CUDI 2017

PUERTO VALLARTA

FIWARE Mexico

Pacific Research Platform

Puerto Vallarta, Jalisco
del 29 de mayo al 02 de junio

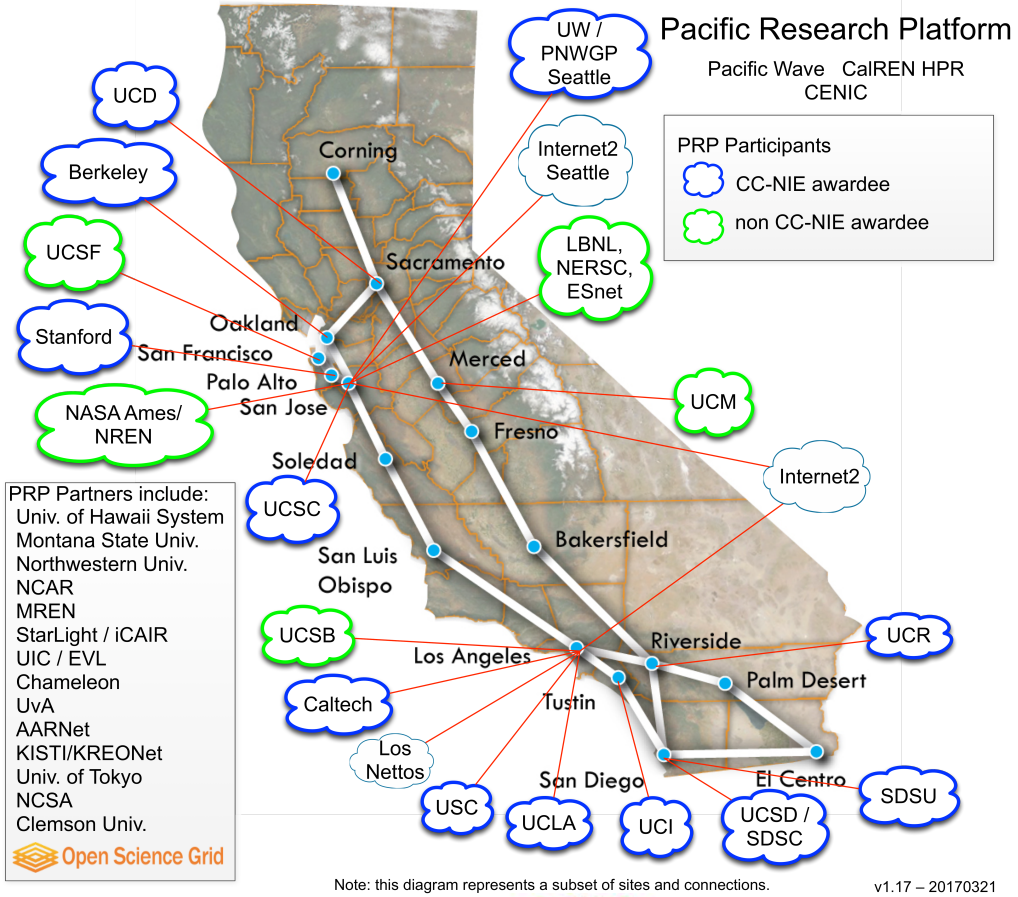
john hess, CENIC

PRP
PACIFIC RESEARCH PLATFORM

CENIC PACIFIC WAVE

Abstract

Research in data-intensive fields is increasingly multi-investigator and multi-institutional, depending on ever more rapid access to ultra-large heterogeneous and widely distributed datasets. Created in 2015, the Pacific Research Platform (PRP) is an NSF-funded regional project to meet the needs of researchers in California, the Western U.S., and beyond. The PRP is working to accelerate discovery: by improving end-to-end high-speed data transfer, data placement / storage, and computing capabilities in collaborative, big-data science, and facilitating direct engagements between campus technical engineers and multi-campus science teams to inform and drive the requirements for the network. The PRP's scope covers a broad range of data-intensive research, including projects from the fields of particle physics, astronomy, biomedical sciences, earth sciences, and computer science and engineering. The PRP is a partnership of more than 20 institutions, including four national supercomputer centers.



NSF CC*DNI Grant
$5M 10/2015-10/2020

PI: Larry Smarr, UC San Diego Calit2

Co-PIs:

- **Camille Crittenden, UC Berkeley CITRIS,**
- **Tom DeFanti, UC San Diego Calit2,**
- **Philip Papadopoulos, UCSD SDSC,**
- **Frank Wuerthwein, UCSD Physics and SDSC**

Science Teams:

- **Visualization and Virtual Reality**
- **Biomedical**
- **Earth Sciences**
- **Particle Physics**
- **Astronomy and Astrophysics**
- **Cryo-EM**
- **Deep Learning & Robotics**
- **High-Performance Wireless**

PACIFIC RESEARCH PLATFORM

CUDI2017 Puerto Vallarta, Jalisco del 29 de mayo al 02 de junio

Agenda

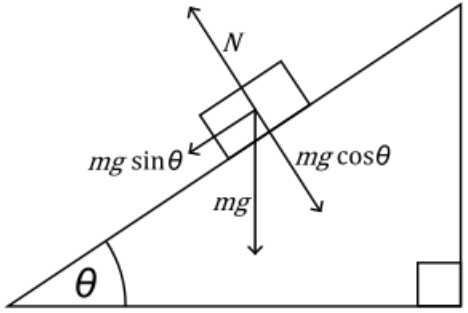
- PRPv1 -- Extending the ESnet Science DMZ model to regional scale
- Science Engagement -- Socio-technical engineering among contributors from science teams, network, HPC, …
- Science Drivers – examples from scientific domains forming the initial scope of the PRP
- PRPv2 -- A test-bed incorporating security, IPv6, SDN/SDX, cooperating research groups
- Considerations -- scaling to national and international models

The Science DMZ* in 1 Slide

Consists of **three key components**, all required:

- "Friction free" network path
  - Highly capable network devices (wire-speed, deep queues)
  - Virtual circuit connectivity option
  - Security policy and enforcement specific to science workflows
  - Located at or near site perimeter if possible
- Dedicated, high-performance Data Transfer Nodes (DTNs)
  - Hardware, operating system, libraries all optimized for transfer
  - Includes optimized data transfer tools such as Globus Online and GridFTP
- Performance measurement/test node
  - perfSONAR
- Engagement with end users

