From Pacific Research Platform to National Research Platform

PRP PACIFIC RESEARCH PLATFORM

Nadya Williams, UCSD
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What is PRP

- **The NSF funded** The Pacific Research Platform (PRP) to the UCSD for 5 years starting October 1, 2015.
- It emerged out of the unmet **demand for high-performing bandwidth** to connect data generators and data consumers.
- The PRP was scaled to be a regional program by design, mainly focusing on West Coast US institutions, although it now includes several long-distance US and transoceanic Global Lambda Integrated Facility (GLIF) partners.
- The PRP is in its 4th year of successfully bringing new, unanticipated science applications, as well as test new means to dramatically improve throughput.

There is demand from the high-performance networking and scientific communities to extend the PRP nationally, and indeed worldwide.

The goal: to prototype a future in which a fully-funded multi-national Global Research Platform emerges

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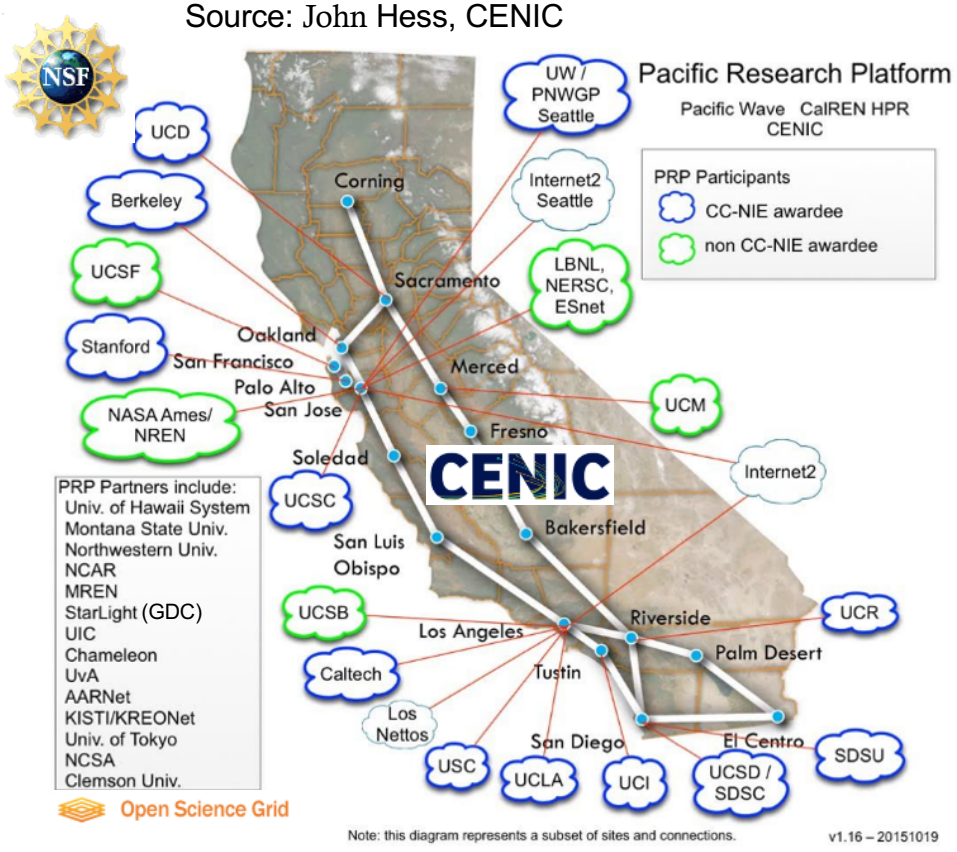
The Pacific Research Platform Networks Connects Campuses to Create a Regional End-to-End *Big Data Superhighway*

Source: John Hess, CENIC



NSF Grant
10/2015-10/2020

PI:

Larry Smarr, UC San Diego Calit2

Co-PIs:

Camille Crittenden, UC Berkeley CITRIS,
Tom DeFanti, UC San Diego Calit2/QI,
Philip Papadopoulos, UCI (former UCSD)
Frank Wuerthwein, UCSD Physics and SDSC

Letters of Commitment from:

50 Researchers from 15 Campuses
32 IT/Network Organization Leaders

CENIC 2016 Innovations in Networking Award for Experimental Applications

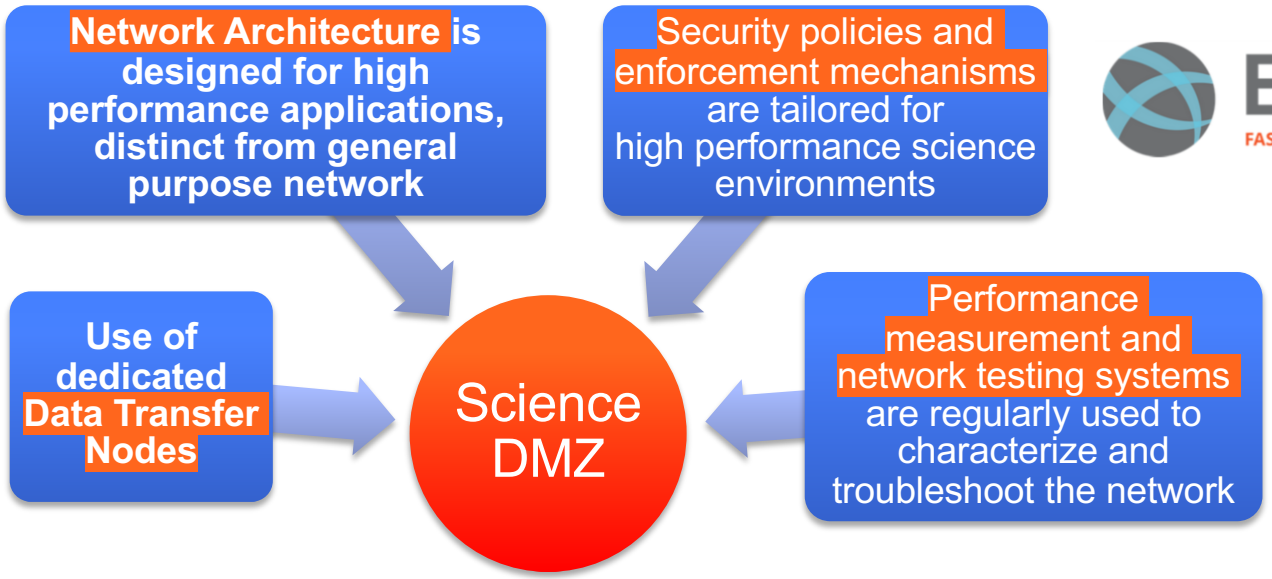
SDSC CITRIS BANATAO INSTITUTE it²

Science DMZ

- **Based on Community Input and on Energy Sciences Network's DMZ Concept (coined in 2010), NSF has Funded Over 100 Campuses to build DMZs**

