

# AutoGOLE / SENSE and Infrastructure For Domain Science Innovation

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([www.startap.net/starlight](http://www.startap.net/starlight))

Global Research Platform Workshop

Co-Located With IEEE International Conference On eScience

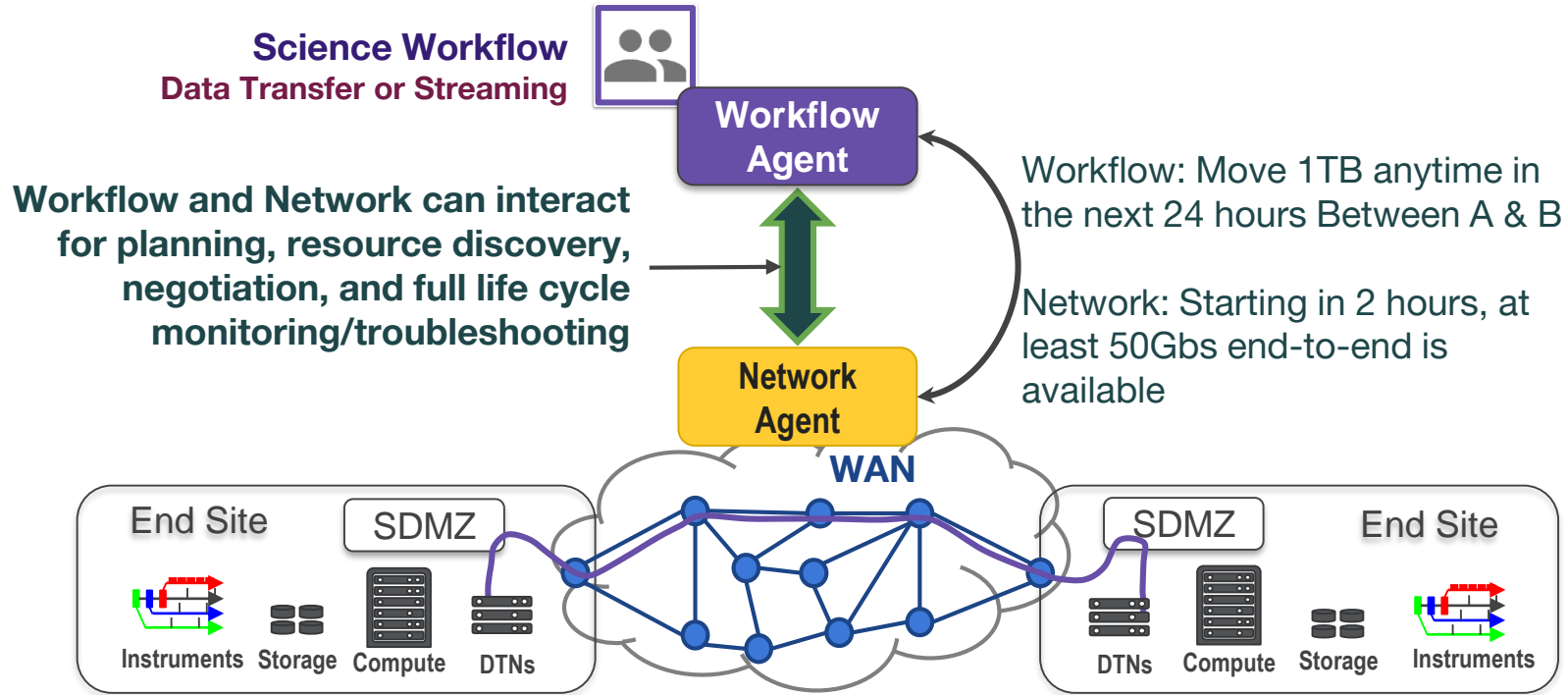
Limassol, Cyprus

October 9-10, 2023

# AutoGOLE / SENSE Objectives and Vision

- Infrastructure Providing Automated “End-to-End” Multi-Domain Network Services
  - Discovering And Integrating Network Resources
  - Managing Network Stacks Inside Attached End Systems (e.g., Data Transfer Nodes - DTNs)
- Leverages Open Source Software Based On:
  - Network Service Interface (NSI): Multidomain Network Provisioning, Particularly Domains Used By Research Communities
  - SENSE: End-System Provisioning and Real-Time Integration with Network Services
- Persistent Infrastructure, Between Production, Prototype, Testbed
  - Network Research, Experiments, Testing
  - Topologies and Services for Domain Science Integration and Research

# AutoGOLE SENSE Objective: Elevate Network to First Class Resource Via API Driven Automation and Orchestration Using Virtualized/Abstractions



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

# Global Research Platform: Global Lambda Integrated Facility Available Advanced Network Resources



Visualization courtesy of Bob Patterson, NCSA; data compilation by Maxine Brown, UIC.



[www.glif.is](http://www.glif.is)

STARLIGHT<sup>SM</sup>

*"The global advancement of science by realizing a multiresource infrastructure through international collaboration."*



## AutoGOLE Open R&E Exchanges



Schematic overview of the GNA-G AutoGOLE

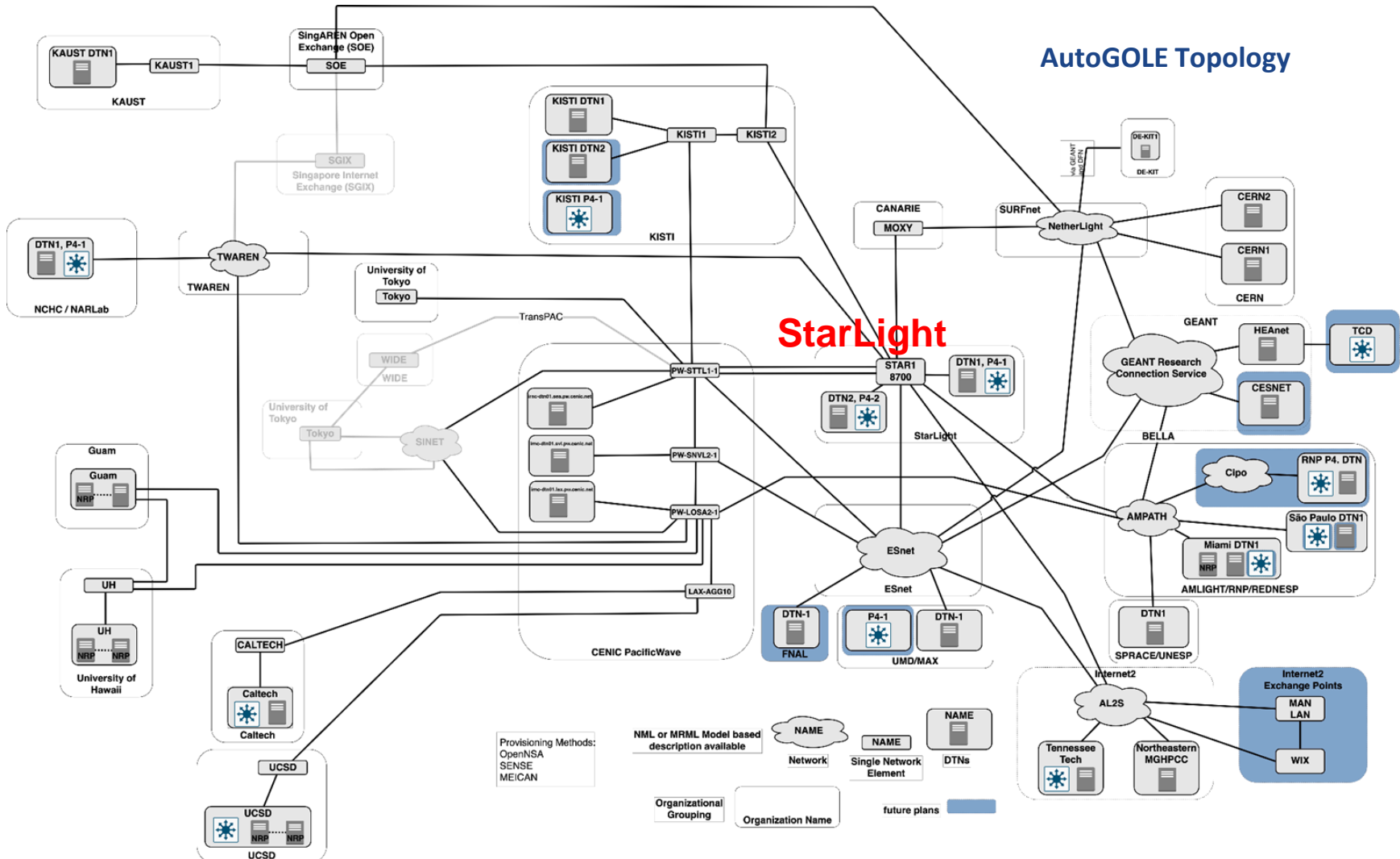
# AutoGOLE Background

- International Research Networking Community Designed Implemented and Operated Distributed Infrastructure To Support Advanced Networking Inter-Domain Service for Research (Beginning ~ 2001), Especially Those Based On Dynamic Lightpaths
- Innovated On Large Scale Optical Networking Testbeds (e.g., “Grid Networking” – Enabling Network To Be 1<sup>st</sup> Class Resource
- Global Lambda Integrated Facility Initiative (GLIF) Managed By International GLIF Organization, Held Annual Meetings, Sponsored Major International Demonstrations (e.g, iGRIDs)
- Created International Open Exchanges – GLIF Open Lambda Exchanges (GOLES) With Automation (AutoGOLE)
- In Practice, Services Were Based Primarily On Dynamic L2 Path Provisioning vs L1 Lightpaths.