Details at http://fasterdata.es.net/science-dmz/



globus

perfSONAR

ESnet

* ***Science DMZ*** is a trademark of The Energy Sciences Network (ESnet)

Our Prototype System – Built for Scientists Out of a Bunch of Independently Managed Networks

- **Challenge:**
  - **Campus DMZs, Regional (e.g., CENIC), National (Internet2), International Networks (e.g., GLIF) are Individually-Architected Systems**
- **How Do <u>They Work Together</u> with Predictable Performance?**
- **➔ PRP is Focused on Disk-to-Disk Data Movement**
  - **From the Eyes of Domain Scientists**
    - **End-to-End for *Their Data* is Their Only Real Metric of Concern (As it Should Be)**

Source: Phil Papadopoulos

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PRP Science DMZ Data Transfer Nodes (DTNs) - Flash I/O Network Appliances (FIONAs)

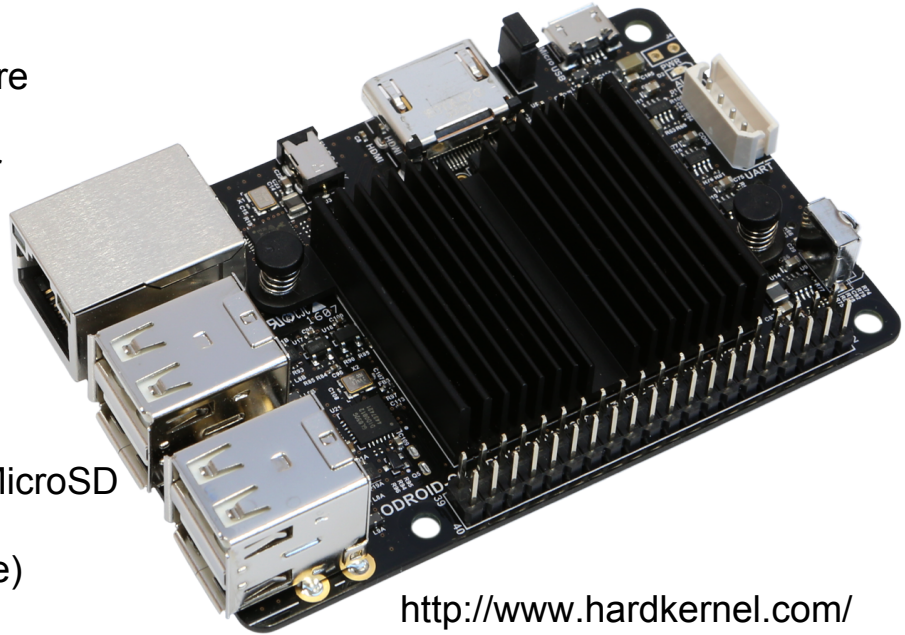
UCSD Designed FIONAs
To Solve the Disk-to-Disk
Data Transfer Problem
at Full Speed
on 10G, 40G and 100G Networks

FIONette -- 1Gb/s,
2TB, $1,000USD

Sources: Phil Papadopoulos, SDSC &
Tom DeFanti, Joe Keefe & John Graham, Calit2

Low-cost perfSONAR nodes

ODROID-C2 - 1Gb/s, 32GB, $100USD:
* Amlogic ARM® Cortex®-A53(ARMv8) 1.5Ghz quad core CPUs
* Mali™-450 GPU (3 Pixel-processors + 2 Vertex shader processors)
* 2Gbyte DDR3 SDRAM
* Gigabit Ethernet
* HDMI 2.0 4K/60Hz display
* H.265 4K/60FPS and H.264 4K/30FPS capable VPU
* 40pin GPIOs + 7pin I2S
* eMMC5.0 HS400 Flash Storage slot / UHS-1 SDR50 MicroSD Card slot
* USB 2.0 Host x 4, USB OTG x 1 (power + data capable)



http://www.hardkernel.com/

Project tracking candidate, low-cost hardware:
https://github.com/perfsonar/project/wiki/Low-Cost-perfSONAR-Nodes

More Than 30 PRP Installed FIONAs: Customized to the Needs of Application Teams

- **Data Transfer Nodes**
  - 1, 10, 40, and 100Gb/s NICs
- **perfSONAR Nodes**
  - 10, 40, and 100Gb/s NICs
- **Storage Transfer Nodes**
  - Up to 160TB of Rotating Disks
  - Nonvolatile Memory Disks (NVMe - 10x Faster than Flash)
- **Compute Transfer Nodes**
  - 12-48 Intel CPU Cores
  - 1-8 GPUs (Delivers Up to 500,000 GPU Core Hours/Day)
- **Visualization Transfer Nodes**
  - 3-45 Tiled displays (up to 180 Megapixels, 2D & 3D)
  - 360-Megapixel SunCAVE Coming Soon