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

- **A Science DMZ integrates 4 key concepts into a unified whole:**



ESnet
FASTERDATA KNOWLEDGEBASE

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Basis of PRP Architecture and Design

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Hardware and Performance Instrumentation

- Key Innovation: UCSD Designed FIONA servers (DTNs) to solve the Disk-to-Disk data transfer problem at full speed on 10/40/100G Networks
- FIONA (Flash IO Network Appliance) servers are tuned to test end-to-end connections
  - can run other software to monitor for security incursions /other issues
  - allow really inexpensive network node and end-site based R&E Cloud capabilities
- perfSONAR and GridFTP logs are then turned into visualizations
- Disk-to-disk throughput measurements (transfers of 10Gb files) were performed 4x a day until the PRP networks and the campus endpoints were tuned and capable of full bandwidth utilization
- PRP approach gives
  - Proactive network measurements of actual performance
  - Early warning of issues to NOC and engineers

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CENIC The Corporation for Education Network Initiatives in California

PACIFIC NORTHWEST GIGAPOP

NSF

CITRIS AND THE BANATAO INSTITUTE

ESnet Energy Sciences Network

SDSC

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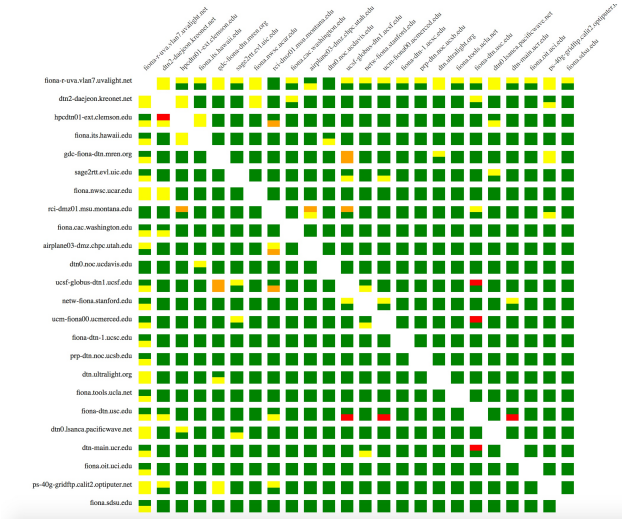
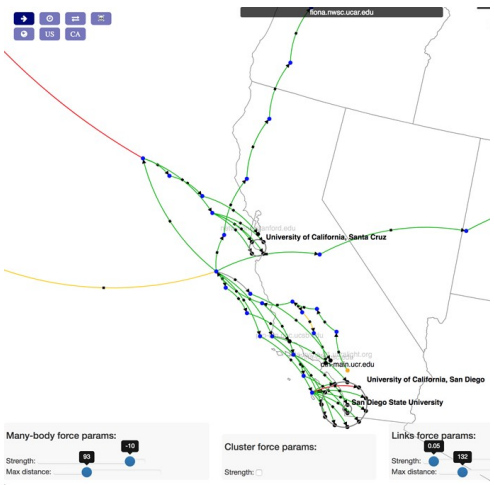
Performances measurements visualization

Disk-to-disk throughput:
10Gb file transfer 4 times/day dual direction, all sites

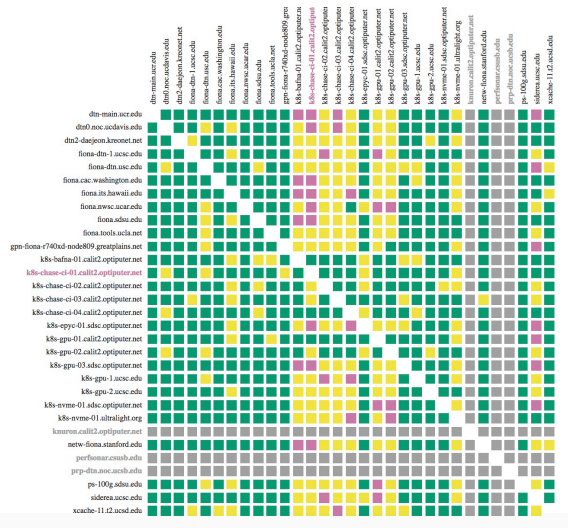


Traceroute: testing & real-time visualization of status of network links



https://traceroute.nautilus.optiputer.n

One-Way Active Measurement Protocol (OWAMP): Unidirectional Characteristics One-Way Delay and One-Way Loss



PRPv1 to PRPv2:
Transition from Network Diagnosing to Application Support

- **PRPv1 first designed, built, and installed ~40 purpose-built FIONAs, DTNs are tuned to measure and diagnose end-to-end 1G, 10G, 40G & 100G connections to CENIC's 100G HPR and National/International Partners**

- **But scientists clearly need more than bandwidth tests:**
  - **They need to share their data at high speed**
  - **Compute on it**
  - **Commercial clouds are not cost-effective for sharing big data**

- **PRPv2 is adding ~4 PBs distributed storage:**
  - **~200GB rotating disk on 14 PRPv1 FIONAs in campus DMZs**
  - **2PB NSF-funded BeeGFS Parallel File Storage at San Diego State University**

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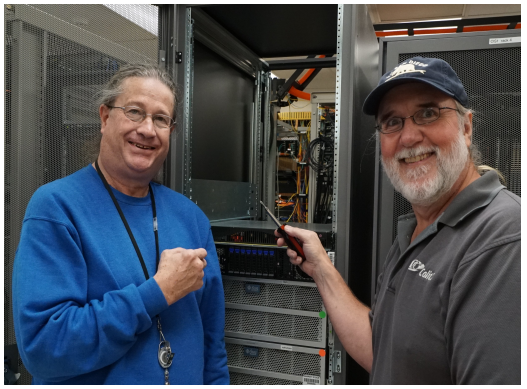
Installing Community Shared Storage and GPUs at UC Merced, UC Santa Cruz, UC Riverside, and Stanford





