



# **Pacific Wave and Pacific Wave U.S. Extensions**

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**AmRP Working Group Meeting**

**September 24, 2021**

# Agenda

- Overview of the Pacific Wave International Exchange.
- Pacific Wave at the core of the National Research Platform (NRP) and the Global Research Platform (GRP).
- On-going activities within Pacific Wave
- Pacific Wave and multi-domain orchestration:
  - Why Multi-domain orchestration is needed.
  - The Pacific Wave infrastructure in support of multi-domain orchestration.
  - Pacific Wave/CENIC and multi-domain orchestration.
  - Multi-domain paths provisioned successfully so far.
- Next steps

# Overview

- Initially funded by the NSF in 2005, Pacific Wave is an open international R&E peering and exchange fabric operated by CENIC and the PNWGP.
- The exchange's primary large-scale backbone nodes are in Los Angeles, San Francisco and Seattle.
- The exchange's core infrastructure extends domestically to Hawaii (UH), Chicago (StarLight), El Paso, Albuquerque and Denver, and internationally to Tokyo via International collaborations.
- Exchange participants:
  - CENIC, PNWGP, Ultralight, Los Nettos, Internet2, ESnet, NOAA N-Wave, DREN, NASA, AARNET, CANARIE, CERNET, CUDI, GEMNET, JGN, KISTI, REANNZ, SINET, TRANSPAC, Transtelco, TWAREN
- Multiple cloud providers of relevance to the R&E communities.

# Pacific Wave, the NRP and the GRP

Gateways to  
NRP/GRP Partners

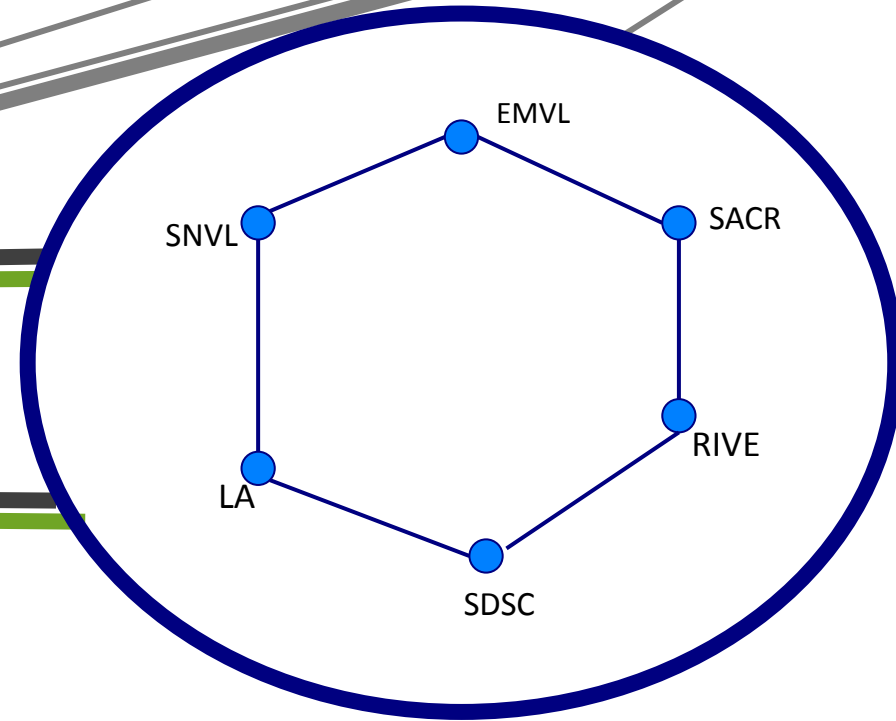
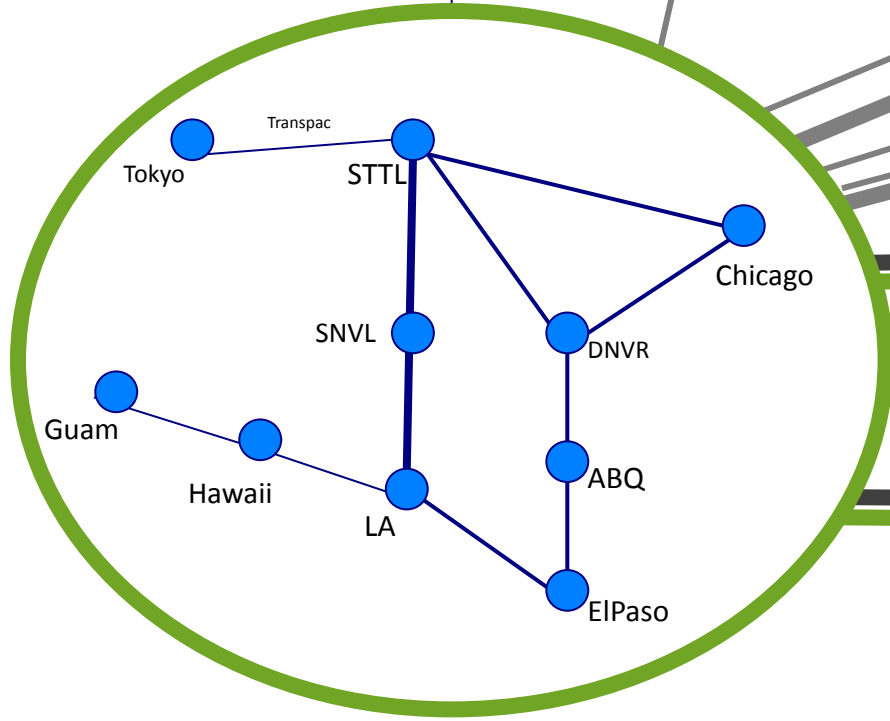
FABRIC