Source: John Graham, Calit2

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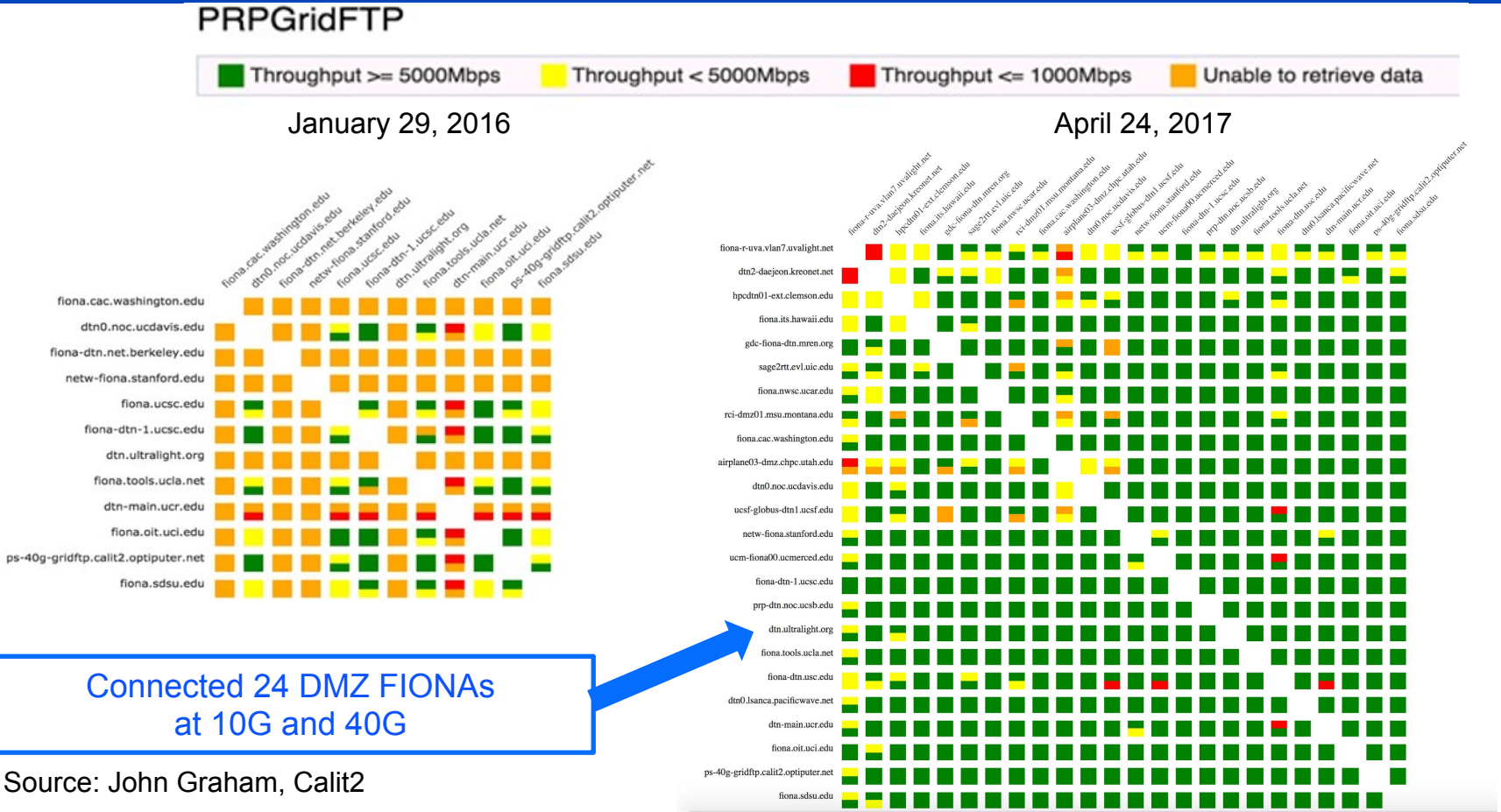
PRP Continues to Expand Rapidly While Increasing Connectivity: 1 1/2 Years of Progress – 12 Sites to 24 Sites



Connected 24 DMZ FIONAs at 10G and 40G

Source: John Graham, Calit2

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We Scale the Working PRP by Providing Multi-Campus Application Teams With Disk-to-Disk Measurements

PRPGridFTP

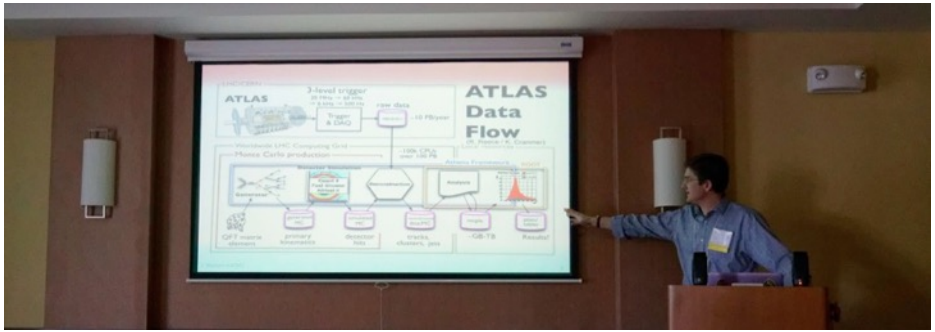
Throughput >= 5000Mbps | Throughput < 5000Mbps | Throughput <= 1000Mbps | Unable to retrieve data | Check has not yet run | Down for Maintenance

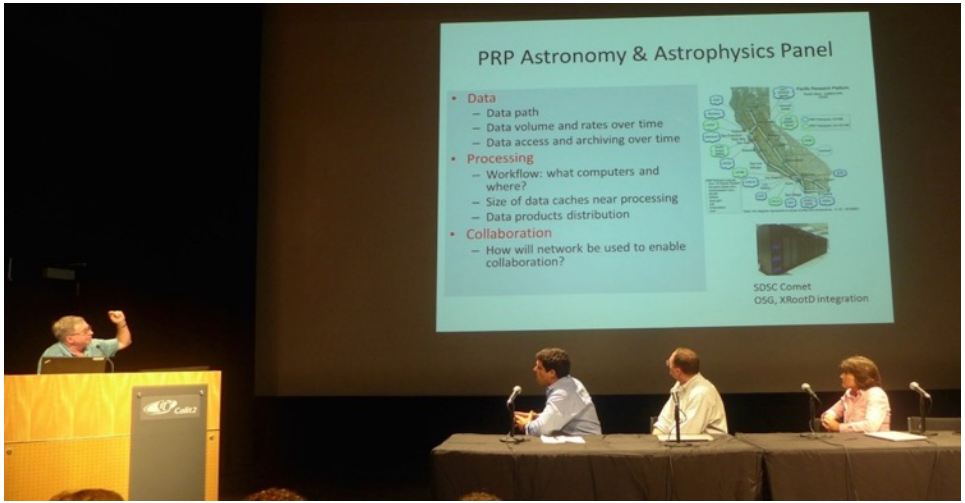
PRPClimateScience

Sources: Larry Smarr and John Graham, Calit2

PACIFIC RESEARCH PLATFORM

PRP Science Engagement Workshops





Source: Larry Smarr, Calit2

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PRP's First 1.5 Years:
Connecting Campus Application Teams and Devices

