



IRNC:RXP SDN / SDX Update

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Pacific Wave: Overview

- Joint project of CENIC (California regional research and education network) and PNWGP (US Pacific Northwest regional research and education)
- Open Exchange supporting both commercial and R&E peers
- Pacific Wave has been partially supported through three separate five-year National Science Foundation grants supporting growth, connectivity and innovation
- Currently serve 29 countries across the Pacific connecting to the Western US
- With PNWGP and TransPac, announced the first 100Gbps Trans-Pacific link from Tokyo to Seattle



Pacific Wave: Overview

CENIC

Pacific Wave and WRN



- Pacific Wave and the Western Region Network provide for a 100Gbps network spanning the Western United States serving PNWGP, CENIC, FRGP, ABQGP and UH.
- Pacific Wave and NSF IRNC awardee PIREN (Univ of Hawaii) work together supporting AARNet links to California and Washington and expansion of high-speed service through the Pacific Islands Region





WITH SUPPORT FROM THE NATIONAL SCIENCE FOUNDATION



Agenda

- Overview of Pacific Wave SDX/SDN infrastructure
- Dynamic Circuit activities (NSI, AutoGOLE, ...)
- Overview of OpenFlow-related Pacific Wave SDX control plane
- SDX activities
- Performance Measurement & Visualization
- Pacific Research Platform
- PRP use cases: Exchange-connected resources
- Suggested Collaboration Opportunities



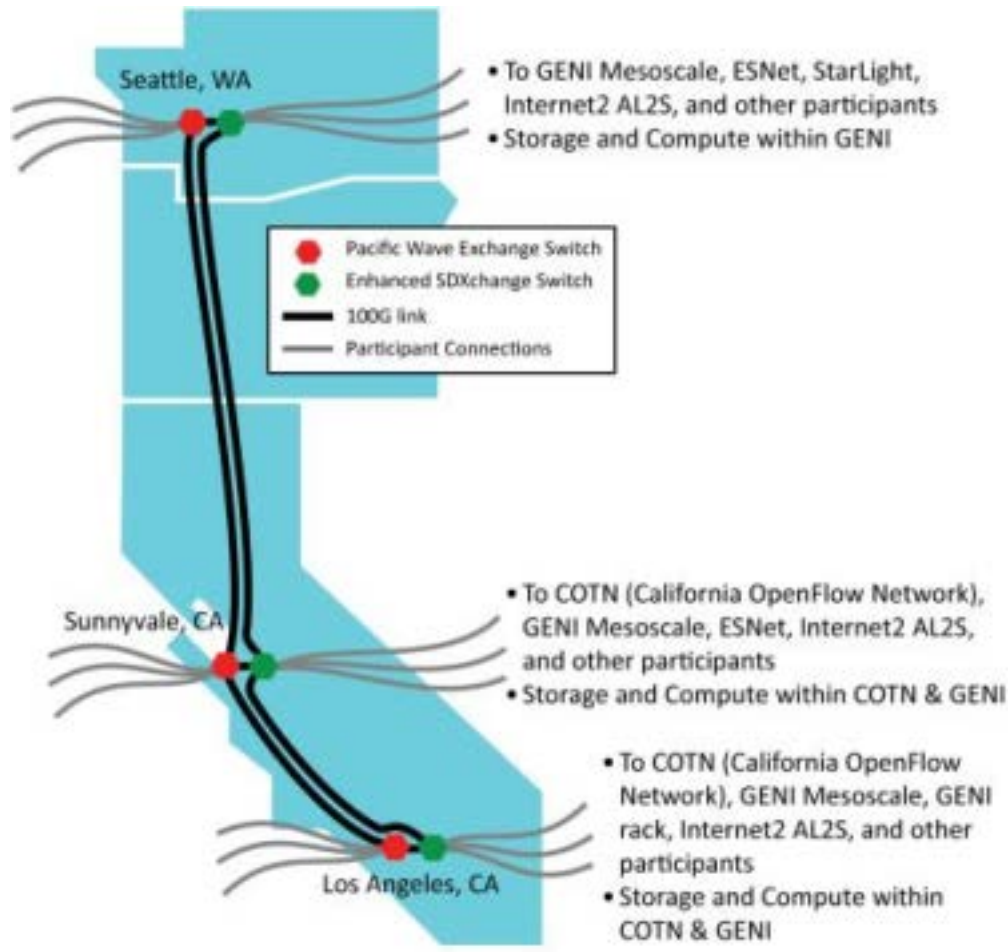
Pacific Wave: NSF IRNC:RXP Award

- Pacific Wave Expansion Supporting SDX & Experimentation (ACI-1451050, September 2015)
 - Continued enhancement, upgrade and evolution of Pacific Wave to support more 100G connections
 - Additional 100G capacity between exchanges points along West Coast
 - SDN/SDX deployment on parallel infrastructure to enable experimentation while maintaining production use of the Pacific Wave exchange
 - Collaboration with other IRNC awardees on SDX development, measurement and monitoring.