# AutoGOLE Background: Network Service Interface (NSI)

- When The GLIF Was Designed, Each Open Exchange Had Its Own Control System
- To Enable Interoperability Among Domains, A Common API For Those Control Systems Was Developed By The Global Grid Forum, A Standards Organization – Network Service Interface (NSI) For Multidomain Network Provisioning
- Additional Tools Were Later Developed, e.g., OpenNSA (Network Service Agent)
- Software-Defined Network for End-to-end Networked Science at the Exascale (SENSE)

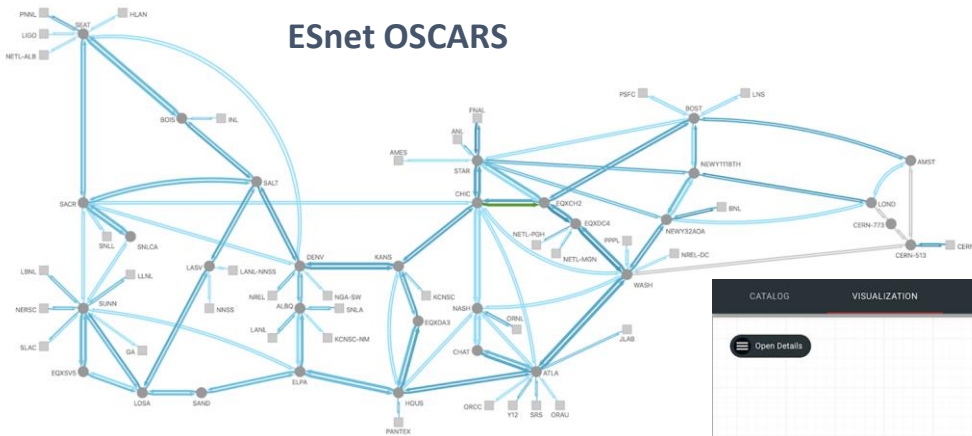
# AutoGOLE Topology





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

## ESnet OSCARS



## Internet2 AL2S



## AutoGOLE/SENSE

A screenshot of the AutoGOLE/SENSE visualization interface. The interface has a dark header with 'CATALOG' and 'VISUALIZATION' tabs, a 'System Refresh On' button, and 'ACCOUNT' and 'LOGOUT' links. The main area displays a complex network graph with nodes and edges. Nodes are represented by purple icons and labels, such as 'unirgl/network/central/2017-topology' and 'unirgl/network/central/2013'. The graph shows a dense network of connections between these nodes. On the right side, there are controls for 'Live data' and a 'Clipboard' button at the bottom right.

# Current AutoGOLE / SENSE GNA Work Group

- 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](mailto:autogole@lists.gna-g.net)
- To Participate, Join Calls
  - Every two weeks on Tuesdays, 10am ET

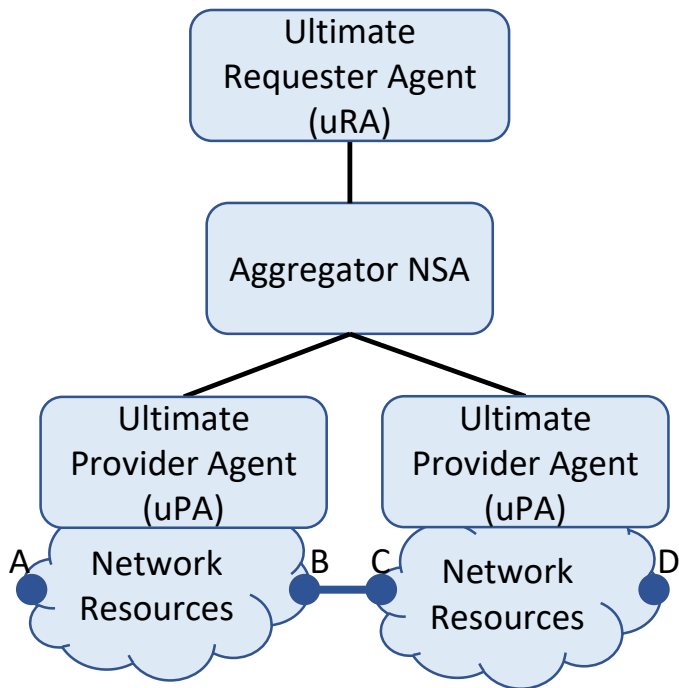


# AutoGOLE / SENSE Work Group Activities

- **Key Objective:**
  - Enabling AutoGOLE Infrastructure to be sufficiently persistent to allow focus on experiments, demonstrations, and research. Worldwide collaboration of open exchange points and interconnected multi-domain R&E networks to deliver automated network services end-to-end, e.g., using NSI for network connections, SENSE for integration of End Systems and Domain Science Workflow facing APIs.
- **Key Work Areas:**
  - **Infrastructure Coordination, Design, and Implementation**
  - **Infrastructure Monitoring and Testing:** Prometheus/Grafana based, Control plane and Dataplane monitoring/troubleshooting
  - **Intelligent network state analysis and realtime decisions:** integrated design and use of multiple systems
  - **User services and APIs:** methods for domain science workflow agents to access services
  - **Enhance robustness of AutoGOLE infrastructure and software:** core software and container based deployments
  - **Experiment, Research, Use Case support:** multiple activities including NOTED, Gradient Graph, P4 Topologies, Named Data Networking (NDN), Data Transfer Systems integration and testing.
-

# OpenNSA

## NSI based Provider (uPA)



# Safnari

## NSI Aggregator



## NSI Safnari

Usage

Connections

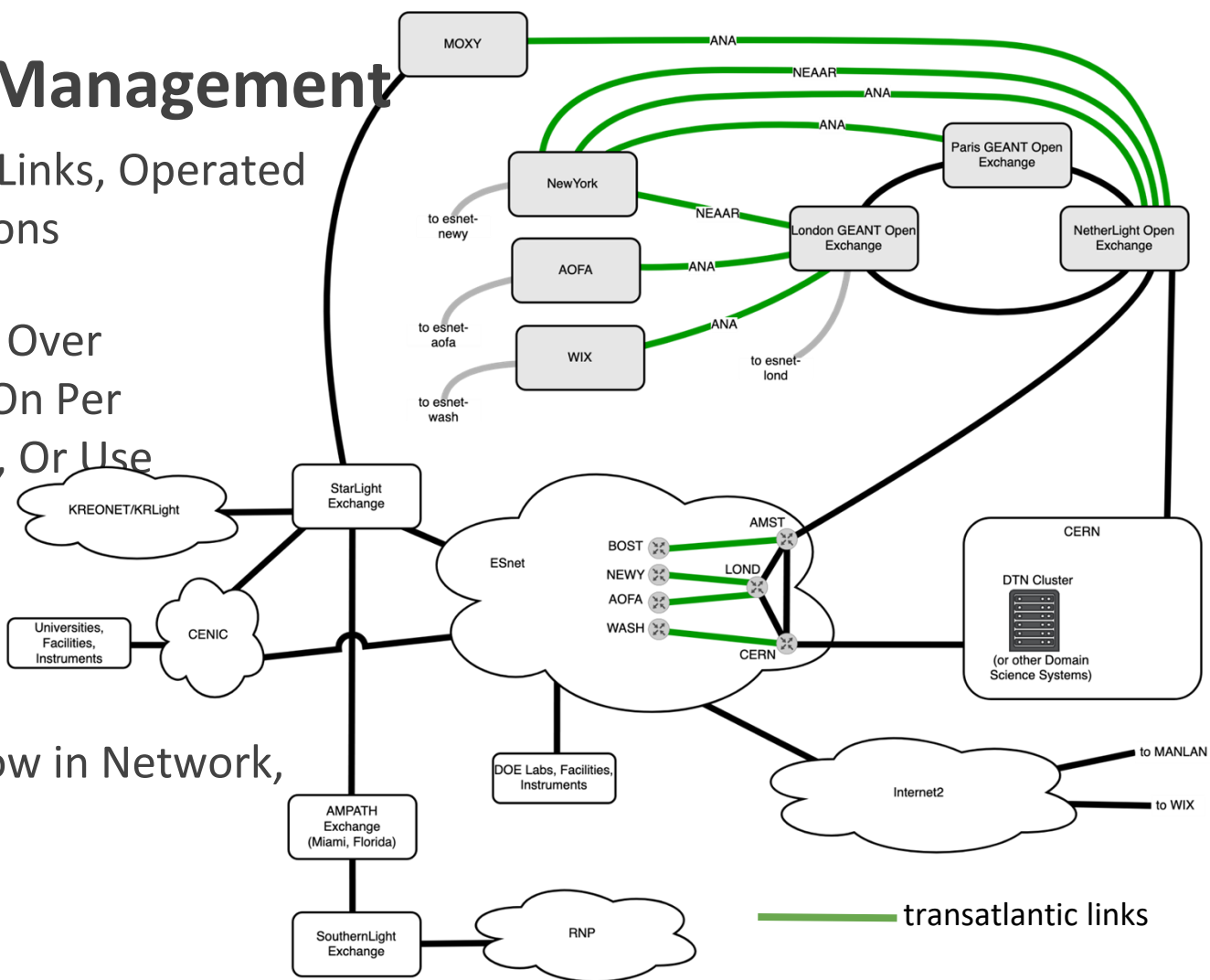
### Connection 6dfa8e66-cd18-4d57-bb3a-5b17c44c267f - CERN DTN - LA DTN with ERO - VLAN3988 - jhess