CMS

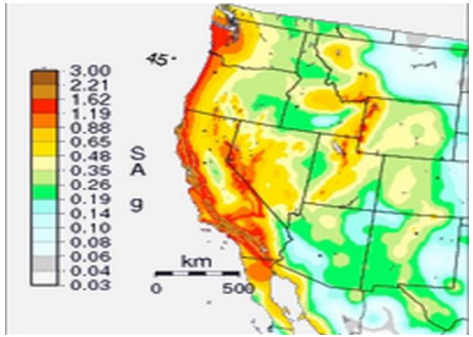
Particle Physics

Biomedical 'omics

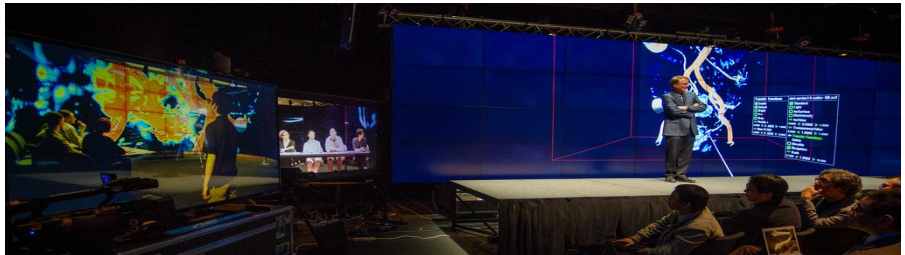
INTERMEDIATE PALOMAR TRANSIENT FACTORY

Telescope Surveys

Earthquake Engineering



Visualization, Virtual Reality, Collaboration



Source: Larry Smarr, Calit2

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100 Gbps FIONA at UCSC Connects the UCSC Hyades Cluster to the NERSC Supercomputer at LBNL

Shawfeng Dong, UCSC Cyber Infrastructure engineer

UCSC Feb 7, 2017

Source: Larry Smarr, Calit2

250 images per night

800GB per night

Dark Energy Spectroscopic Instrument

Supporting UCSC Remote Access
to Large Data Subsets
of the Dark Energy Spectroscopic Instrument (DESI) and
AGORA Galaxy Simulation Data
Produced at NERSC.

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PRP Will Link the Laboratories of the Pacific Earthquake Engineering Research Center

PEER

PACIFIC EARTHQUAKE ENGINEERING RESEARCH CENTER

http://peer.berkeley.edu/

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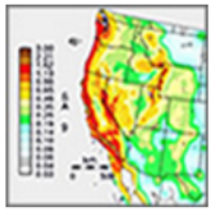
PEER Mega Research Programs

Tall Buildings Initiative

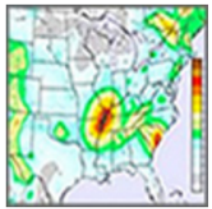
Transportation Systems

Lifelines & NGL

Tsunami

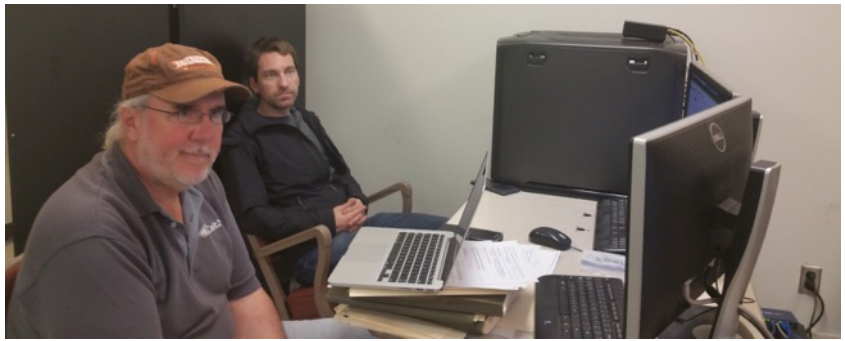


NGA-West 2



NGA-East

Global GMPE



John Graham Installing FIONette at PEER Feb 10, 2017

PEER Labs: UC Berkeley, Caltech, Stanford, UC Davis, UC San Diego, and UC Los Angeles

Source: Larry Smarr, Calit2

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PRP Now Enables Distributed Virtual Reality

PRP

WAVE@UC San Diego

WAVE @UC Merced

Transferring 5 CAVEcam Images from UCSD to UC Merced:
2 Gigabytes now takes 2 Seconds (8 Gb/sec)

Source: Larry Smarr, Calit2

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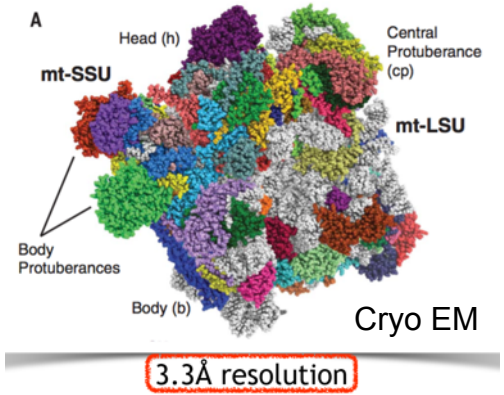
The Prototype PRP Has Attracted New Application Drivers