Pacific Wave: SDX/SDN Infrastructure

- Recent Past & Current - Project Year 1 Activities:
 - Traditional Switching infrastructure from Tokyo through West Coast, with interconnection through Starlight, and to the East (see earlier image)
 - SDX nodes in Western US: leveraging an existing node in Seattle and adding an IRNC grant-funded node in Los Angeles
 - 100G-connected to common exchange and reachable by any participant
 - Intel x86 Control Nodes Positioned in Seattle and Los Angeles
- Planned 2016/2017 - Project Year 2 Activities:
 - Additional, IRNC grant-supported 100G SDN switching node
 - Higher-flexibility SDN switching nodes

Pacific Wave: SDX interconnects and services

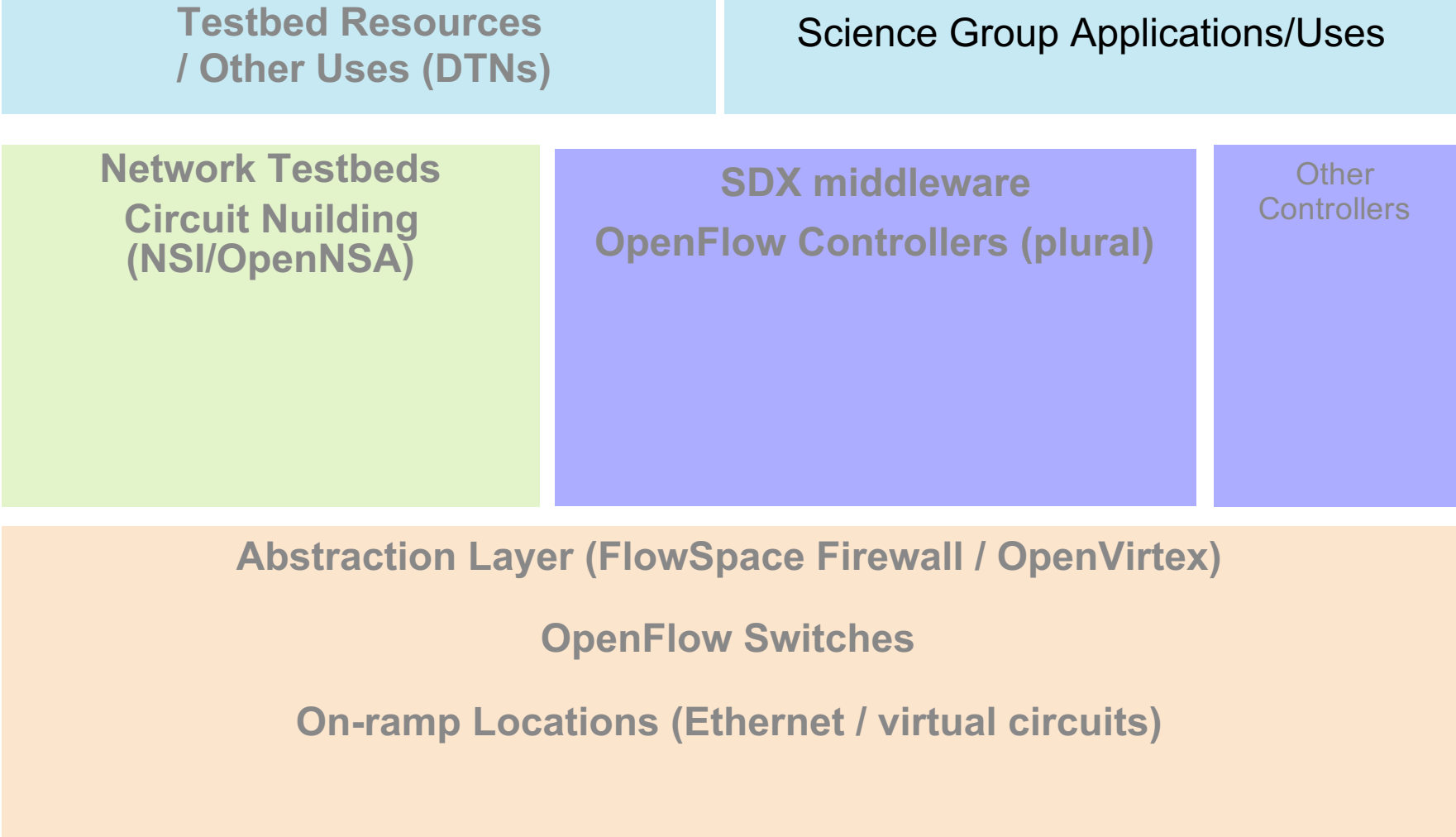


Traditional Peerings between all Pacific Wave participants can remain on the Pacific Wave Exchange Switches.