**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	<b>From</b> lsanca.pacificwave.net:2016:topology:dtn0.lsanca?vlan=3988 <b>To</b> lsanca.pacificwave.net:2016:topology:losa2-pw-sw-1_e1_1?vlan=3988	Released, Inactive	none
SN-740979f3c0	snvaca.pacificwave.net:2016:nsa	<b>From</b> snvaca.pacificwave.net:2016:topology:snv12-pw-sw-1_e7_2?vlan=3988 <b>To</b> snvaca.pacificwave.net:2016:topology:snv12-pw-sw-1_e2_2?vlan=3988	Released, Inactive	none
ST-64a9e1b353	stt1wa.pacificwave.net:2016:nsa	<b>From</b> stt1wa.pacificwave.net:2016:topology:icas-stt1wa01-03_e1_1?vlan=3988 <b>To</b> stt1wa.pacificwave.net:2016:topology:icair-grp?vlan=3988	Released, Inactive	none
IC-b47da37bc7	icair.org:2013:nsa	<b>From</b> icair.org:2013:topology:pwave-grp?vlan=3988 <b>To</b> icair.org:2013:topology:nl-cern1?vlan=3988	Released, Inactive	none
19001CS08-ANA	canarie.ca:2017:nsa	<b>From</b> canarie.ca:2017:topology:CHCG1?vlan=3988 <b>To</b> canarie.ca:2017:topology:ANA1?vlan=3988	Released, Inactive	none
890861b8-c20f-4968-aa4e-a670ef507c6	netherlight.net:2013:nsa:safnari	<b>From</b> netherlight.net:2013:production7:ana-1?vlan=3988 <b>To</b> netherlight.net:2013:production7:cern-1?vlan=3988	Released, Inactive	none

# Important: Link Management

- Multiple Transatlantic Links, Operated By Multiple Organizations (MultiDomain)
- Adding Flexible Control Over How They Are Utilized On Per Flow, Group, or Project, Or Use Basis
- Not Managing Every Flow in Network, But Any Selected Flow



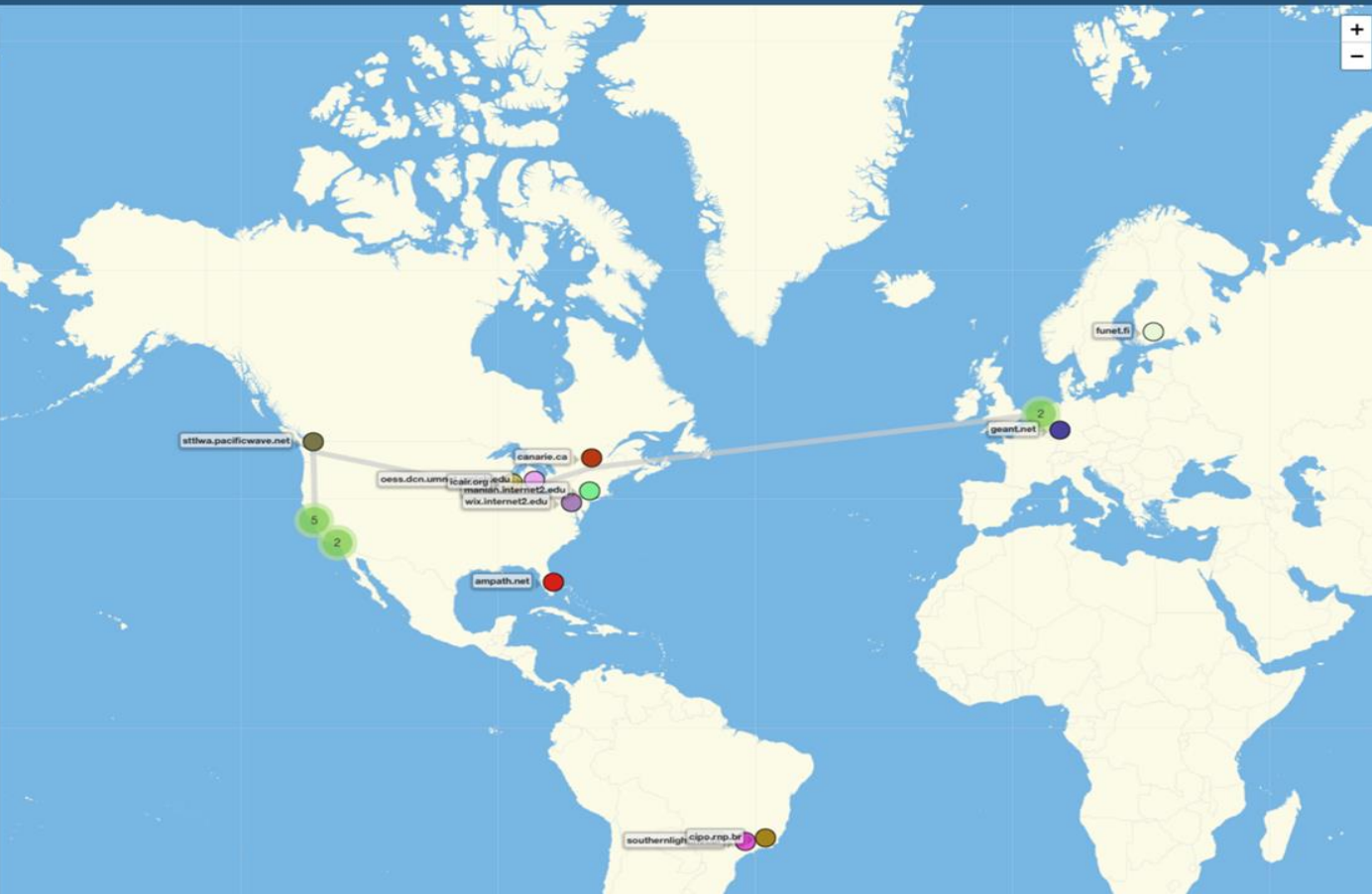
# MEICAN – NSI Visualization and Provisioning

Step 1: Path

Source

- Isanca.pacificwave.net  
Network: Isanca.pacificwave.net:2016  
Port: dtn0.Isanca  
VLAN: 3987
- snvaca.pacificwave.net  
Network: snavaca.pacificwave.net:2016  
Port: snvl2-pw-sw-1\_e2\_2  
VLAN: 3987
- sttlwa.pacificwave.net  
Network: sttlwa.pacificwave.net:2016  
Port: icair-grp  
VLAN: 3987
- icair.org  
Network: icair.org:2013  
Port: nl-cern1  
VLAN: 3987
- canarie.ca  
Network: canarie.ca:2017  
Port: ANA1  
VLAN: 3987
- netherlight.net  
Network: production7  
Port: Asd001A\_8700 07-8/2 CERN  
VLAN: 3987

Destination

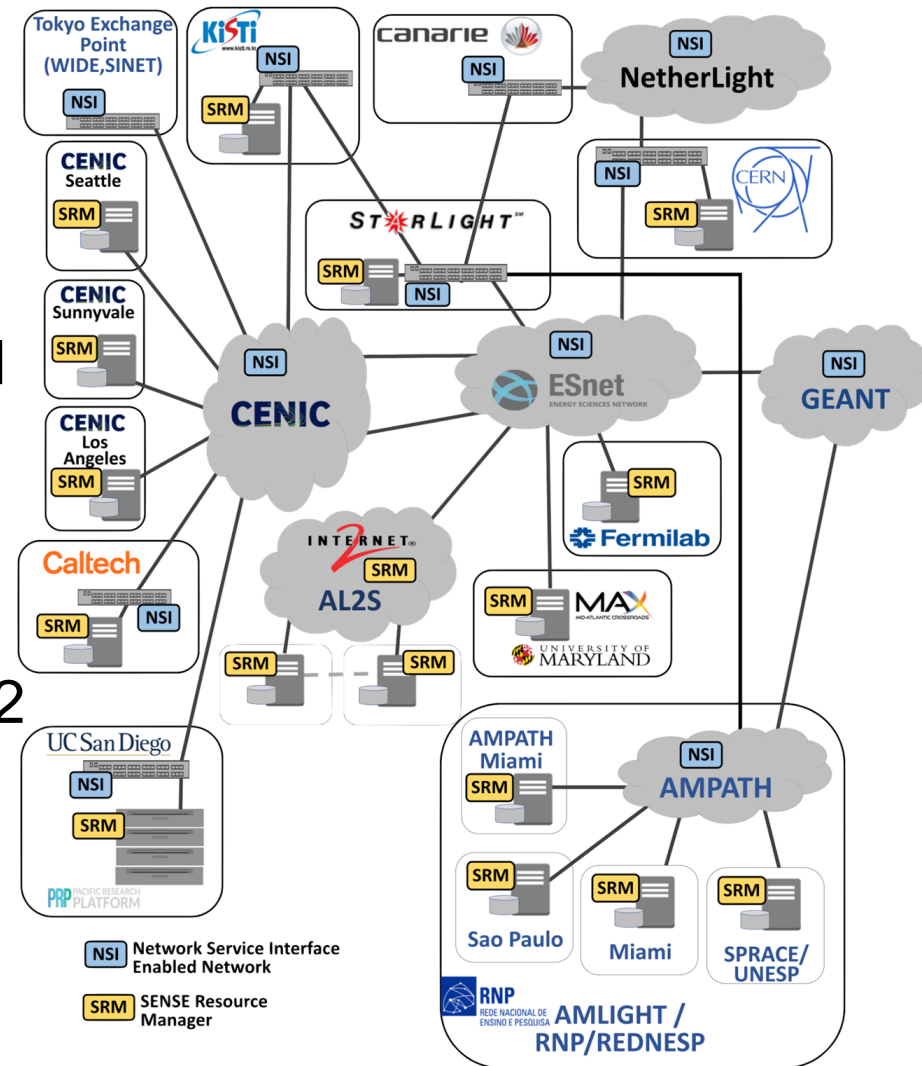


# Software-Defined Network for End-to-End Networked Science at the Exascale (SENSE)

- Integration of End-Site Resources and Science Workflows
- Automated Provisioning and Traffic Engineering of Paths Across Multi-Domain Wide Area Networks and Open Exchange Points
- Value Added To Science Applications Via Integration Of These Services With:
  - End Site Network, Compute, and Storage Infrastructure
  - Science Workflow Agents and Middleware
  - Developing Capabilities For Higher Capacities: 400/800 Gbps/Tbps E2E WAN Services