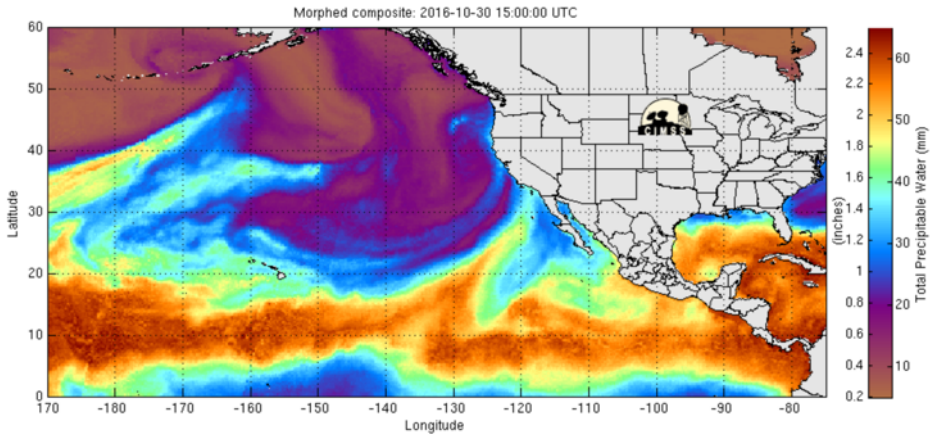
Evolved from the IPython Project



Cryo EM

Frank Vernon - Expansion of HPWREN

Tom Levy, Cultural Heritage



Scott Sellars, Marty Ralph
Center for Western Weather and Water Extremes

Source: Larry Smarr, Calit2

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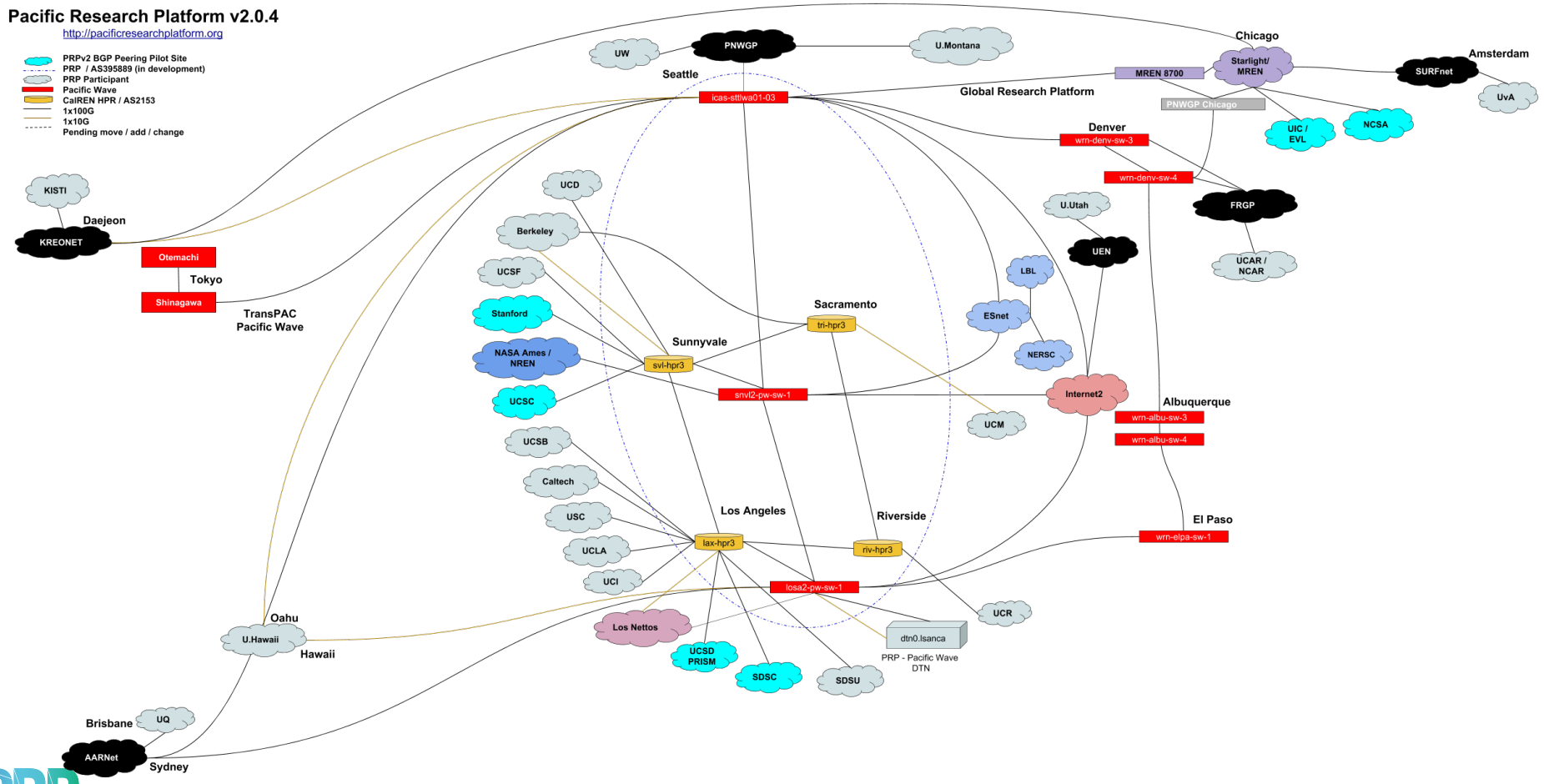
What do we envision for PRPv2

Among the technical challenges we have encountered with PRPv1: selectively announcing reachability of Science DMZ resources; choosing a traffic-engineered path; developing and implementing tools to ensure traffic fits within participants security model. We are now deploying a PRPv2 BGP pilot to explore solutions:

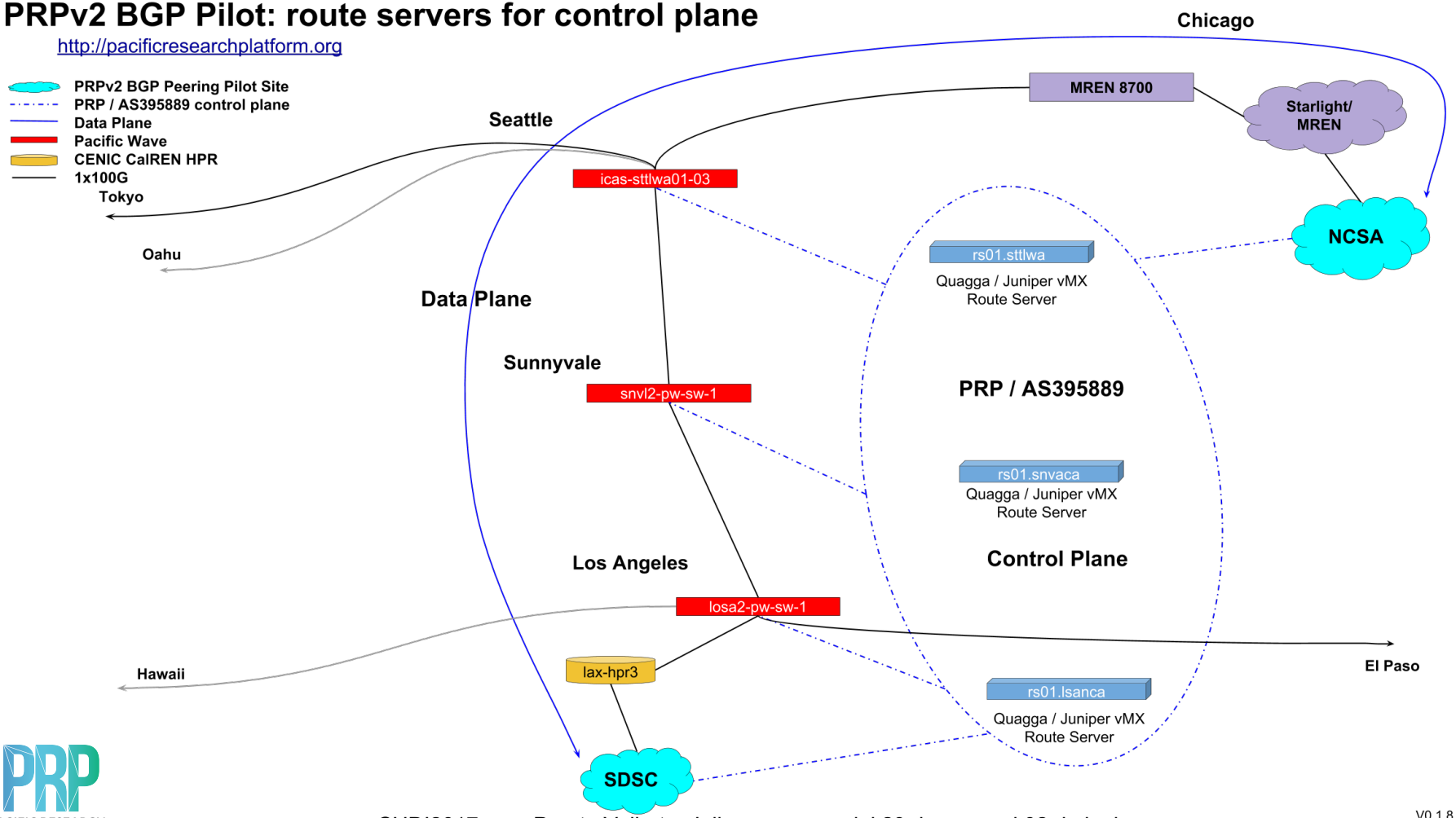
- An ARIN-assigned ASN: Pacific Research Platform / AS395889
- Route Servers at exchange points form the control-plane to determine reachability of Science DMZ resources, with traffic traversing high-speed data-plane
- BGP Communities for tagging classes of Science DMZ networks
- Peering will be native IPv6 only (may support IPv4 as transport)
- Initial phase will include UCSD, SDSC, UCSC, Stanford, NCSA, UIC/EVL
- Stretch goals: BGP + SDN/SDX for dynamically provisioned 'super-channels' supporting data movement among cooperating research groups



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

PRPv2 BGP Pilot: route servers for control plane

http://pacificresearchplatform.org



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

Dynamic Circuit Services: AutoGOLE / NSI Pilot

- NSI-orchestrated circuit services available to participants traversing each of the Seattle, Sunnyvale, and Los Angeles GOLEs
- During initial implementation each Pacific Wave GOLE in the pilot operates as its own NSI domain, e.g. Los Angeles as lsanca.pacificwave.net:2016
- NSA -- OpenNSA, separate OpenNSA instances for each GOLE; each instance managing a single device; each instances configured for c-plane & d-plane peering with adjacent Pacific Wave GOLE
- Control-plane peering (with NSI Aggregators) -- ESnet, NetherLight, and StarLight
- Data-plane peering -- ESnet, StarLight, and SINET (Caltech pending)
- Provisioning -- we are participating in the pilot of RNP's MEICAN webUI https://wiki.rnp.br/display/secipo/AutoGOLE+MEICAN+Pilot