SDX Services can be accessed via direct connection to Enhanced SDXchange Switches *OR* via connections to the Pacific Wave Exchange Switches.

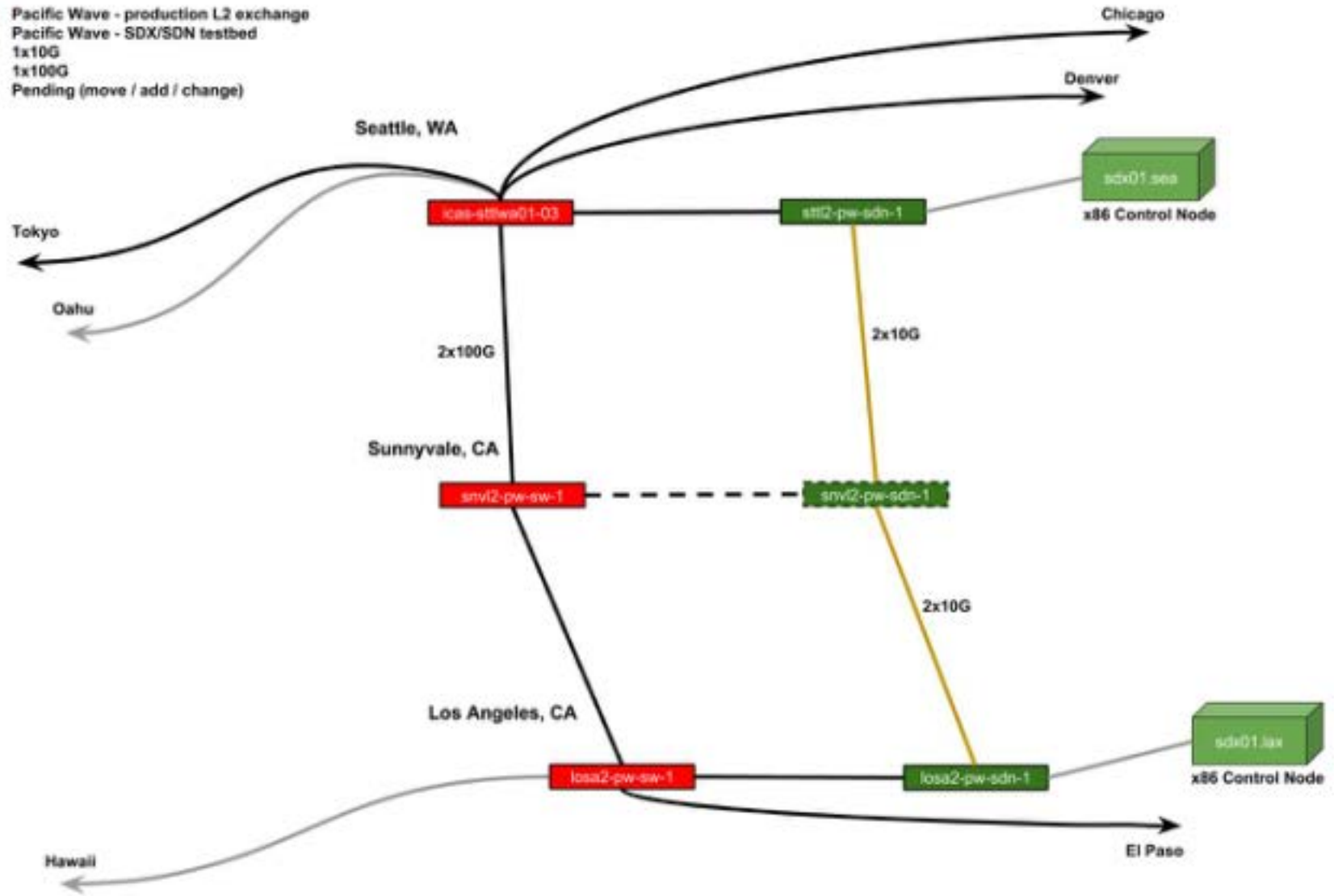
Mixed connections can also take place between participants where one is connected to the Pacific Wave Exchange Switch and the other to an Enhanced SDXchange Switch.

Pacific Wave: SDX Control Plane



Pacific Wave: SDX Control Plane

- █ Pacific Wave - production L2 exchange
- █ Pacific Wave - SDX/SDN testbed
- █ 1x10G
- █ 1x100G
- - - Pending (move / add / change)



NOTE: this diagram represents a subset of sites, devices, and connections

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Pacific Wave: SDX Activities in Year 1

Class/Type:	Circuit Based	SDN Experimentation	Testbed Support
Examples on Pacific Wave:	NSI, AutoGOLE, OSCARS	CalTech, Starlight, and UCSD data transfer aide through SDN path control	PRAGMA-ENT, Treehouse, AARNet, ...
Other Examples:	OSCARS, OESS, ...		SENSE, GENI, many others