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Use Kubernetes to Manage Across the PRPv2

https://kubernetes.io

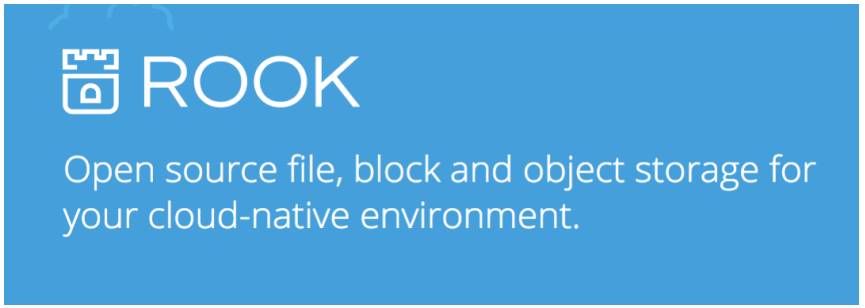
Kubernetes: open-source system for automating deployment, scaling, and management of containerized applications.

Kubernetes is a way of stitching together a collection of machines into, basically, a big computer

Craig Mcluckie, Google CEO

Everything at Google runs in a container."

Joe Beda, Google



https://rook.io/

- based on an embedded version of Ceph
- runs as a cloud native service for optimal integration with applications in need of block, object or file storage
- turns storage software into services that are: self-managing, self-scaling, self-healing

Allows the PRP:

- **deploy PBs of distributed storage at $10/TB/yr**
- **add GPUs for Data Science**
- **measure and monitor usage**

