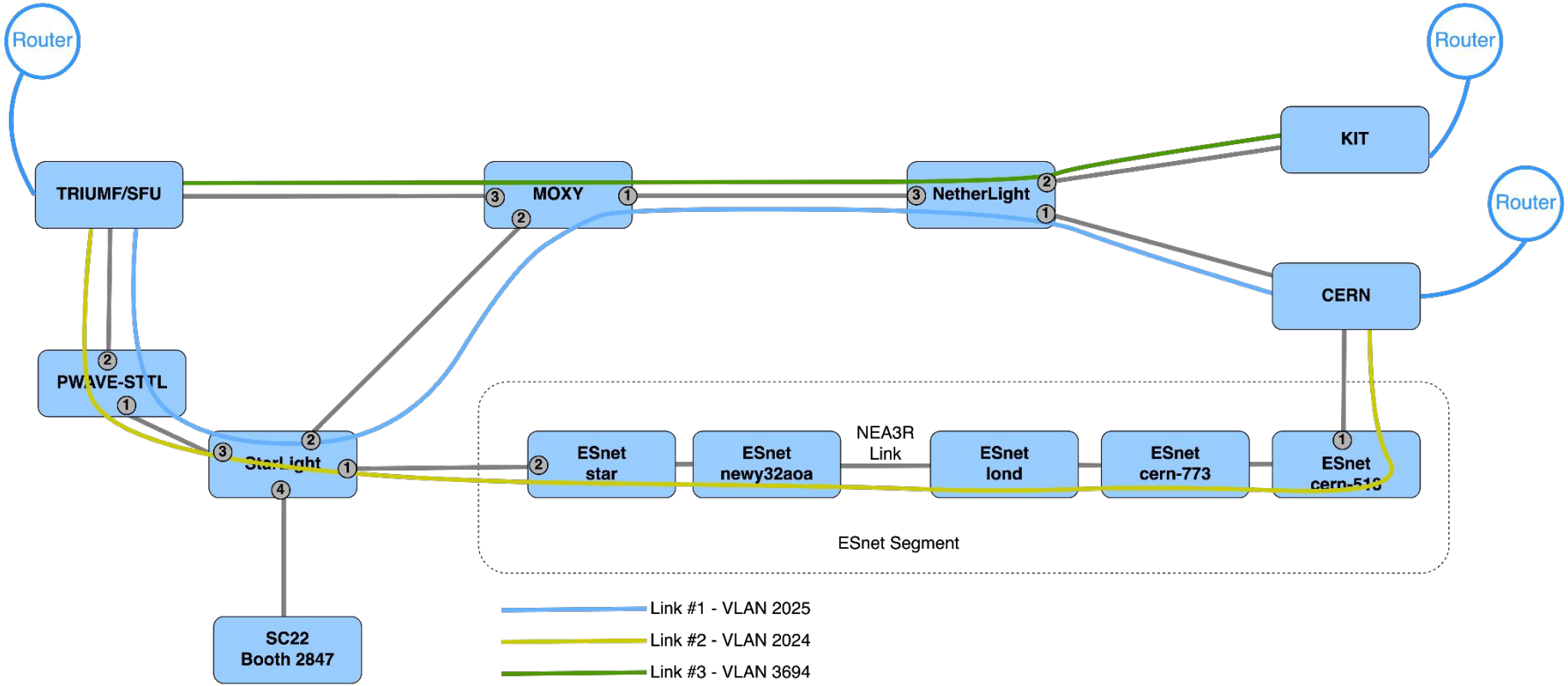



- Allows workflows to identify data flows which are higher priority
- Allows the network to traffic engineer to fully utilize all network paths