Class/Type:	Pipeline/Service-Chains or DTN assisted	PacificWave SDX Exploration	Other Domain Science Applications
Examples on Pacific Wave:	UCR/Kisailus, NSCC/Singapore, and SanDiego	More Planned for 2016/17	PRP, Genomics, HEP, ...
Other Examples:	Starlight exploring some possibilities, many in research papers	iSDX/NOISE-LAB, ONOS-SDX, CASTOR	eVLBI event-support

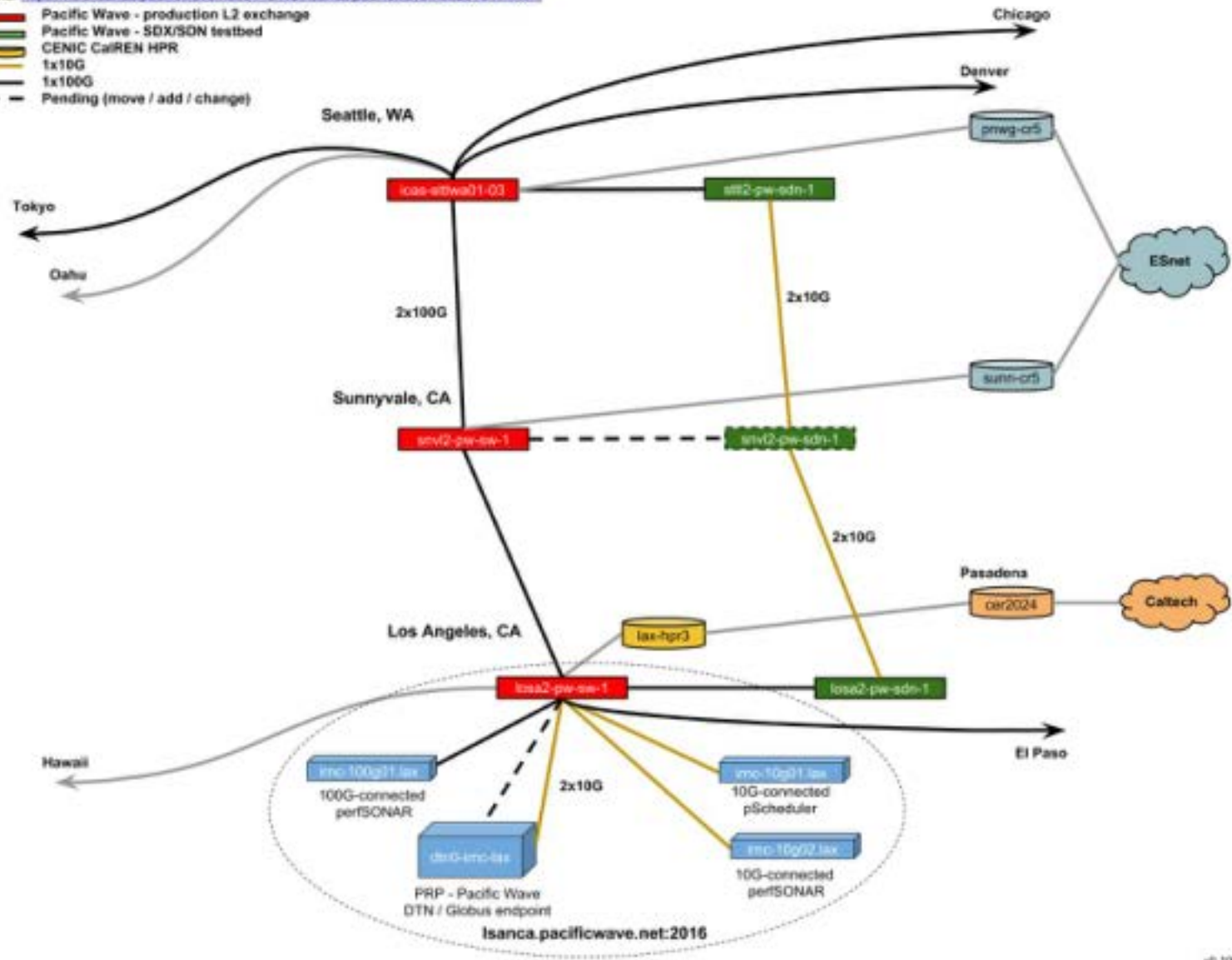
Pacific Wave: Dynamic Circuit Services

- AutoGOLE / NSI -- Phase v0.01
 - Pacific Wave Los Angeles: `Isanca.pacificwave.net:2016`
 - OpenNSA managing a single device (Brocade MLXe), with traditional L2 switching
 - control-plane: registered with ESnet Aggregator (`nsi-aggr-west.es.net`)
 - data-plane: STPs with Caltech and ESnet (Seattle and Sunnyvale)
 - local resources: PRP DTN, and 10G & 100G-connected pS nodes
 - provisioning: MEICAN (in pilot)
- Extend AutoGOLE / NSI to other Pacific Wave PoPs / GOLEs
- Incorporate SDX/SDN