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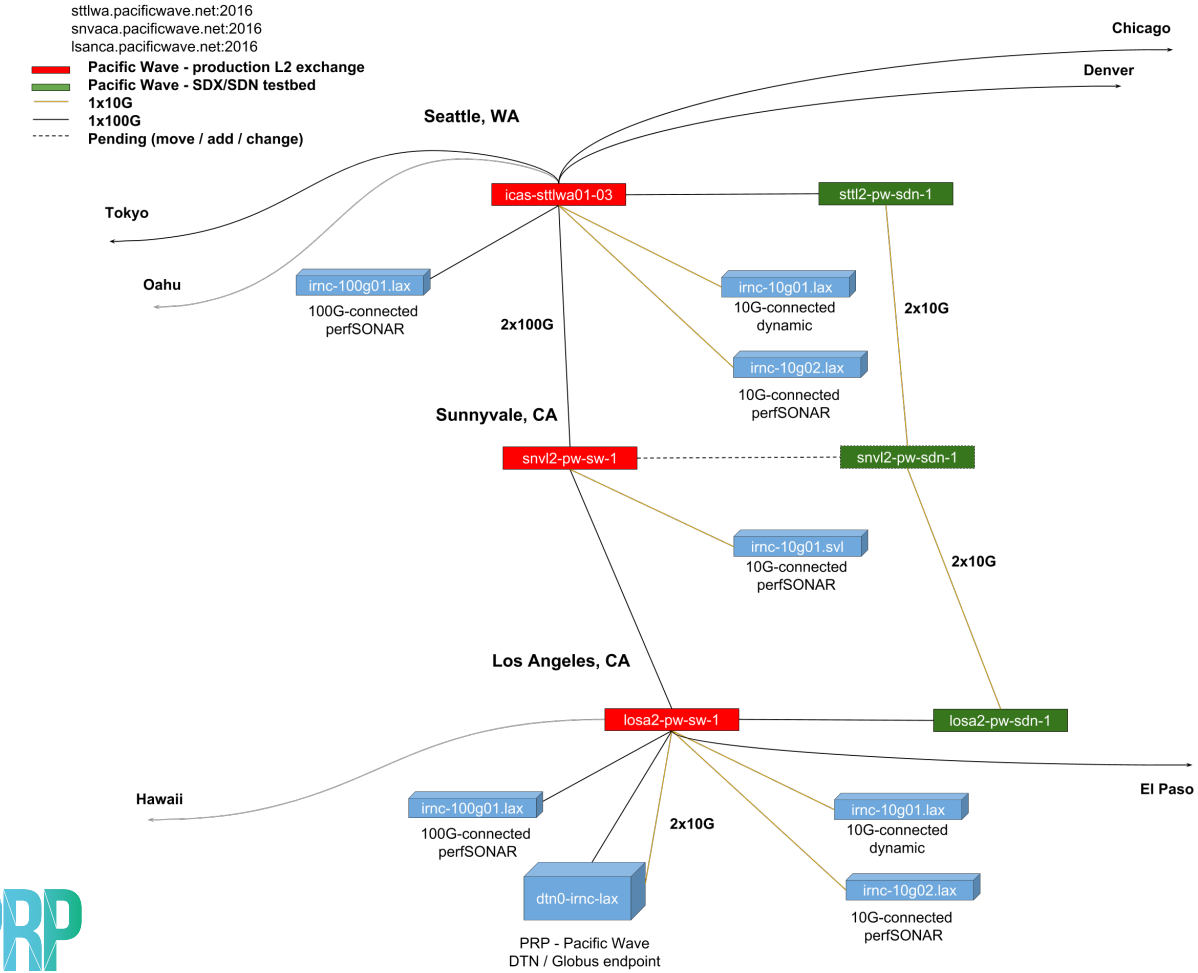
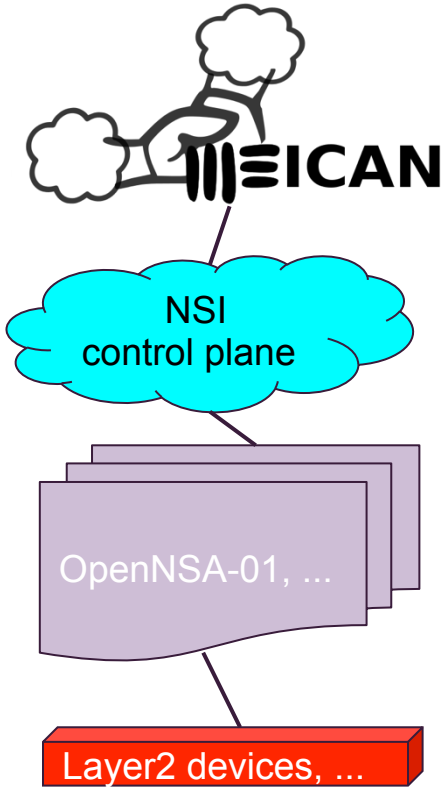
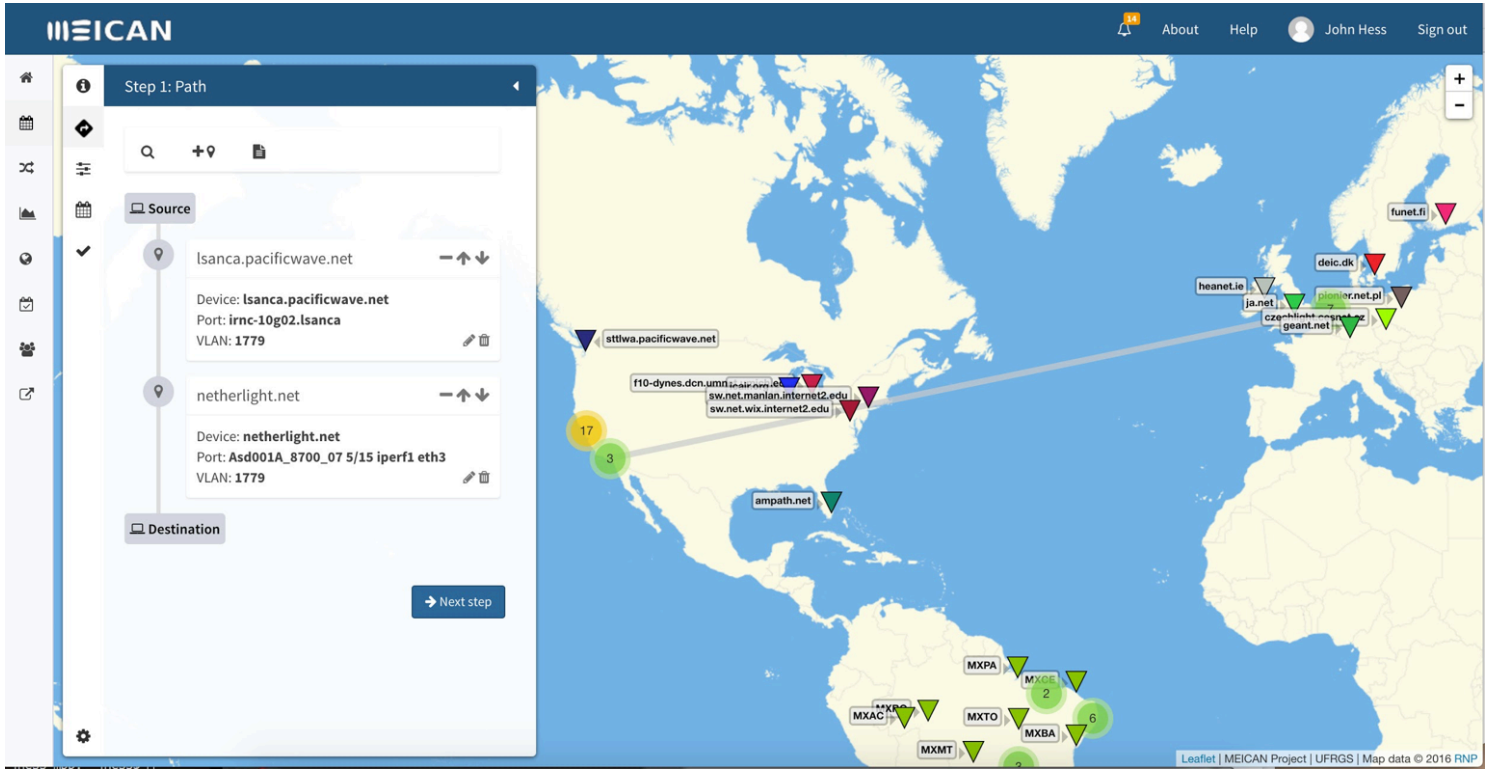
Pacific Wave: AutoGOLE - NSI