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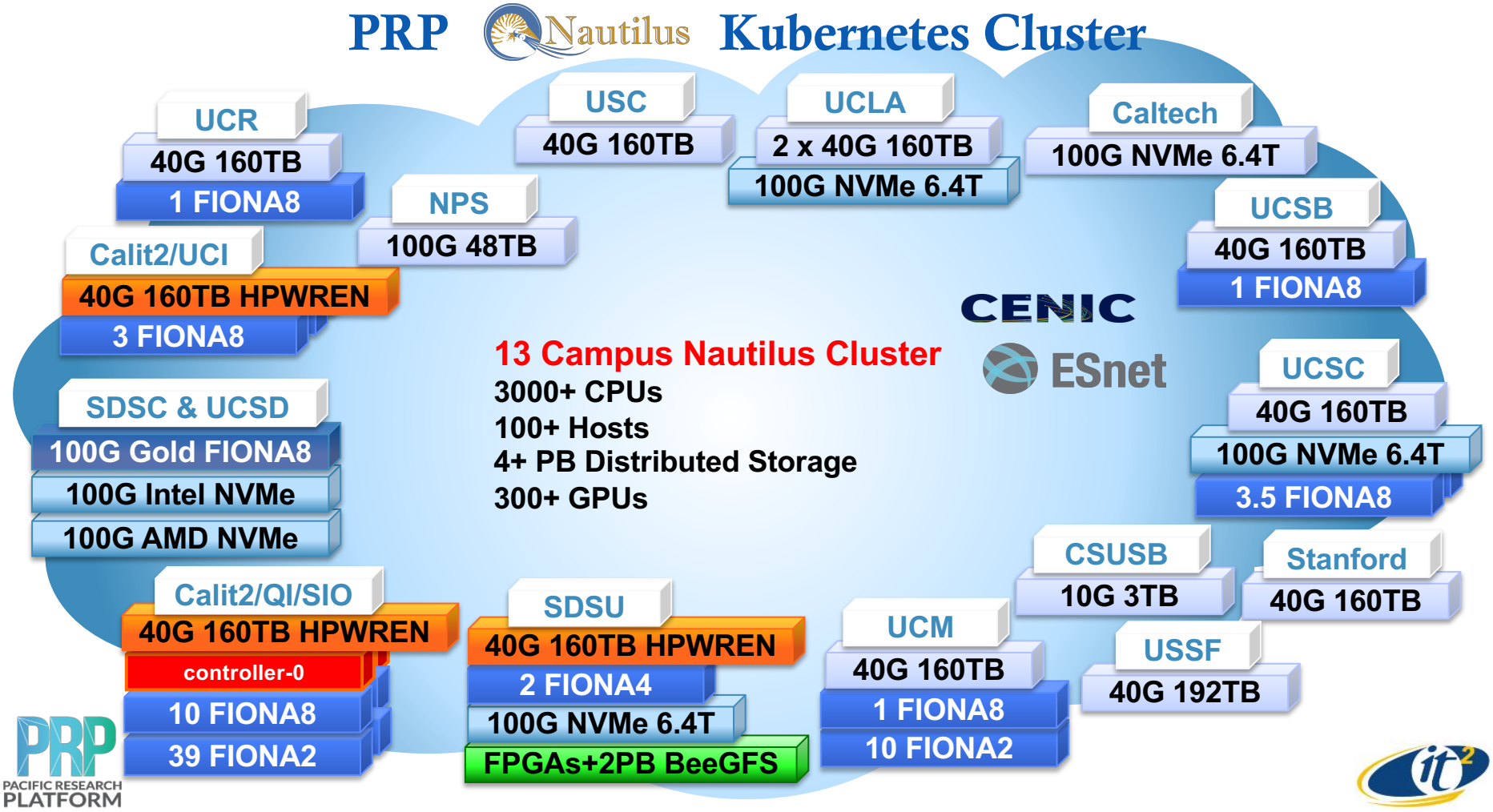
PRP
Nautilus
Kubernetes Cluster
UCR
40G 160TB
1 FIONA8
USC
40G 160TB
UCLA
2 x 40G 160TB
100G NVMe 6.4T
Caltech
100G NVMe 6.4T
NPS
100G 48TB
UCSB
40G 160TB
1 FIONA8
Calit2/UCI
40G 160TB HPWREN
3 FIONA8
CENIC
ESnet
13 Campus Nautilus Cluster
3000+ CPUs
100+ Hosts
4+ PB Distributed Storage
300+ GPUs
SDSC & UCSD
100G Gold FIONA8
100G Intel NVMe
100G AMD NVMe
UCSC
40G 160TB
100G NVMe 6.4T
3.5 FIONA8
CSUSB
10G 3TB
Stanford
40G 160TB
Calit2/QI/SIO
40G 160TB HPWREN
controller-0
10 FIONA8
39 FIONA2
SDSU
40G 160TB HPWREN
2 FIONA4
100G NVMe 6.4T
FPGAs+2PB BeeGFS
UCM
40G 160TB
1 FIONA8
10 FIONA2
USSF
40G 192TB
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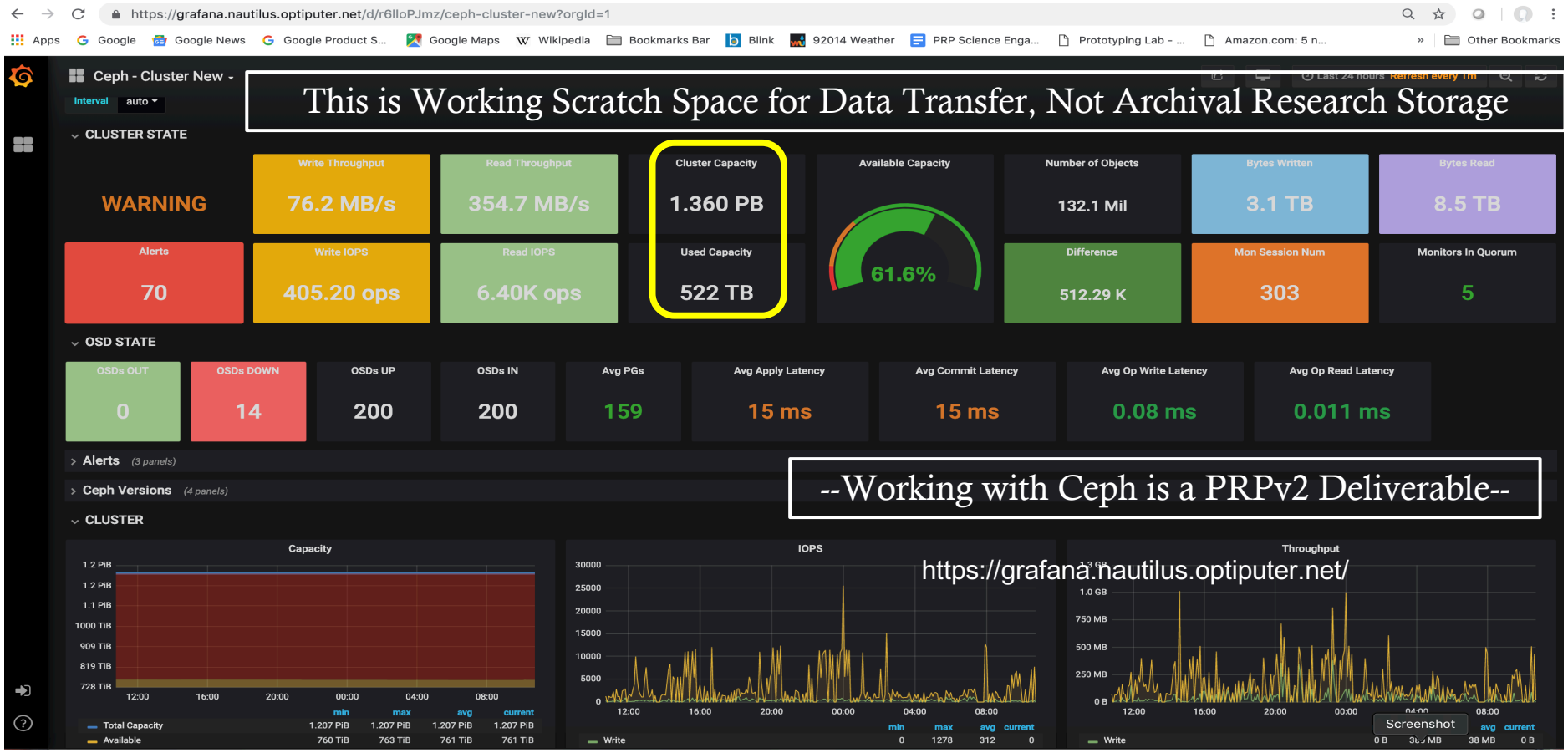
Grafana Allows Detailed Real-Time Monitoring of the Nautilus Cluster