Pacific Wave: AutoGOLE/NSI - Phase v0.01

NSA: OpenNSA; Switching Platform: Brocade MLXe - traditional L2 switching
 NML: <https://ns0.isanca.pacificwave.net:9443/NSI/isanca.pacificwave.net:2016.nml.xml>

- █ Pacific Wave - production L2 exchange
- █ Pacific Wave - SDX/SDN testbed
- █ CENIC CalREN HPR
- █ 1x10G
- █ 1x100G
- - - Pending (move / add / change)



NOTE: this diagram represents a subset of sites, devices, and connections

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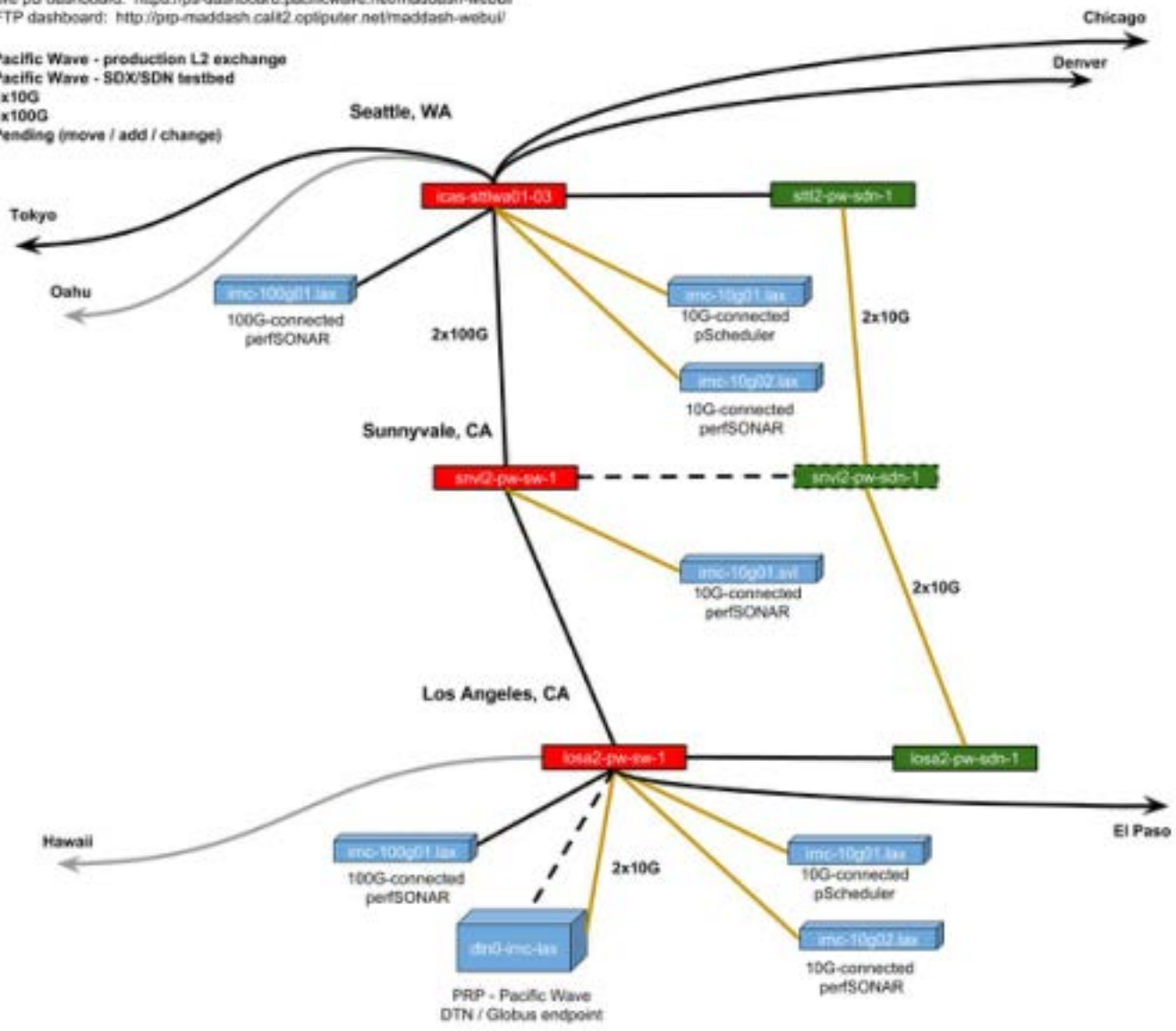
Pacific Wave: Measurement and Visualization