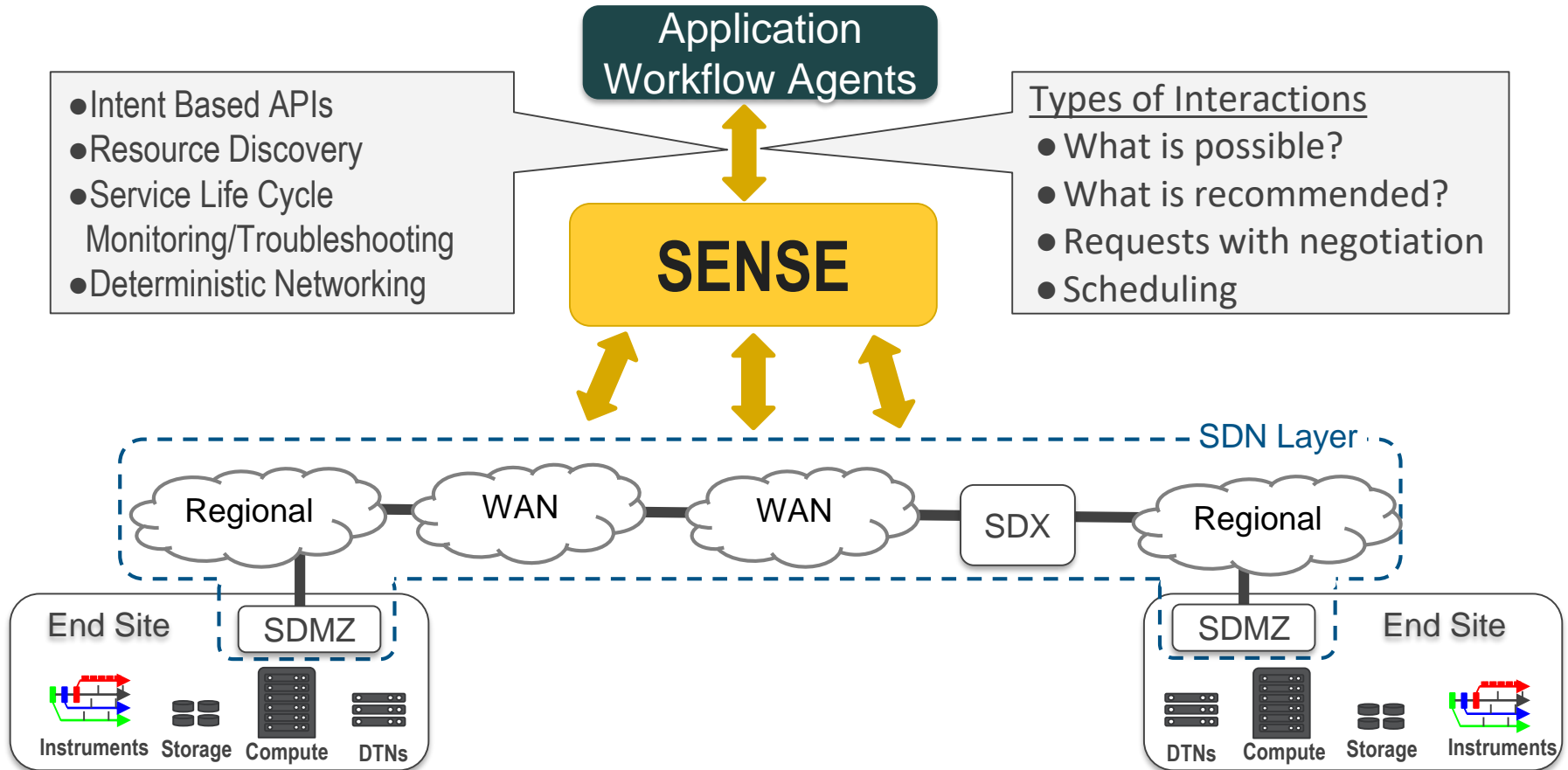
# AutoGole/SENSE

- AutoGOLE, NSI, and SENSE Together Provide Mechanisms For End-To-End Services Including Network And Attached End Systems (e.g., DTNs).
- Possible Provisioning: Layer 2 Isolation, Guaranteed QoS, Managing Flows Path/Link Usage





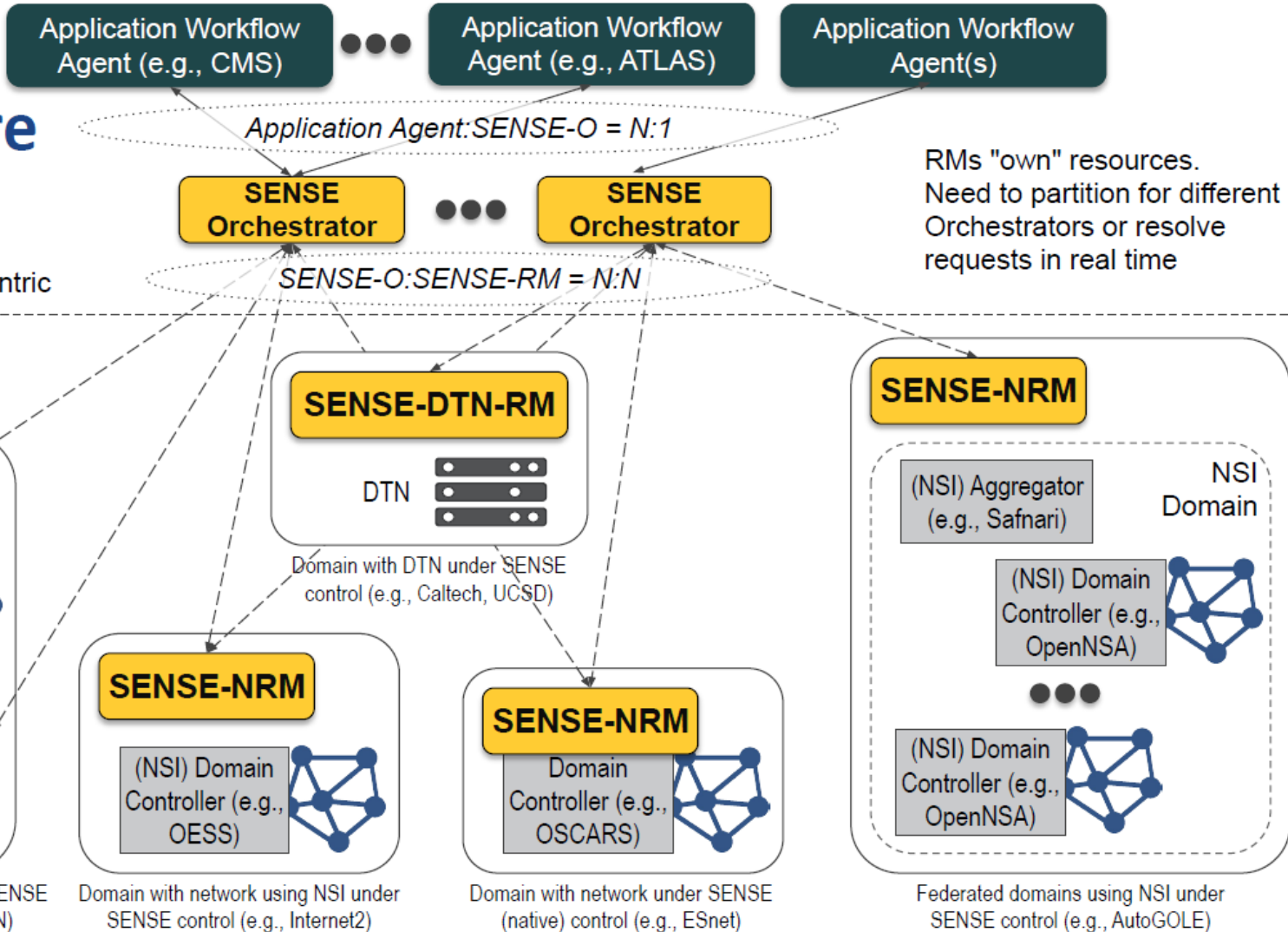
# Workflows Can “Coordinate” With End-to-End Networked Cyberinfrastructure