ESNET

StarLight

CANARIE

Internet2



Pacific Wave: 300G-->500G (09/14/2021): LA-SNVL;  
300G: SNVL-STTL

CENIC High Performance Research Network  
over CENIC's optical backbone



- Partner Exchange Links
- Participant Links
- - - Prospective Links
- AP-REX Links
- Pacific Wave Backbone

- Pacific Wave POP
- AP-REX POP
- Pacific Research Platform (PRP)
- PRP Science DMZ Fabric
- Software Defined Network
- Commercial Peering Points (Amazon, Google, & Microsoft)

- WESTERN REGIONAL NETWORKS**  
States served by WRN members:
- ABQG: New Mexico GigaPoP
  - CENIC: California
  - FRGP: Colorado & Wyoming
  - PNWGP: Washington, Montana, Alaska, Oregon & Idaho
  - UH: Hawaii

With support from the National Science Foundation



# On-going Activities

- Pacific Wave is enhancing its monitoring, measurement and analysis capabilities in collaboration with UCSD by exporting flow data to UCSD's Interactive Global Research Observatory Knowledge base (IGROK) cluster.
  - We will be leveraging IGROK's ML techniques to identify flow-based anomalies and help isolate other factors contributing to end-to-end performance degradation.
- To facilitate route exchange between international and domestic RENO, we are piloting route servers at the Seattle, Sunnyvale, and LA exchange locations. The Pacific Wave route servers will participate in the RPKI deployment and help ensure the integrity of the routes announced by exchange participants.
  - CENIC and PNWGP are pilot participants
- We are upgrading our transport from 100G optical channels to Spectrum.
- We are evaluating new transport technologies such as coherent 100Gbps and 400Gbps pluggable coherent optics and we will be deploying these new solutions within the Pacific Wave infrastructure.