- 10G-connected pS nodes deployed in Seattle, Sunnyvale, and Los Angeles
- 10G-connected pScheduler node in testing at Los Angeles: moving to pS 4.0RC1
- 2x10G-connected PRP-contributed DTN in testing at Los Angeles
 - GridFTP testpoint on PRP MaDDash
 - Globus-managed endpoint for science data movement
 - platform for exploring ICN, NDN, ...
- 100G-connected perfSONAR nodes in testing at Seattle and Los Angeles
 - currently Centos 6.8 w/pS 3.5.x
 - moving to CentOS 7.2 w/pS 4.0RC1
- Pacific Wave perfSONAR dashboard beta testing MaDDash 2.0RC1
 - central esmond MA
 - a collaboration of Pacific Wave participants and partners
- IRNC NOC Performance Engagement Team

Pacific Wave: Measurement Infrastructure

Pacific Wave pS dashboard: <https://ps-dashboard.pacificwave.net/maddash-webui/>
 PRP GridFTP dashboard: <http://gtp-maddash.calit2.optiputer.net/maddash-webui/>

- Pacific Wave - production L2 exchange
- Pacific Wave - SDX/SDN testbed
- 1x10G
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Pacific Wave: Measurement Visualization

Pacific Wave perfSONAR Dashboard: a collaborative project of Pacific Wave partner and participant networks

[Dashboards](#)
[Reports](#)
[Settings](#)
[Participants & Partners, and Affiliations](#)

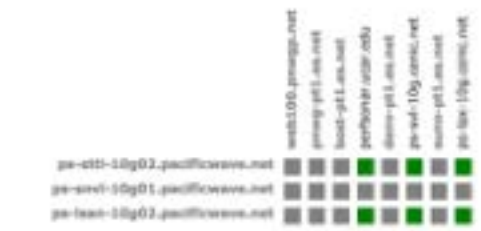
Last page refresh time: September 30, 2016 04:43:01 AM PDT

Pacific Wave Dashboard

Pacific Wave - IPv4 Throughput

■ Throughput >= 900Mbps
 ■ Throughput < 900Mbps
 ■ Throughput <= 500Mbps
 ■ Unable to retrieve data
 ■ Check has not yet run

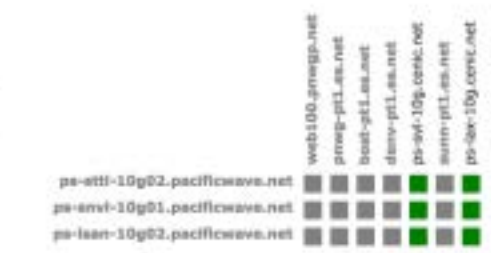
⚠ Found a total of 10 problems involving 8 hosts in the grid



Pacific Wave - IPv6 Throughput

■ Throughput >= 900Mbps
 ■ Throughput < 900Mbps
 ■ Throughput <= 500Mbps
 ■ Unable to retrieve data
 ■ Check has not yet run

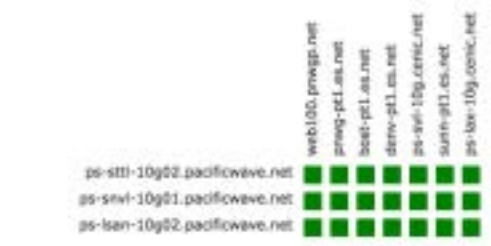
⚠ Found a total of 11 problems involving 8 hosts in the grid



Pacific Wave - IPv6 Packet Loss

■ Loss rate is <= 0
 ■ Loss rate is >= 0
 ■ Loss rate is >= 0.01
 ■ Unable to retrieve data
 ■ Check has not yet run