# SENSE Architecture

Collaboration / Project Centric

Resource Administrative  
Domain Centric



# SENSE – Orchestrator View: Model Based Resources

CATALOG    DETAILS    DRIVERS    **VISUALIZATION**    ADMIN    System Refresh On ✓    ACCOUNT    LOGOUT

urn:ogf:network:sc-test.cenic.net:2020:aristaeos\_s0

PREVIOUS    NEXT

*hasBidirectionalPort* (6)

- urn:ogf:network:sc-test.cenic.net:2020:aristaeos\_s0:Ethernet10-1
- urn:ogf:network:sc-test.cenic.net:2020:aristaeos\_s0:Ethernet9-1
- urn:ogf:network:sc-test.cenic.net:2020:aristaeos\_s0:Port-Channel501
- urn:ogf:network:sc-test.cenic.net:2020:aristaeos\_s0:Port-Channel502
- urn:ogf:network:sc-test.cenic.net:2020:aristaeos\_s0:Ethernet1-1

New data available!

urn:ogf:network:trp-nautilus.io:2020


urn:ogf:network:sc-test.cenic.net:2020

urn:ogf:network:ultralight.org:2013

Browser    Instances    Search    Clipboard

# SENSE Orchestrator - User Template

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

Service Template Example 

Allocation and Editable VLAN Range

Licenses

tlehman - 3 slot(s) given.  
allocation

+

MAKE EDITABLE

Selected: DATA > CONNECTIONS > 0 > TERMINALS > 1 >

VLAN\_TAG

Validator (optional)  
3987-3989

Use a list of comma-separated values, a numeric range, or a raw regex without slashes (ex. \*.uri:\*)

```
object ▶ data ▶ connections ▶ 0 ▶ terminals ▶ 1 ▶ vlan_tag
▼ DNC root schema {2}
  ▼ data {2}
    type : Multi-Path P2P VLAN
    ▼ connections [1]
      ▼ 0 {4}
        ▼ bandwidth {2}
          qos_class : guaranteedCapped
          capacity : 1000
        ▼ suggest_ip_range [1]
          ▼ 0 {2}
            start : 10.251.86.10/24
            end : 10.251.86.20/24
          name : Connection 1
        ▼ terminals [2]
          ▼ 0 {3}
            vlan_tag : any
            assign_ip : true
            uri : urn:ogf:network:calit2.optiputer.net:2020:k8s-gen4-01.calit2.optiputer.net
          ▼ 1 {3}
            vlan_tag : 3987
            assign_ip : true
            uri : urn:ogf:network:cern.ch:2013:cixp-surfnet-dtn.cern.ch
        service : dnc
```

JSON View    Alias

**Also Ref:**  
**Jupyter Notebooks**

# AutoGole/SENSE Control Plane Monitoring

General / Home ☆ 🔊

General dashboards

- All Status (Variable) ☆
- Full DTN Monitoring (Variable) ☆
- Home ☆

### Dashboards for SiteRM

- NRM\_CENIC SiteRM ☆
- T2\_BR\_SPRACE SiteRM ☆
- T2\_CH\_CERN SiteRM ☆
- T2\_US\_Caltech\_Test SiteRM ☆

### Alerts for SiteRM

- SiteRM Agent Not OK for T2\_US\_SDSC **ALERTING** for 4 days
- SiteRM Debugger Not OK for T2\_US\_SDSC **ALERTING** for 4 days
- SiteRM Ruler Not OK for T2\_US\_SDSC **ALERTING** for 4 days
- HTTP Status Code alert for T3\_BR\_RNP **PAUSED** for 12 days

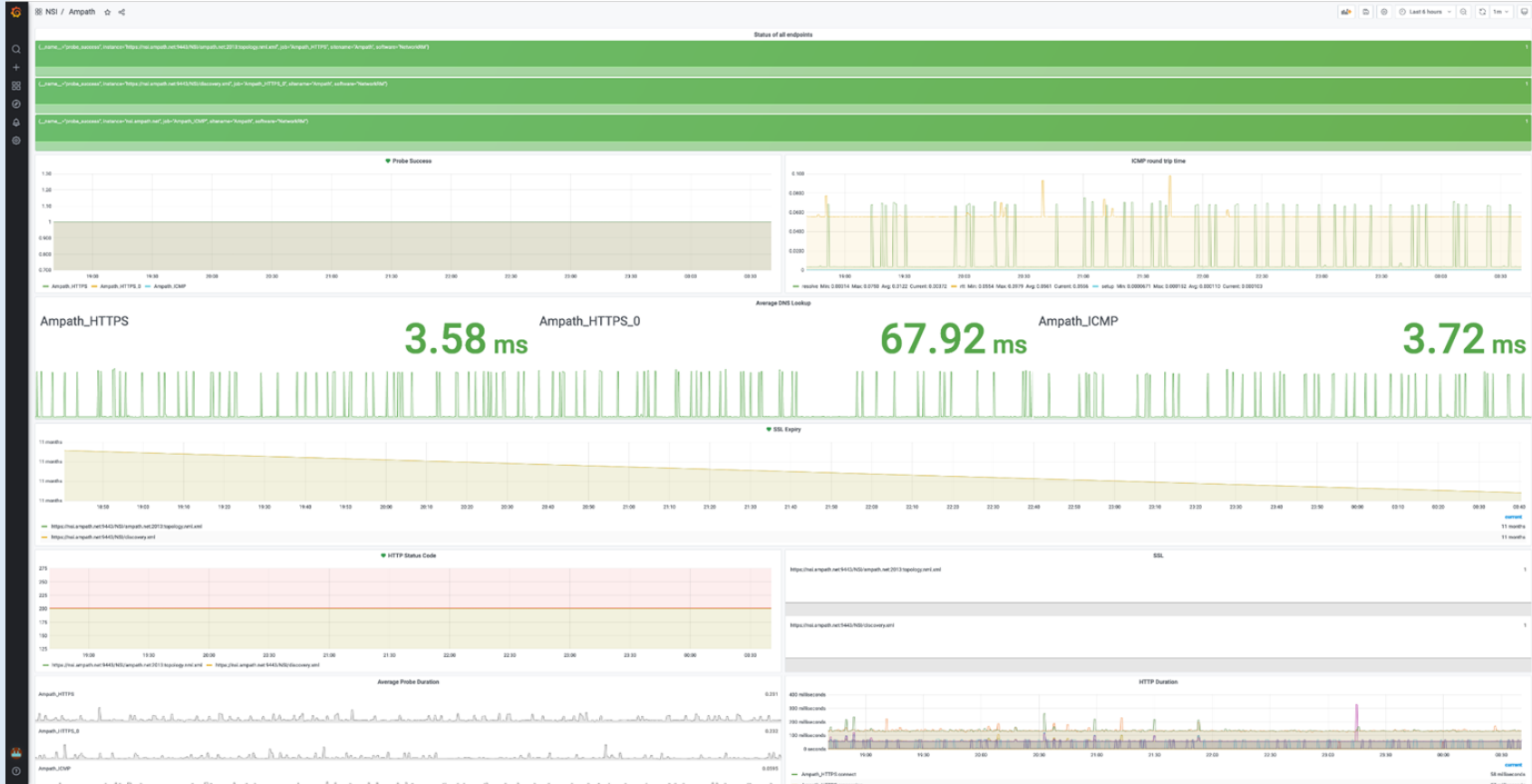
### Dashboards for NSI

- Ampath NSI ☆
- Canarie NSI ☆
- ESNet NSI ☆
- GEANT NSI ☆

### Alerts for NSI

- HTTP Status Code alert for Canarie **ALERTING** for 2 months
- HTTP Status Code alert for ESNet **ALERTING** for 2 months
- HTTP Status Code alert for GEANT **ALERTING** for 9 days
- HTTP Status Code alert for HEANet **ALERTING** for 9 days

# SENSE/AutoGole Control Plane Monitoring

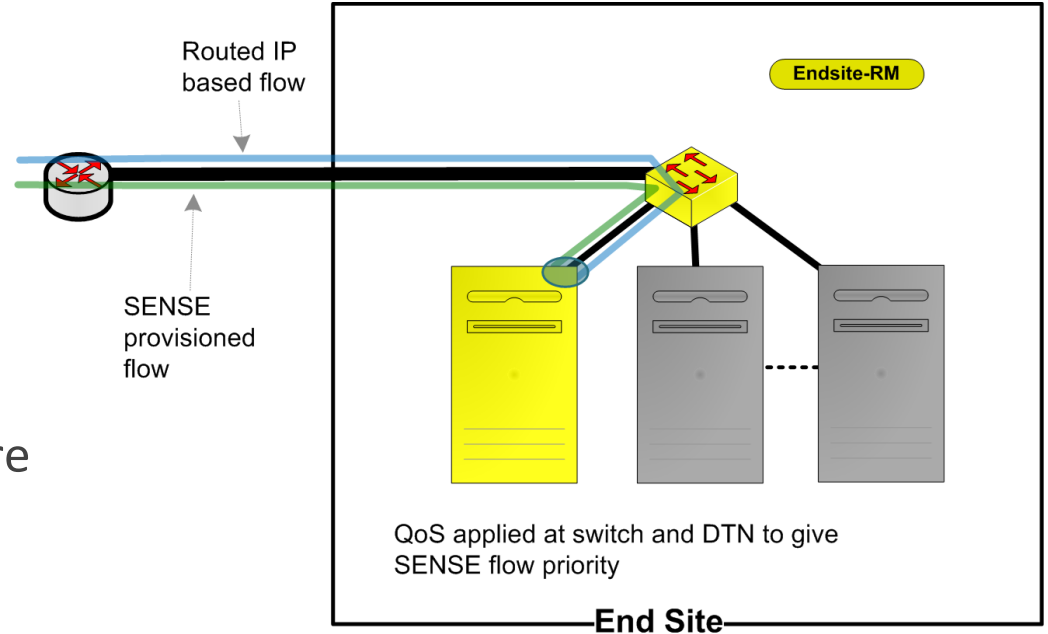
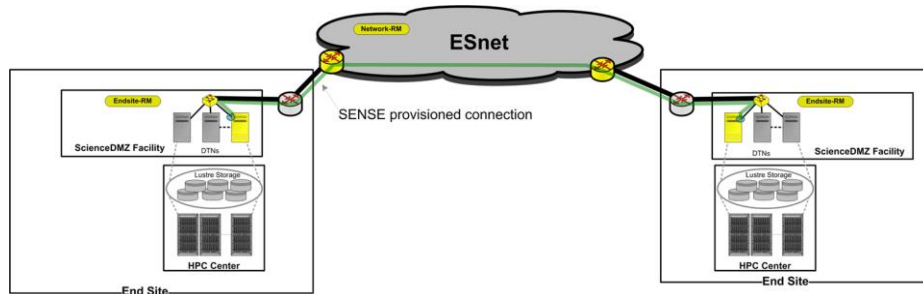