PRP's First 2.5 Years: Connecting Multi-Campus Application Teams and Devices

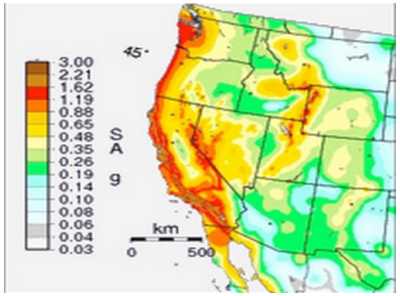
CMS

Particle Physics

Biomedical 'omics

Telescope Surveys

Earth Sciences
Engineering



Visualization, Virtual Reality, Collaboration

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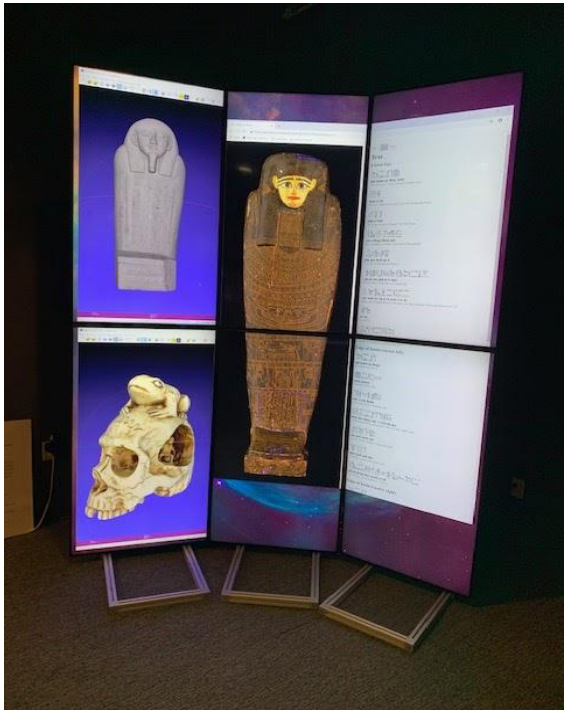
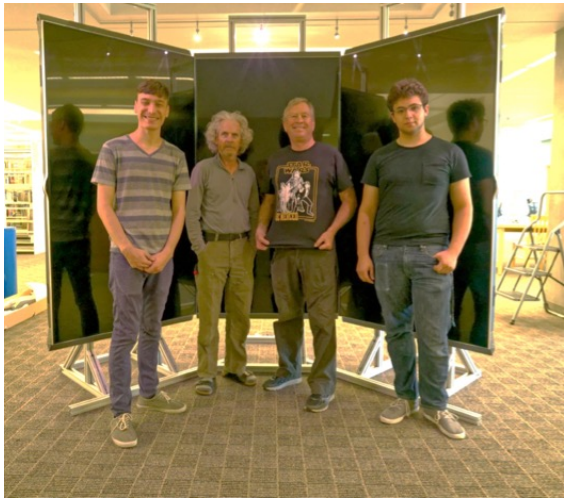
PRP Links At-Risk Cultural Heritage and Archaeology Datasets at UCB, UCLA, UCM and UCSD with CAVEkiosks

48 Megapixel CAVEkiosk
UCSD Library



48 Megapixel CAVEkiosk
UCB CITRIS Tech Museum



24 Megapixel CAVEkiosk
UCM Library

UC President Napolitano's Research Catalyst Award to

- UCSD (Tom Levy),
- UCB (Benjamin Porter),
- UCM (Nicola Lercari),
- UCLA (Willeke Wendrich)

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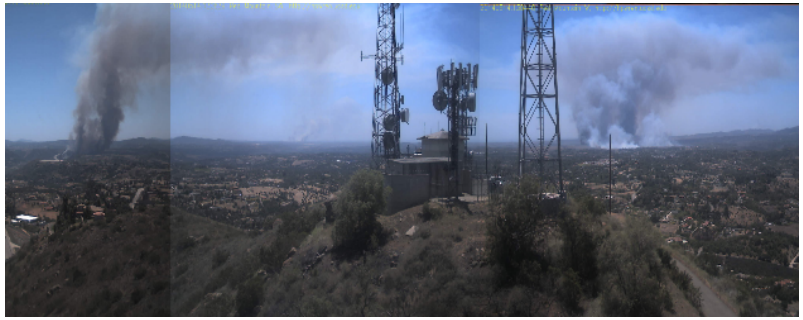
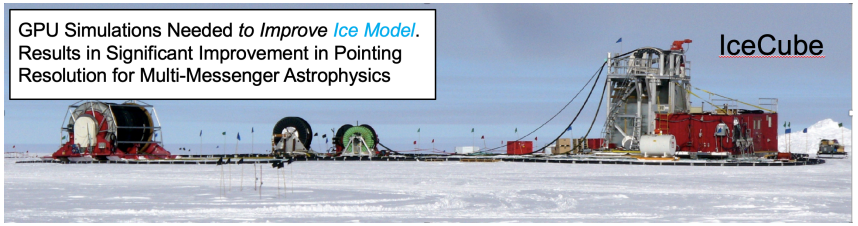
The Prototype PRP Has Attracted New Application Drivers

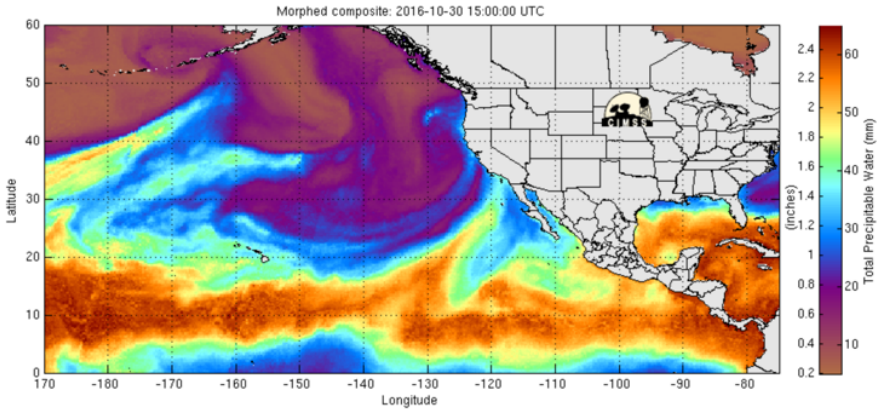


Frank Vernon, Graham Kent, & Ilkay Altintas, **Coupling Wireless Wildfire Sensors to Real Time Computing**



Frank Würthwein **OSG – IceCube** **Increasing Resolution for Multi-Messenger Astrophysics**

Jules Jaffe – **Undersea Microscope:** **ML for Automated Image Analysis and Classification**



Scott Sellars, Marty Ralph **Center for Western Weather and Water Extremes:** **4D object segmentation of NASA water Vapor Data**

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New NSF CHASE-CI Grant Creates a Community Cyberinfrastructure

MSU
UCB
Stanford
UCM
UCSC
Caltech
UCI
UCR
UCSD
SDSU

CI-New: Cognitive Hardware and Software Ecosystem Community Infrastructure (CHASE-CI)

For the Period September 1, 2017 – August 31, 2020

SUBMITTED – January 18, 2017

PI: Larry Smarr, Professor of Computer Science and Engineering, Director Calit2, UCSD
Co-PI: Tajana Rosing, Professor of Computer Science and Engineering, UCSD
Co-PI: Ken Kreutz-Delgado, Professor of Electrical and Computer Engineering, UCSD
Co-PI: Ilkay Altintas, Chief Data Science Officer, San Diego Supercomputer Center, UCSD
Co-PI: Tom DeFanti, Research Scientist, Calit2, UCSD

- **NSF Grant for High Speed "Cloud" of 256 GPUs for 30 Faculty & their students at 10 Campuses for Training AI Algorithms on Big Data**
- **Adding a Machine Learning Layer Built on Top of the Pacific Research Platform**

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SDSC JACOBS SCHOOL OF ENGINEERING UC San Diego

FIONA8: a FIONA with 8 GPUs
Supports PRP Data Science Machine Learning

Goal: Machine Learning researchers need a new cyberinfrastructure

8 Nvidia GTX-1080 Ti / RTX 2080-Ti GPUs

Design: John Graham, Calit2

~$20,000	Extensible to
32 AMD cores	64 AMD cores
256GB RAM	1TB RAM
1TB NVMe SSDs	16TB NVMe SSDs
Dual 10G ports	

"Until cloud providers are willing to find a solution to place commodity (32-bit) game GPUs into their servers and price services accordingly, I think we will not be able to leverage the cloud effectively."