✅ No problems found in grid

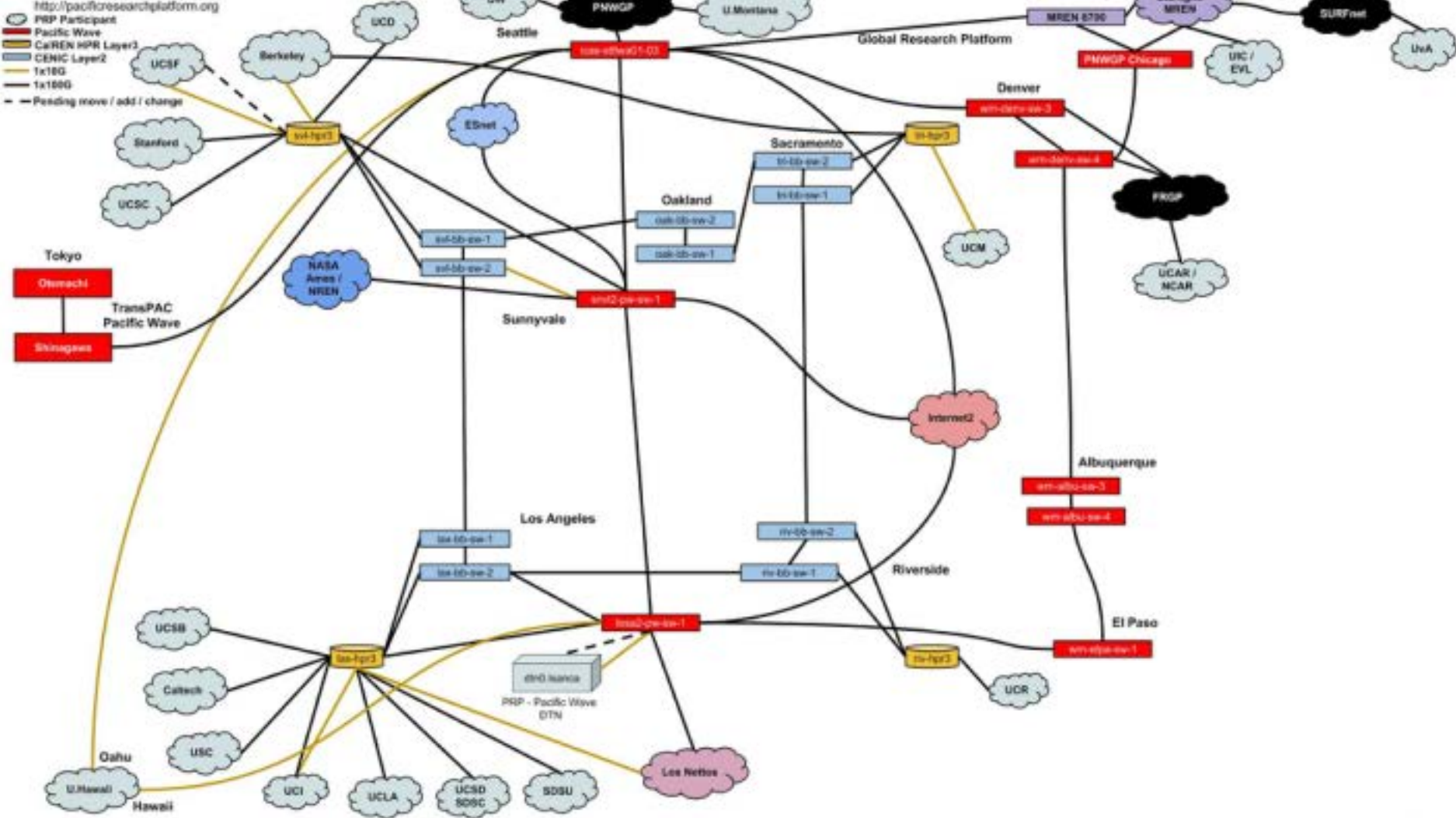


Pacific Research Platform

- NSF CC-NIE and similar projects represent significant investments in campus infrastructure including SDN, Science DMZ's (~130 projects)
- But scientists are still struggling with the complexity of using the network and interoperability between different implementations of Science DMZ's
- PRP focuses on enabling the science communities across the Pacific region to make effective use of the high performance infrastructure
- Kick-off meeting at Stanford (December 2014):
 - take advantage of the regional infrastructure
 - perfSONAR_for measurement / analysis
 - MaDDash for visualization
- Include DTN's: use a common software suite for data movement; reflect disk-to-disk performance on MaDDash
- PRPv0 demonstrated as a proof-of-concept at the CENIC Conference

Pacific Wave: Supporting collaboration

Pacific Research Platform v1



NOTE: This diagram represents a subset of sites, devices, and connections

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Pacific Research Platform

“For the hardest problems—not just in physics but in climate science and genomics—there are massive teams working around the world,” says ESnet director Greg Bell. “Our job is to make geography irrelevant.”