# SENSE Use Cases

- **Data Transfer Node Priority Flow (SENSE Enabled DTNs)**
  - Deterministic end-to-end data transfers
- **DOE Superfacility**
  - Workflows which use SuperFacility APIs and Network (SENSE) APIs
- **Exascale for Free Electron Lasers (ExaFEL)**
  - Streaming the data from the Linac Coherent Light Source (LCLS)
- **Large Hadron Collider/ Compact Muon Solenoid (LHC/CMS) Rucio/File Transfer Service (FTS)**
  - Coordination of SENSE services with workflow driven data transfers

# SENSE Enabled DTNs

- SENSE DTNs can be deployed next to production DTNs
- No impact to standard DTN operations
- Just adds a “priority flow” feature



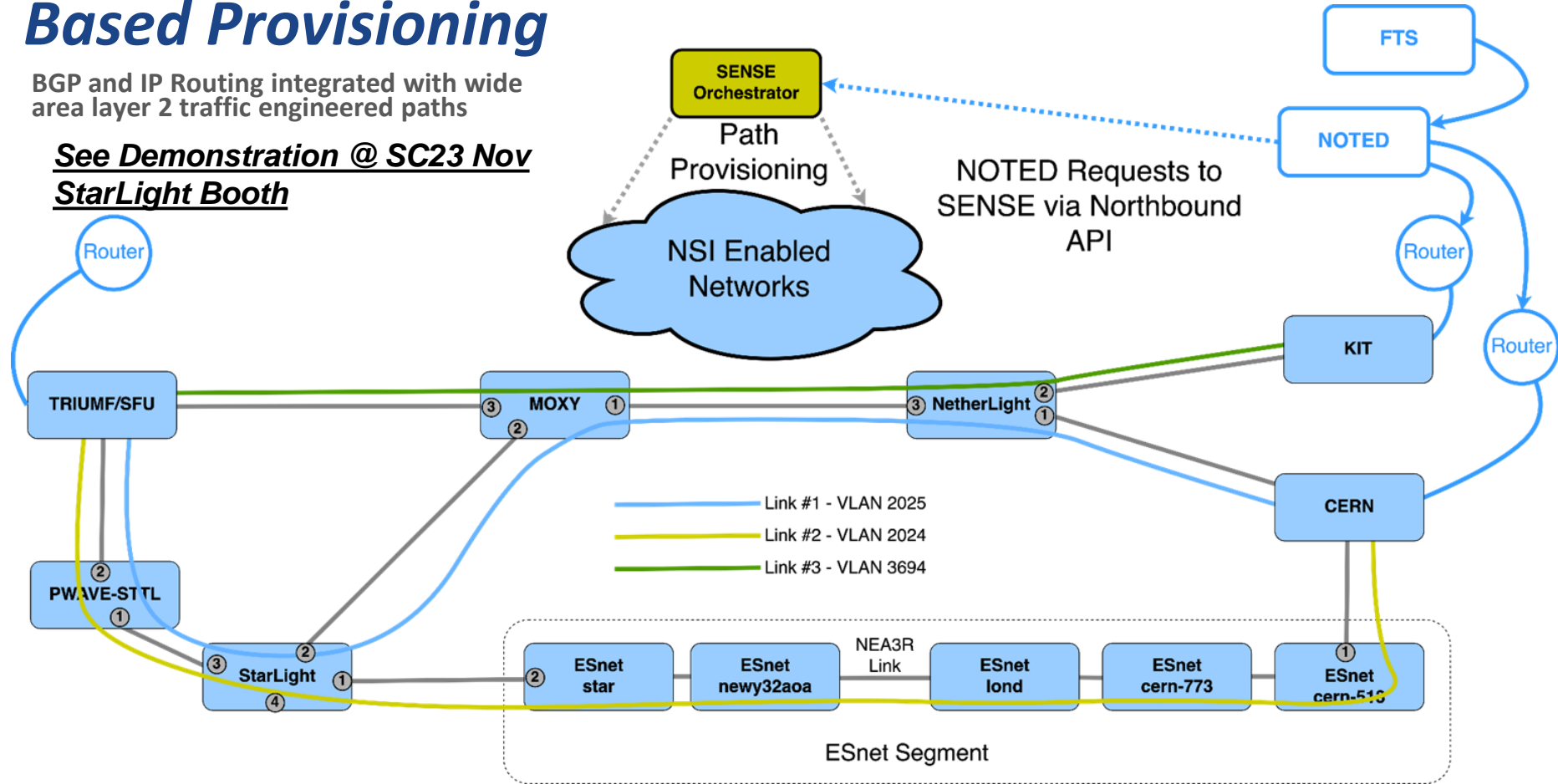
- Scheduled and guaranteed resources, network and end system
- Can be included as part of application workflow planning



# NOTED Example: AI Based Provisioning

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

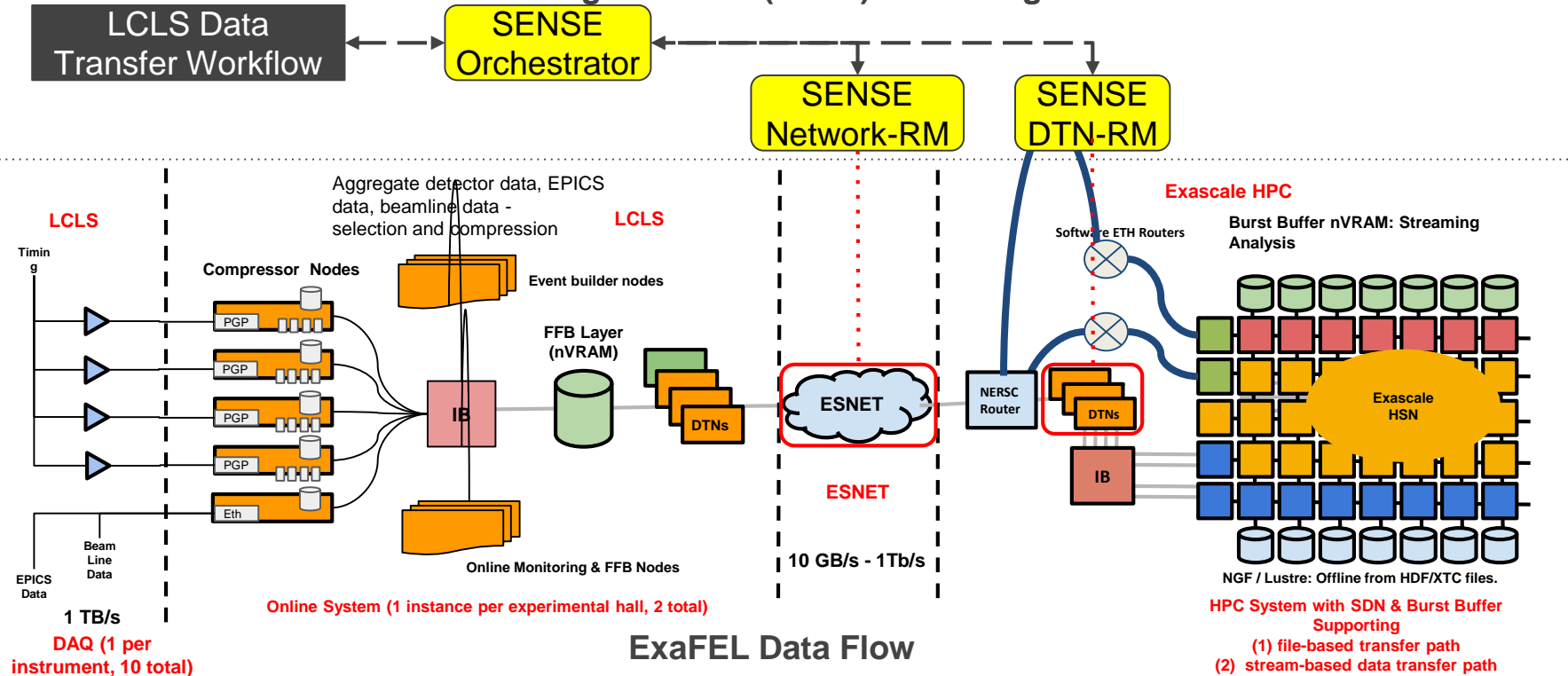
See Demonstration @ SC23 Nov StarLight Booth