"There is an actual scientific infrastructure need here, surprisingly unmet by the commercial market, and perhaps CHASE-CI is the perfect catalyst to break this logjam."

--UC Berkeley Professor Trevor Darrell

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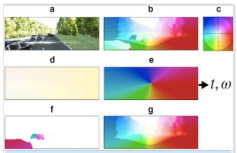
PRP Provides Kubernetes services for Application Research, Development and Collaboration

jupyterhub

A multi-user version of the notebook designed for companies, classrooms and research labs

GitLab Continuous Integration & Delivery

The IceCube Science Program Spans Fundamental Physics to Observational Astronomy

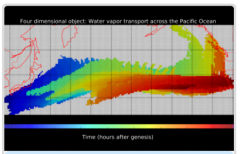


Carl-uci

University of California, Irvine: Reinforcement learning and motion decomposition

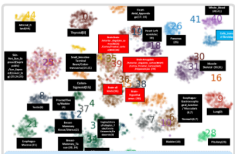
Chei-ml

University of California, San Diego and SIO: Deep learning for coral species segmentation



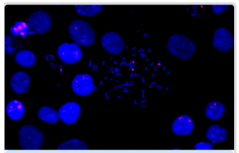
Connect

University of California, San Diego: Machine Learning in Earth Sciences



Deepgtex-prp

Clemson University: Deep Learning in Oncogenomics

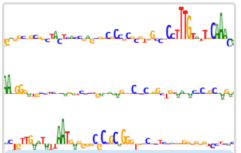


Ecdna

University of California, San Diego: Deep Learning for medical imaging

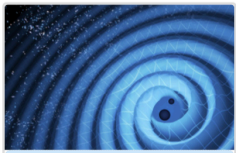
Ecewcsng

University of California, San Diego: Deep Learning for sensor data processing



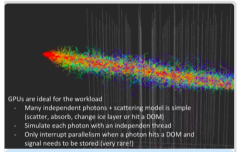
Kundajelab

Stanford University: Deep Learning in Genomics



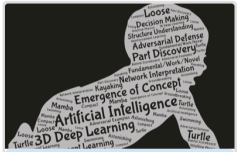
OSG

University of California, San Diego: Cashing infrastructure



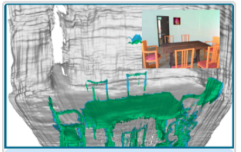
OSGgpus

University of California, San Diego: Photon propagation simulation



UCSD-haosulab

University of California, San Diego: Machine learning methods based on point cloud



Ucicompvis

University of California, Irvine: Machine Learning in Computer vision

Viscomp

University of California, San Diego: Deep Learning in Computer graphics

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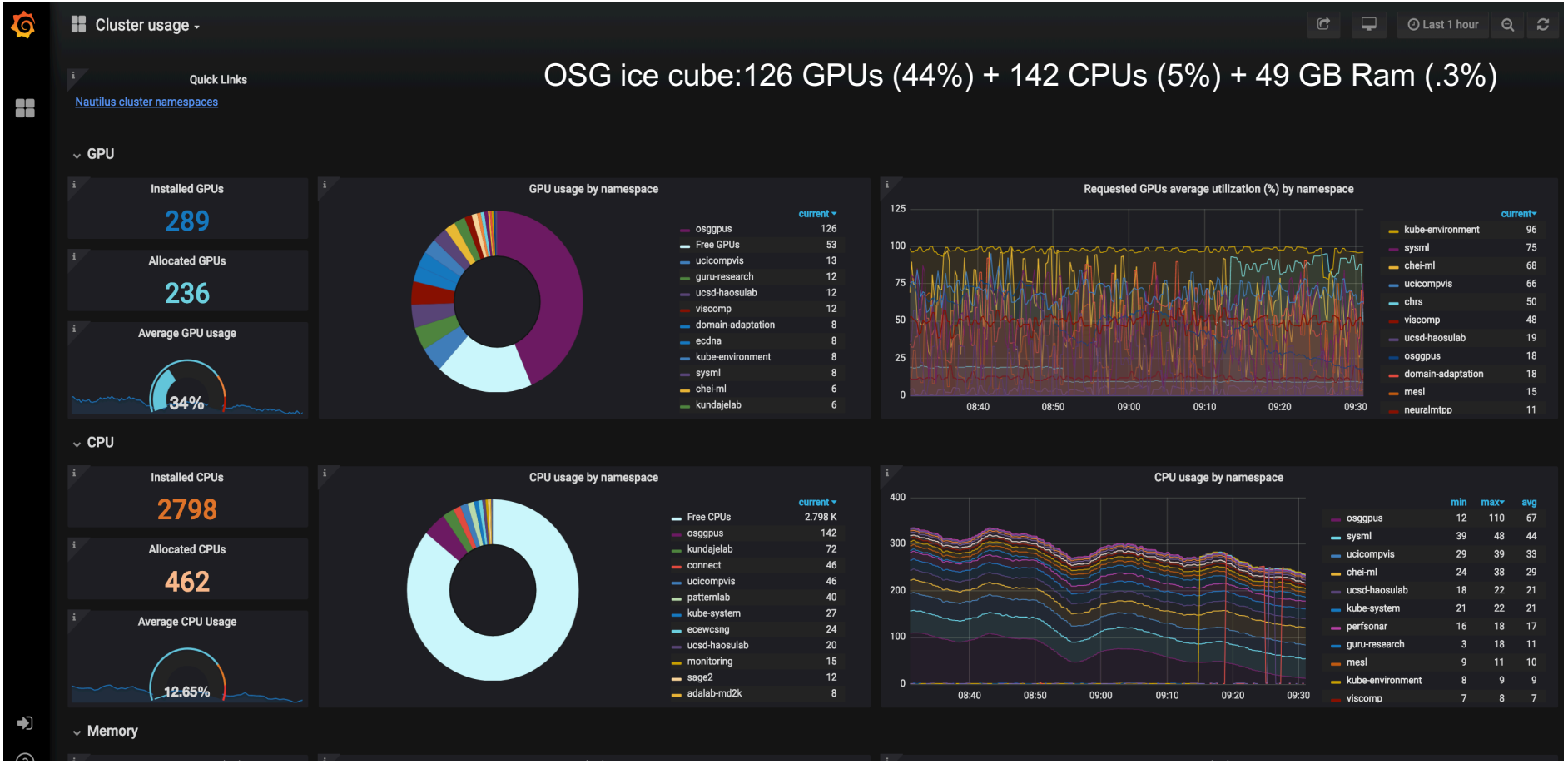
PRP Cluster Resources Usage