# On-going Activities

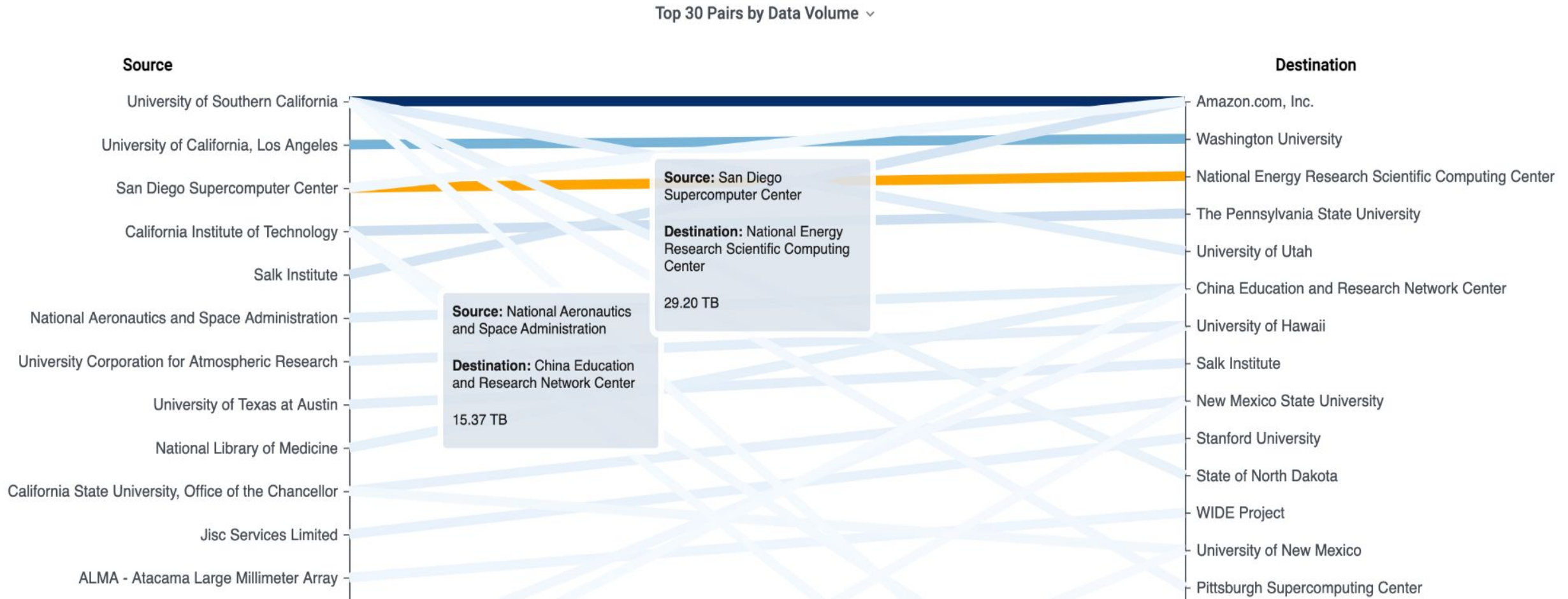
- We participate in the global GNA-G AutoGOLE/NSI project, which provision paths dynamically and on-demand:
  - Our goal is to move orchestrated inter-domain dynamic provisioning of circuits toward 'production' pilot initiatives that can benefit projects such as the LHCONE.
- We are experimenting with migrating our AutoGOLE/SENSE environment to Kubernetes.