# ExaFEL Use Case - Superfacility Automation Prototyping

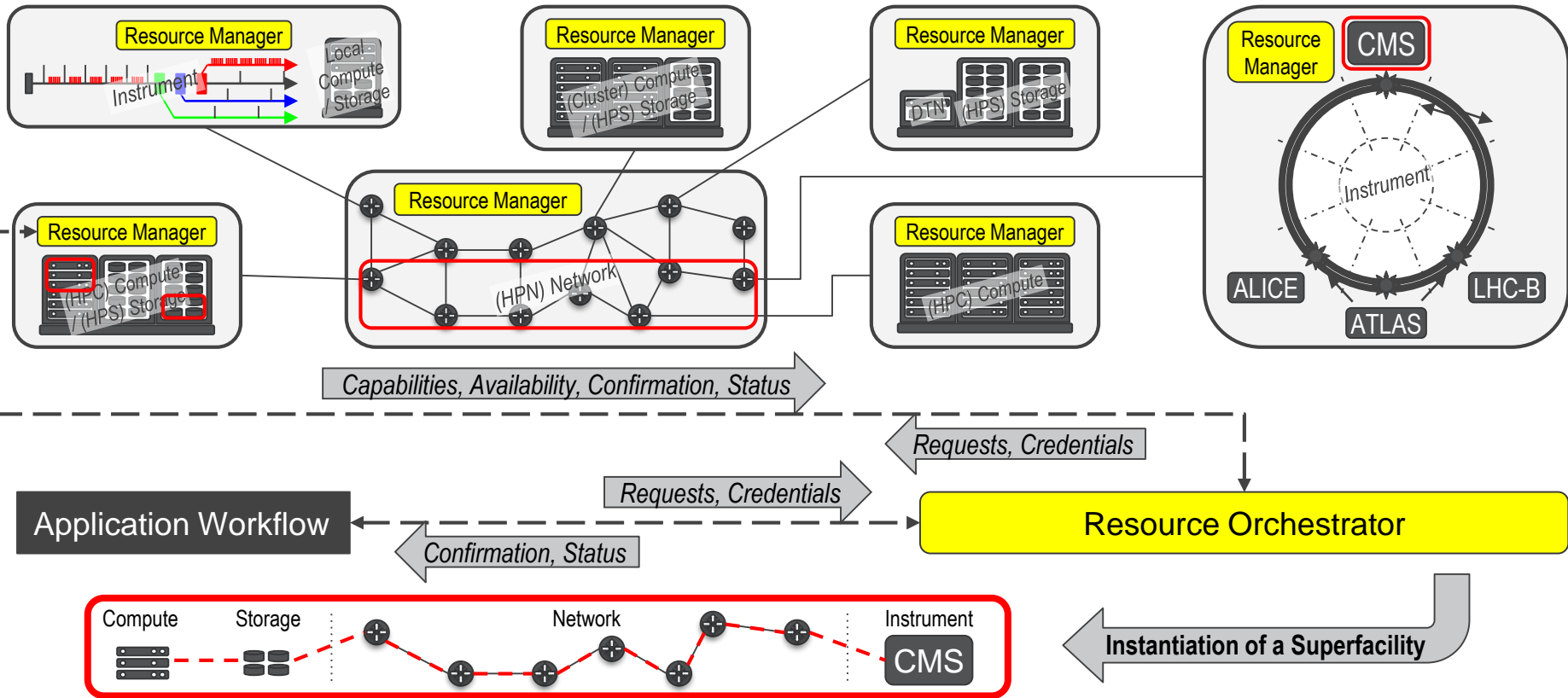
SDN for End-to-End Networking @ Exascale (SENSE)

Linac Coherent Light Source (LCLS) Streaming



ExaFEL is part of the Exascale Computing Project (ECP) initiative

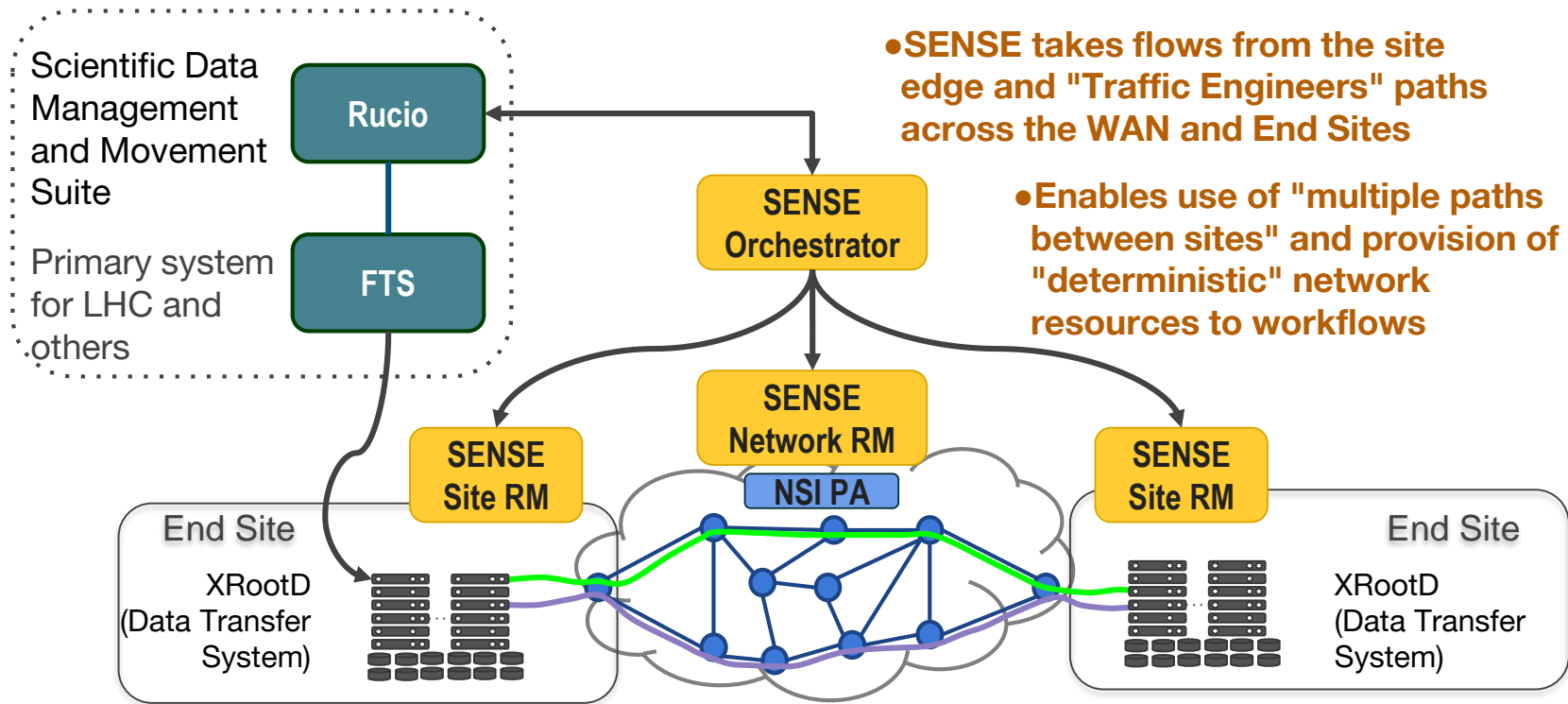
# Superfacility Automation Ideas/Options



SENSE is part of ESnet's collaboration with NERSC as part of their Superfacility project