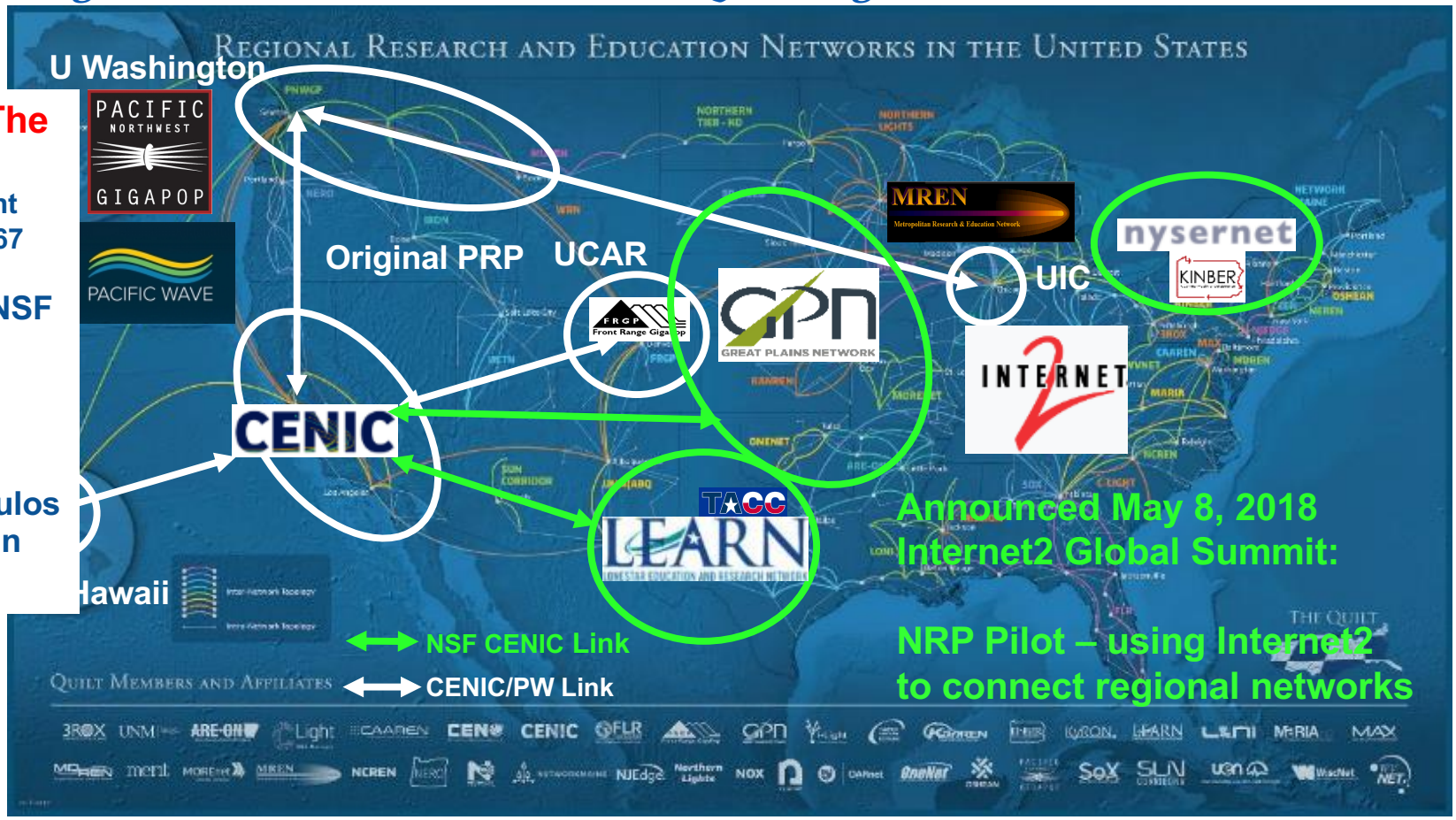


2018-2019 PRP Deliverable: NRP Pilot: 18-Month National-Scale Experiment: Using CENIC & Internet2 to Connect Quilt Regional R&E Networks