# Pacific Wave/CENIC and Multi-domain Orchestration via AutoGOLE/SENSE

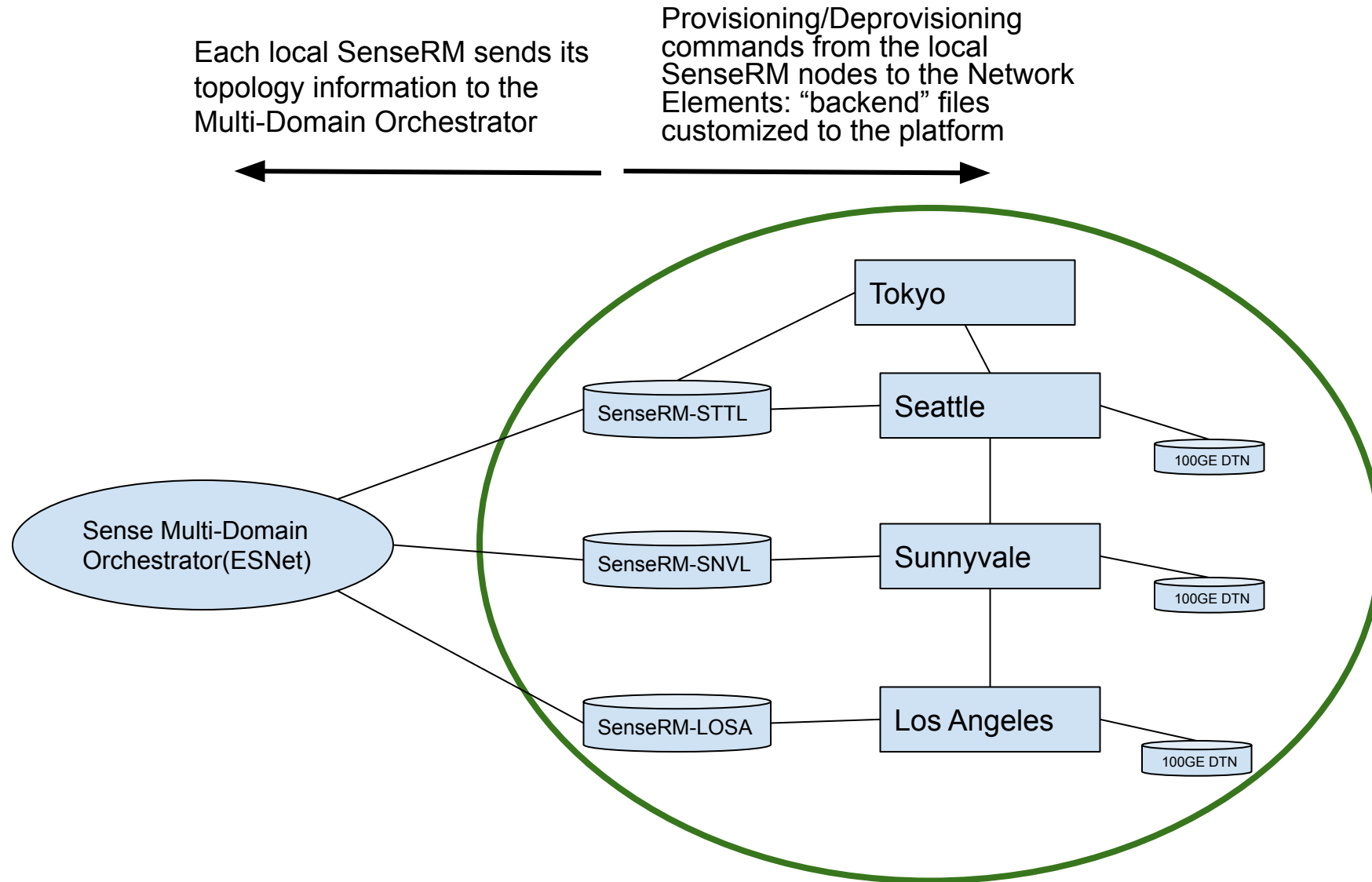


# Why Multi-Domain Orchestration is