# SENSE and Rucio/FTS/XRootD Interoperation

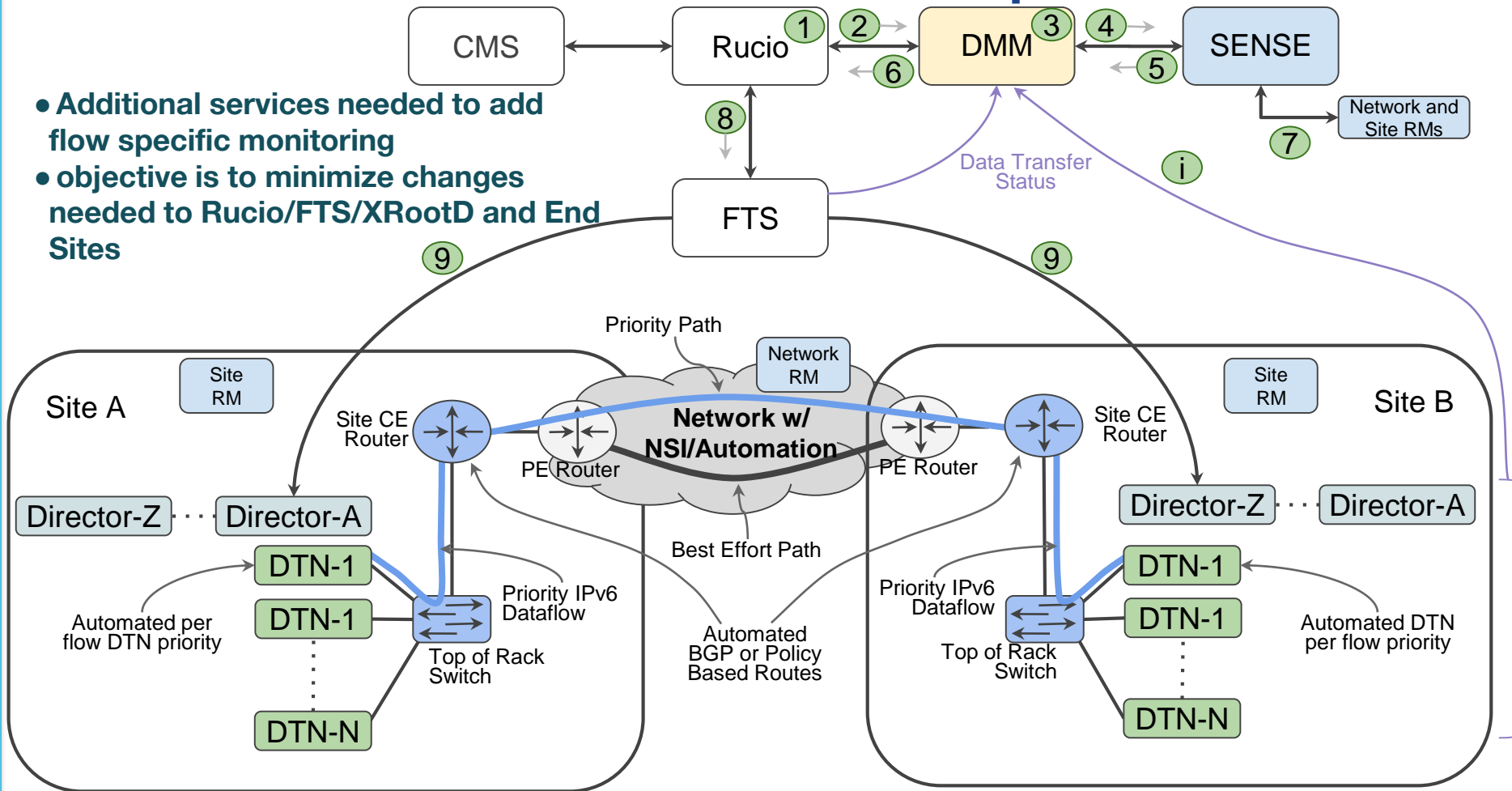
- Rucio identifies groups of data flows (IPv6 subnets) which are "high priority"



- SENSE takes flows from the site edge and "Traffic Engineers" paths across the WAN and End Sites
- Enables use of "multiple paths between sites" and provision of "deterministic" network resources to workflows

# SENSE and Rucio/FTS/XRootD Interoperation

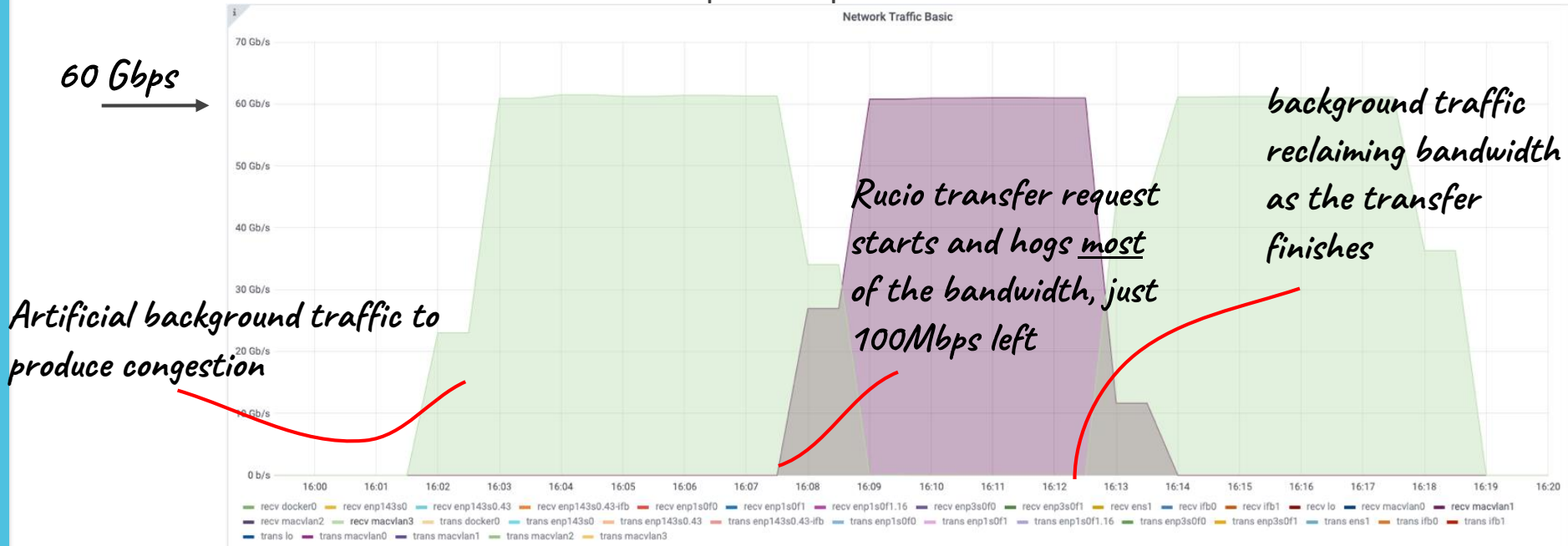
- Additional services needed to add flow specific monitoring
- objective is to minimize changes needed to Rucio/FTS/XRootD and End Sites



# Development and Testing Ongoing

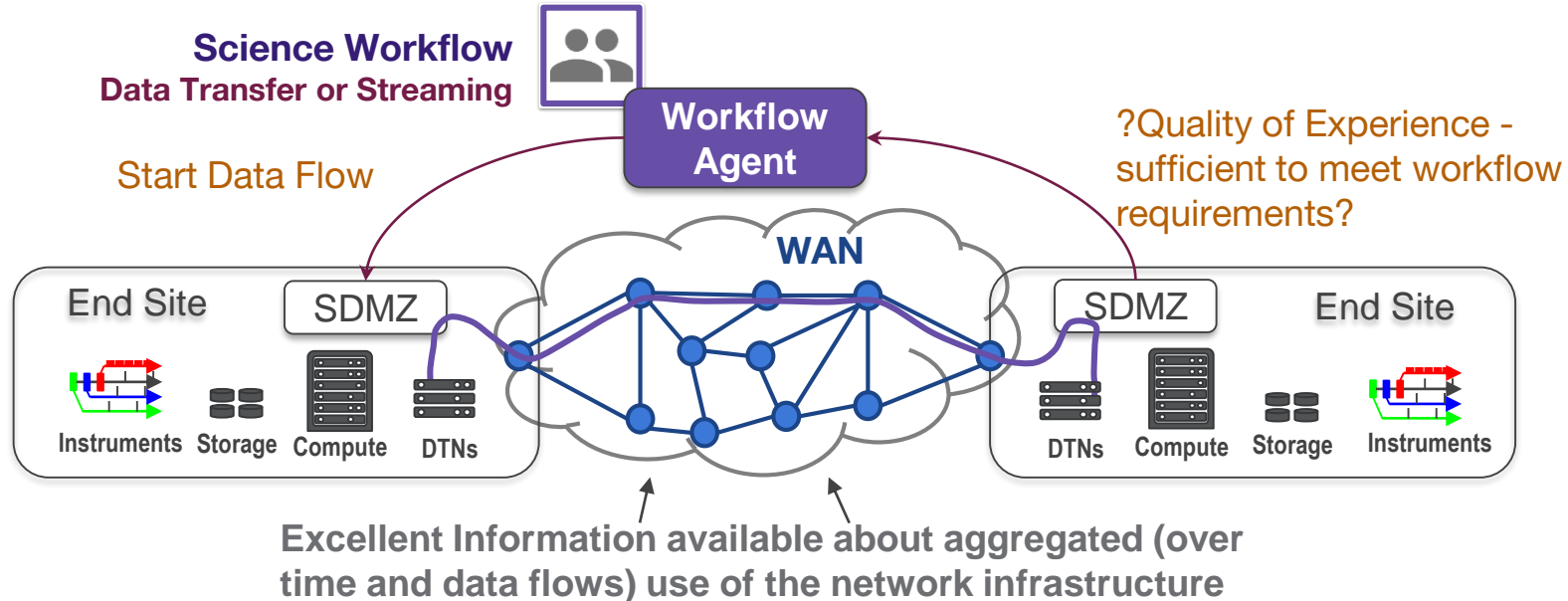
Creating a priority service between 2 sites:

- On demand i.e. triggered solely by the creation of a rule in Rucio
- On a congested network path (to show QoS)
- Just for the duration of the transfer request in question



# Future Goal: 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



# Adding A Network Or Site to AutoGOLE/SENSE infrastructure

- Create a design for where/how to attach to the existing infrastructure
- Develop a deployment plan for network and/or site resources
- Can use the following as a reference:
  - ◆ [AutoGOLE SENSE Implementation Guide.pdf](#)
- Possible software components that need installed and configured:
  - ◆ NSI Network Provider Agent
    - [OpenNSA](#)
  - ◆ SENSE Site Resource Manager
    - [Site-RM](#)
  - ◆ Perhaps others depending on site details
- Join Tuesday calls and slack workspaces:
  - ◆ [autogolealarms.slack.com](#)
  - ◆ [nren.slack.com](#)



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**Thanks To The Global Research  
Platform & IEEE International  
eScience Communities!**