Towards The NRP
3-Year Grant
OAC-1826967

Funded by NSF

PI: Smarr
Co-Pis:
- Altintas
- Papadopoulos
- Wuerthwein
- Rosing



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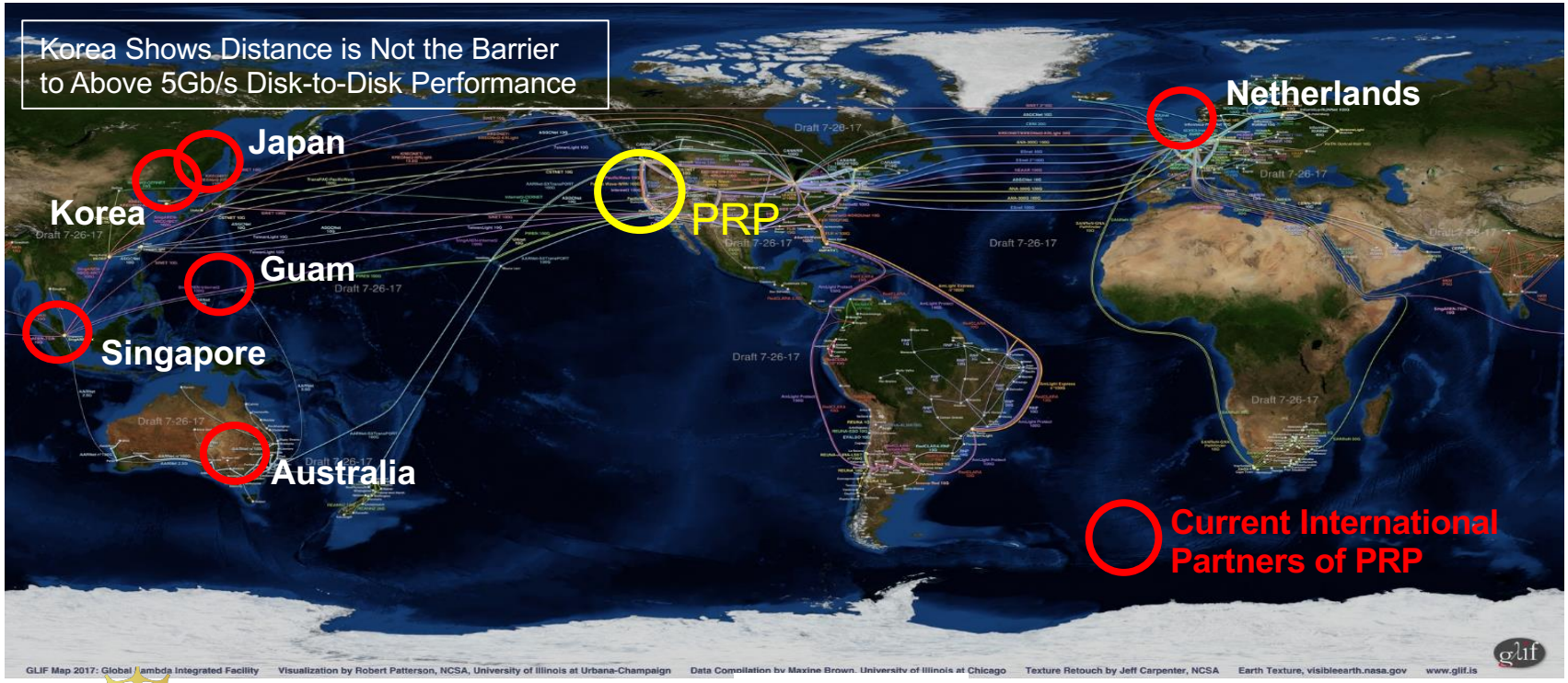
Expanding to the Global Research Platform
Via CENIC/Pacific Wave, Internet2, and International Links



PRP PACIFIC RESEARCH PLATFORM NSF CENIC ESnet CITRIS AND THE BANATAO INSTITUTE

http://pacificresearchplatform.org

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The success of NRP/GRP depends on

- NRP platform must be easy for scientists to implement and use
- Scientists want to do science, not networking or IT
- NRP is a social engineering project as well as a technical networking/IT project
- ScienceDMZ/DTN architecture is an effective science enabler
- Science Engagement process is crucial to scaling up
- Human trust to establish cooperation across institutions
- It took time for PRP participants to work together
  - to learn individual roles & strengths and weaknesses
  - to learn to rely on/trust their collaborators
- Trust is a human-intensive endeavor, one relationship at a time, not readily scalable. But can foster:
  - Identify and document successful collaborations (like PRP)
  - Emphasize peer to peer communications at all levels

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Engaging More Scientists: newly designed and updated PRP Website

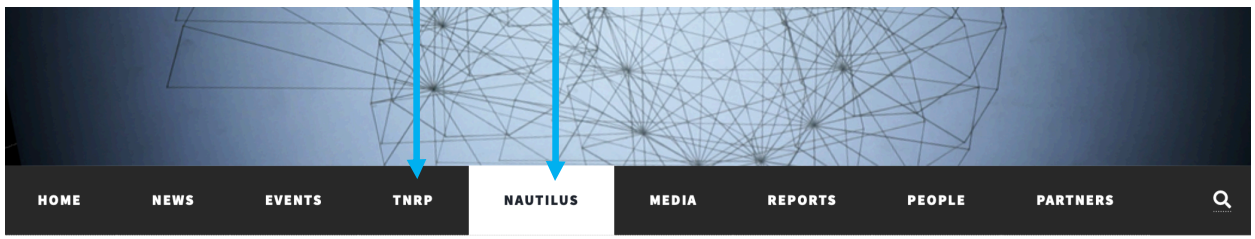
http://pacificresearchplatform.org

PRP website http://pacificresearchplatform.org

PRP/TNRP pilot engagement team

- Meeting schedules & agendas
- Meeting notes

PRP Nautilus cluster



Media & reports

NAUTILUS DOCUMENTATION

Nautilus is a HyperCluster for running containerized Big Data Applications. It is using Kubernetes for managing and scaling containerized applications and Rook for automating Ceph data services.

The following pages provide documentation for Nautilus cluster users and administrators, information about namespaces and applications running in them and the cluster map.

You are ...

Cluster user | Cluster administrator | Browsing namespaces | Wondering where is Nautilus?

User and admin documentation

Use cases

Cluster nodes

Acknowledgements of PRP support

- **US National Science Foundation Awards:**

  CNS-1456638, CNS-1730158, ACI-1540112, ACI-1541349, & OAC-1826967

- **University of California Office of the President CIO**
- **Calit2 and Calit2's Qualcomm Institute**
- **San Diego Supercomputer Center and UCSD's Research IT and Instructional IT**
- **Partner Campuses: UCB, UCSC, UCI, UCR, UCLA, USC, UCD, UCSB, SDSU, Caltech, NU, UWash UChicago, UIC, UHM, CSUSB, HPWREN, UMo, MSU, NYU, UNeb, UNC,UIUC, UTA/Texas Advanced Computing Center, FIU, KISTI, UVA, AIST**
- **CENIC, Pacific Wave/PNWGP, StarLight/MREN, The Quilt, Kinber, Great Plains Network, NYSERNet, LEARN, Open Science Grid**
- **Internet2, DOE ESnet, NCAR/UCAR and Wyoming Supercomputing Center**

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Thank you!

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