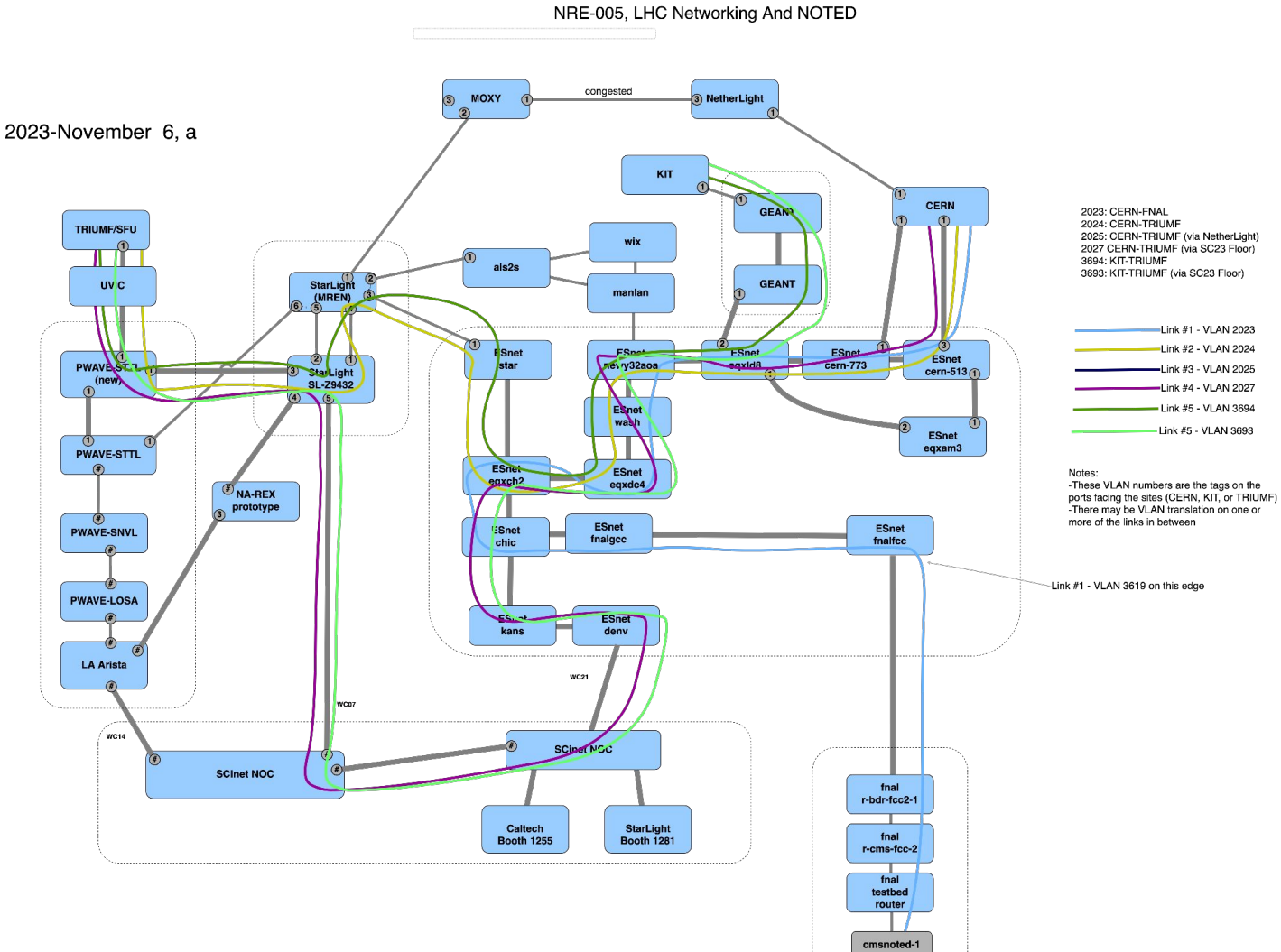
# NOTED Testing Example

- BGP and IP Routing integrated with wide area layer 2 traffic engineered paths

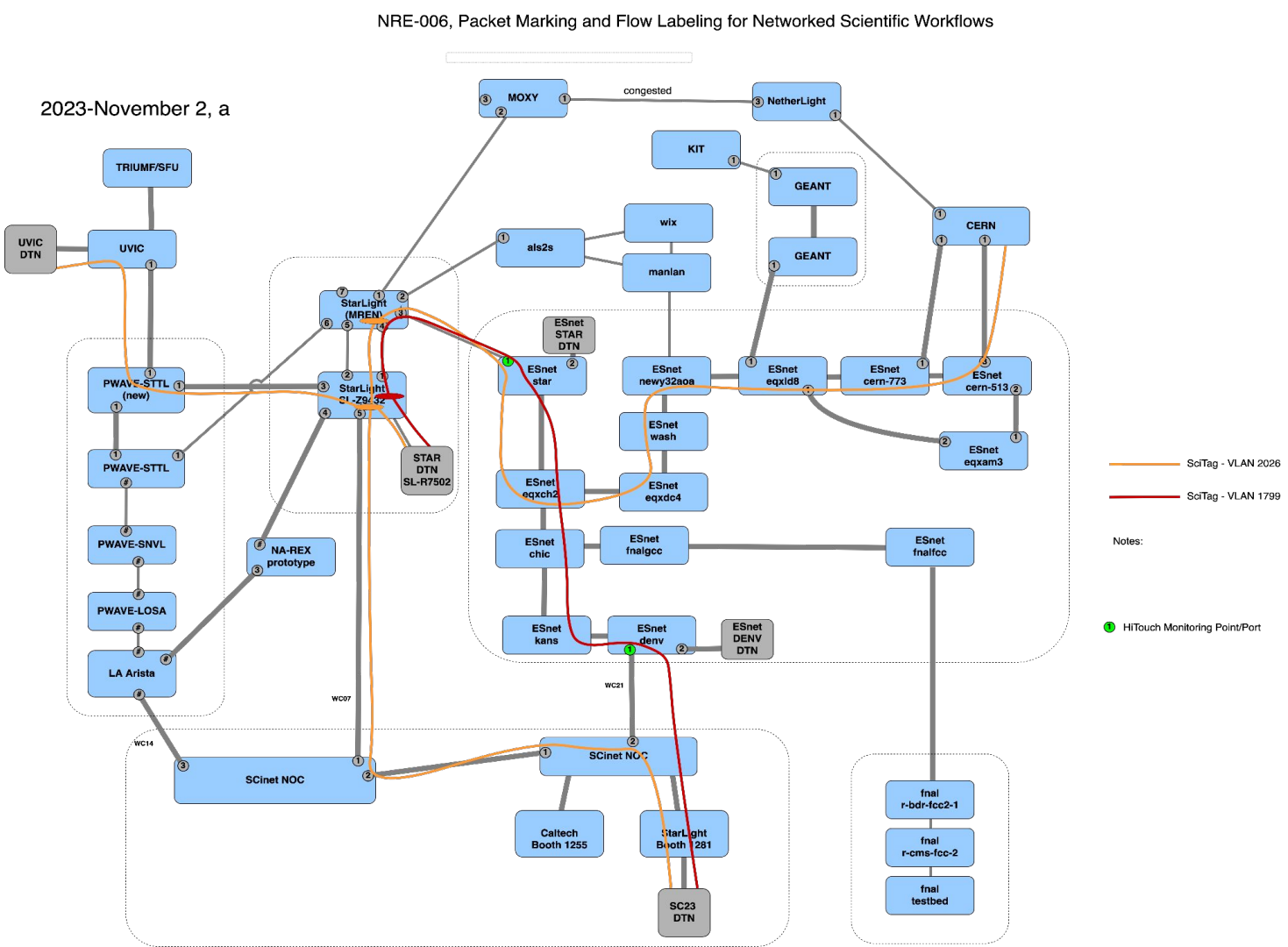


# NOTED Example



# Packet Marking Example



# Important Link Management

- There are multiple transatlantic links, operated by multiple organizations
- Desire is to be able to more flexibly control how these are utilized on per flow, group, or use basis
- Do not want to manage "every" flow in the network, however should be able to manage "any" flow in the network