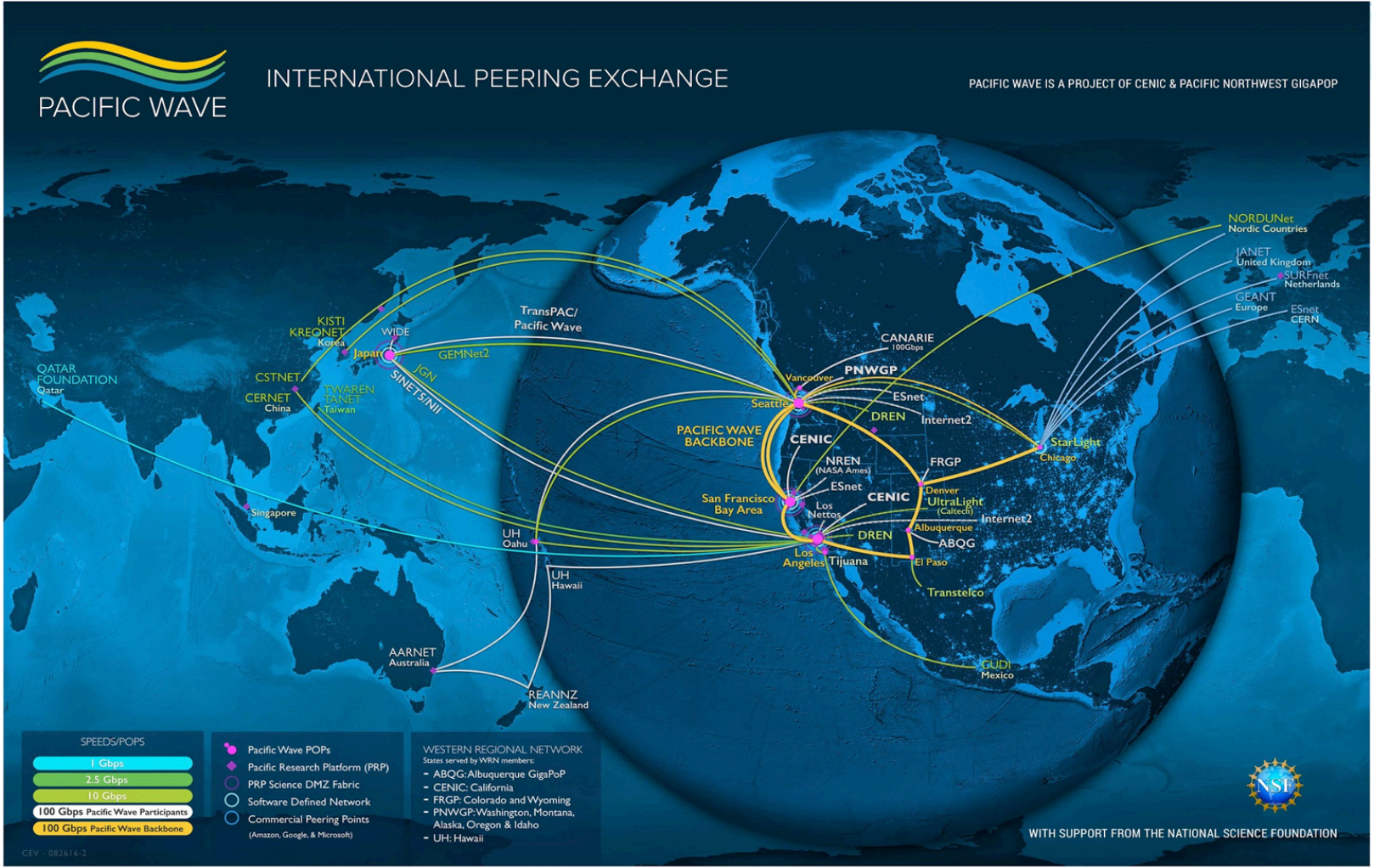




NOTE: this diagram represents a subset of sites, devices, and connections

Dynamic Circuit Services: MEICAN // Circuit Reservation




PACIFIC WAVE
INTERNATIONAL PEERING EXCHANGE
PACIFIC WAVE IS A PROJECT OF CENIC & PACIFIC NORTHWEST GIGAPOP
NORDUNet
Nordic Countries
JANET
United Kingdom
SURFnet
Netherlands
GEANT
Europe
ESnet
CERN
CANARIE
100Gbps
PNWGP
Vancouver
Seattle
ESnet
DREN
Internet2
PACIFIC WAVE
BACKBONE
CENIC
NREN
(NASA Ames)
ESnet
San Francisco
Bay Area
CENIC
Los
Nettos
DREN
Los
Angeles
Tijuana
FRGP
Denver
UltraLight
(Caltech)
Internet2
Albuquerque
ABQG
El Paso
Transtelco
StarLight
Chicago
GUDI
Mexico
TransPAC/
Pacific Wave
KISTI
KREONET
Korea
WIDE
Japan
GEMNet2
IGN
SINET5/NII
CSTNET
China
CERNET
TWAREN
TANET
Taiwan
QATAR
FOUNDATION
Qatar
Singapore
UH
Oahu
UH
Hawaii
AARNET
Australia
REANNZ
New Zealand
SPEEDS/POPS
1 Gbps
2.5 Gbps
10 Gbps
100 Gbps Pacific Wave Participants
100 Gbps Pacific Wave Backbone
Pacific Wave POPs
Pacific Research Platform (PRP)
PRP Science DMZ Fabric
Software Defined Network
Commercial Peering Points
(Amazon, Google, & Microsoft)
WESTERN REGIONAL NETWORK
States served by WRN members:
- ABQG: Albuquerque GigaPoP
- CENIC: California
- FRGP: Colorado and Wyoming
- PNWGP: Washington, Montana, Alaska, Oregon & Idaho
- UH: Hawaii
CEV - 082616-2
NSF
WITH SUPPORT FROM THE NATIONAL SCIENCE FOUNDATION

“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

Resources

Pacific Research Platform
http://pacificresearchplatform.org/
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/

Pacific Wave
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https://ps-dashboard.pacificwave.net

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

PNWGP
http://www.pnwgp.net/

Pacific Research Platform

Questions?