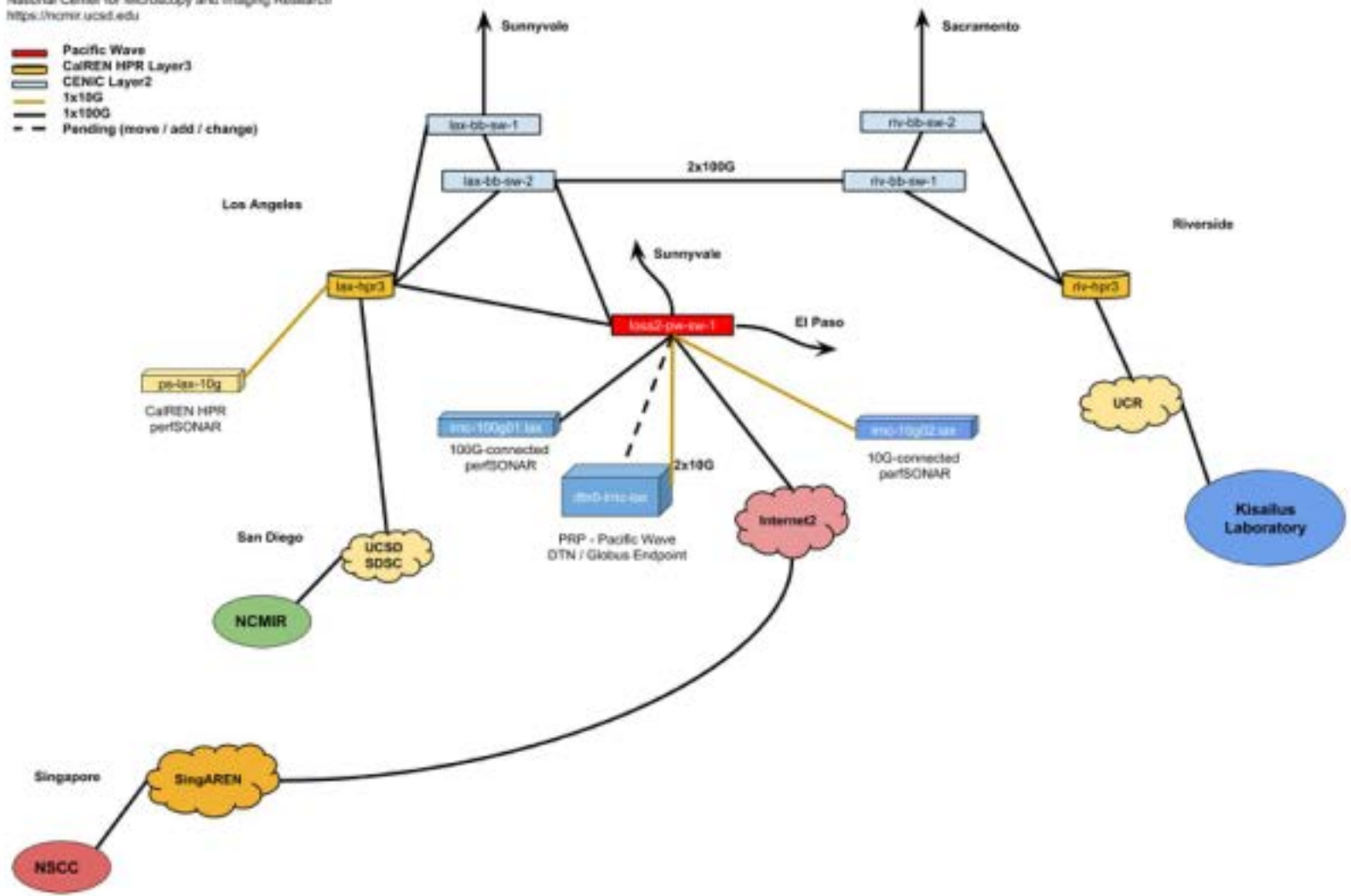
Inter-Institutional ScienceDMZ (PRP) kick-off meeting, Stanford, November 2014

“WHAT TO EXPECT IN 2015: ULTRAFAST DATA TRANSFER SPEEDS UP SCIENCE” Popular Science, December 2014

Pacific Wave: PRP use cases

NCMIR
 National Center for Microscopy and Imaging Research
<https://ncmir.ucsd.edu>

- Pacific Wave
- CalREN HPR Layer3
- CENIC Layer2
- 1x10G
- 1x100G
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PRP Roadmap

■ PRPv1

- A routed Layer 3 architecture
- Tested, measured, optimized, with multi-domain science data
- Bring many of our science teams up
- Each community with its own certificate-based access to its specific federated data infrastructure.

■ PRPv2

- Incorporating SDN/SDX, AutoGOLE / NSI
- Advanced IPv6-Only version with robust security features
- Trusted Platform Module (TPM) hardware
- Support bit-rates up to 100Gbps in bursts and streams
- Develop means to operate a shared federation of caches

Pacific Wave: Future Work and Collaborations

- Domain-Science and Research Applications
- SDN Exploration
 - SDN virtualization and/or interdomain SDX control
 - Applications which leverage SDN as an underlying technology,
- Circuit-Based Communication
 - Other slides have much more content; there is interest in continuing to evolve these capabilities.
- DTN / ICN / NDN integration at exchange points
- Testbeds (and Testbeds as a Service) - NFV, Starlight applications, Grid'5000

Resources:



Pacific Wave
<http://www.pacificwave.net/>
<https://ps-dashboard.pacificwave.net>



CENIC
<http://www.cenic.org/>
<https://ps-dashboard.cenic.net>



PNWGP
<http://www.pnwgp.net/>



Pacific Research Platform
<http://pacificresearchplatform.org/>
http://cenic.org/files/publications/PRP_Overview_%C6%92.pdf
<http://prp-maddash.calit2.optiputer.net/maddash-webui/>



Calit2
<http://www.calit2.net/>



CITRIS
<http://citris-uc.org/>



ESnet
<http://www.es.net/>
<http://fasterdata.es.net/>
<http://ps-dashboard.es.net/>



NSF
<http://www.nsf.gov/>
GLIF16, Miami 30 September, 2016



Thanks!

Pacific Wave: Collaboration Opportunities

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