Needed

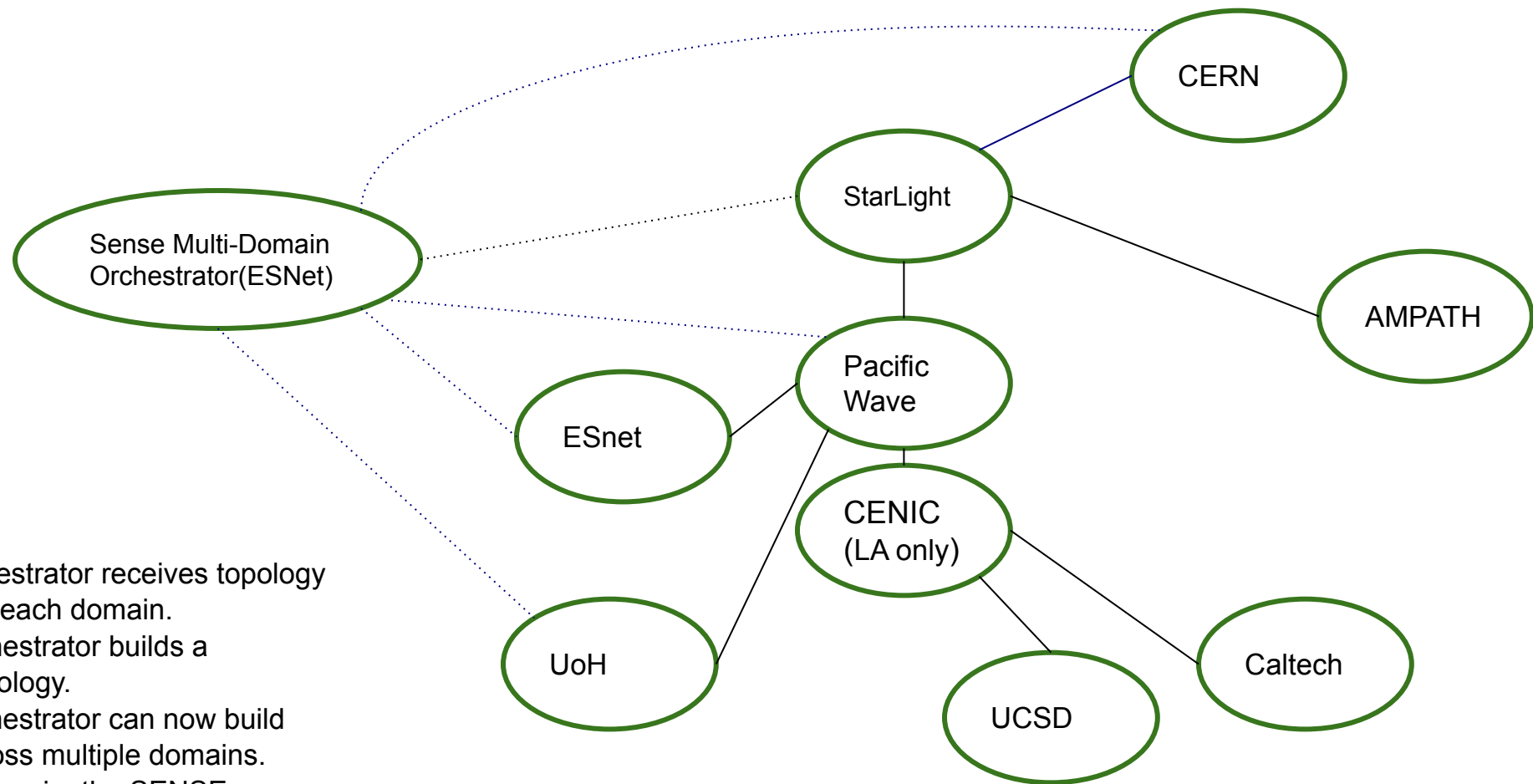
- Big Science is multi-domain.
- How challenging it is to provision paths across multiple domains.



# The Pacific Wave Infrastructure in Support of Multi-Domain Orchestration

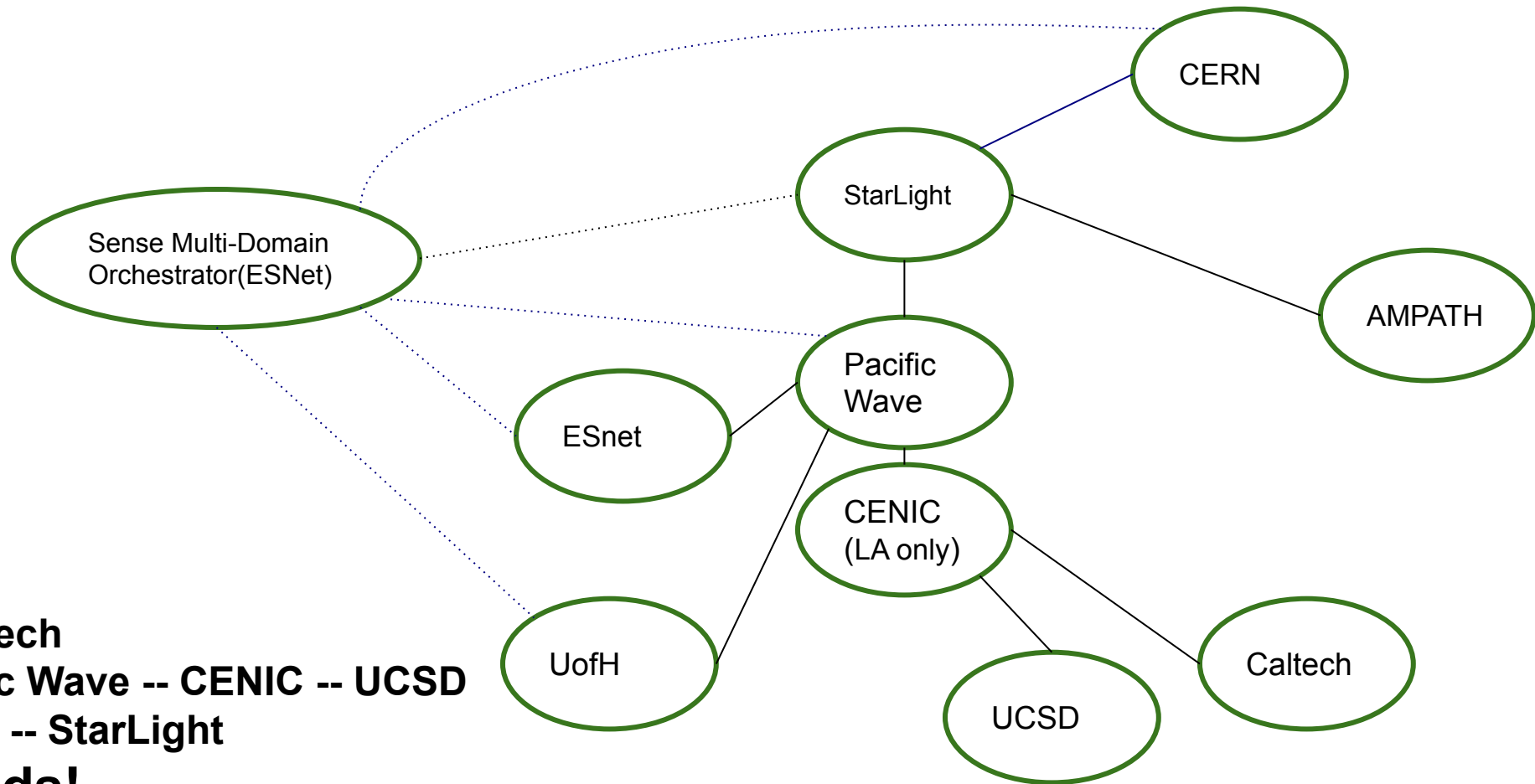


# Pacific Wave/CENIC and Multi-Domain Orchestration



- The SENSE orchestrator receives topology information from each domain.
- The SENSE orchestrator builds a multi-domain topology.
- The SENSE orchestrator can now build layer2 paths across multiple domains.  
---Within each domain, the SENSE orchestrator reaches out to the local orchestrator to have the path provisioned.

# Paths Successfully Provisioned Dynamically and on Demand



- UCSD -- Caltech
- UoH -- Pacific Wave -- CENIC -- UCSD
- Pacific Wave -- StarLight

**In few Seconds!**

- UCSD -- AmPath via StarLight

# Next Steps

- Expand AutoGOLE/NSI testing domestically and internationally:
  - [ California-based institutions ] -- Pacific Wave -- ESnet -- SURFnet -- CERN
  - Future International testing including through StarLight.
  - Use the DTNs in the domains as a resource for end to end performance testing prior to putting production traffic. This work being done within the framework of the AutoGOLE/SENSE working group.
- Analyze the IGROK data.
- 400GE+ on core segments, transition to Spectrum services.
- Transition the Pacific Wave route servers to Production.

**We look forward to working with you on many of these initiatives.**