“PRP, NRP, GRP, & the Path Forward”

Presentation
2nd National Research Platform Workshop
Bozeman, MT
August 6, 2018

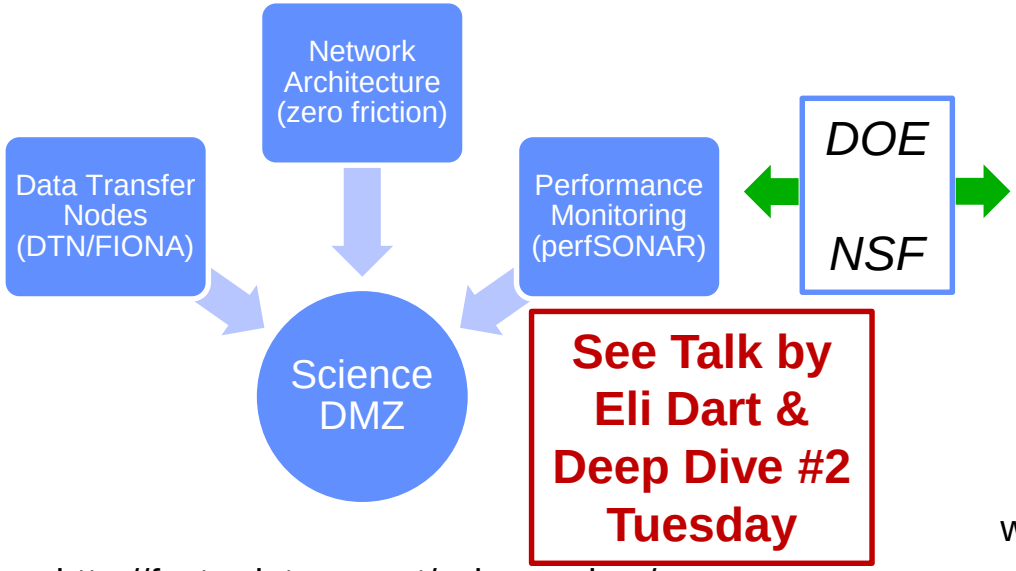
Dr. Larry Smarr
Director, California Institute for Telecommunications and Information Technology
Harry E. Gruber Professor,
Dept. of Computer Science and Engineering
Jacobs School of Engineering, UCSD
http://lsmarr.calit2.net

PRP PACIFIC RESEARCH PLATFORM

it²

ESnet's ScienceDMZ Accelerates Science Research: DOE & NSF Partnering on Science Engagement and Technology Adoption

ScienceDMZ Coined in 2010 by ESnet
Basis of PRP Architecture and Design



See Talk by Eli Dart & Deep Dive #2 Tuesday

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

NSF CC* program (2012+) Funded Deployment of ScienceDMZ on 200 Univ. campuses



www.nsf.gov/funding/pgm_summ.jsp?pims_id=504748

Slide From Inder Monga, ESnet

PRP PACIFIC RESEARCH PLATFORM
OIN Operating Innovative Networks
GlobalNOC
ESnet FASTERDATA KNOWLEDGEBASE
INTERNET2
it2

Logical Next Step: The Pacific Research Platform Networks Campus DMZs to Create a Regional End-to-End Science-Driven "Big Data Superhighway" System



PACIFIC RESEARCH PLATFORM

Source: John Hess, CENIC

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/QI,**
- **Philip Papadopoulos, UCSD SDSC,**
- **Frank Wuerthwein, UCSD Physics and SDSC**

Letters of Commitment from:

- 50 Researchers from 15 Campuses
- 32 IT/Network Organization Leaders

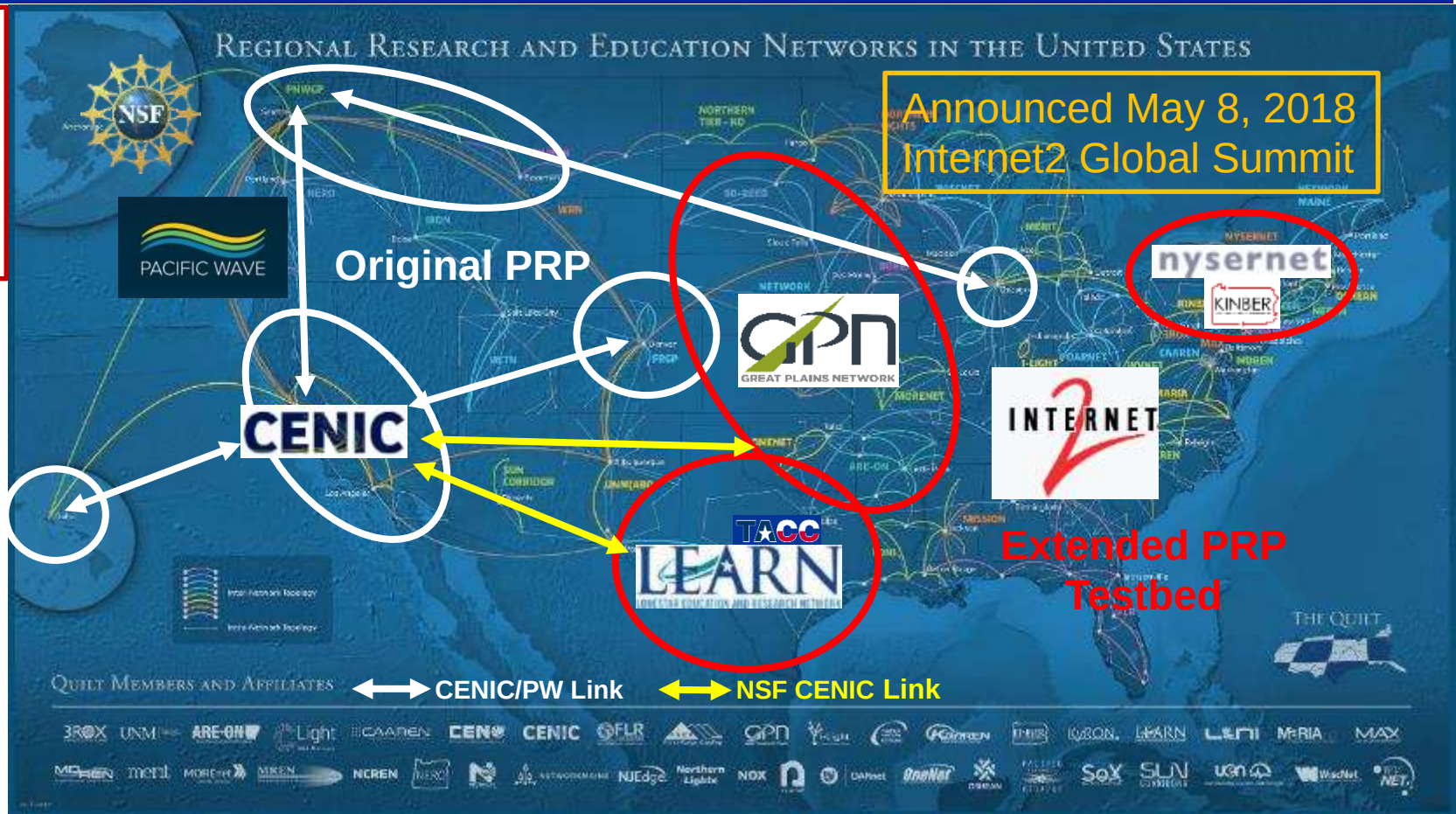
NSF Program Officer: Amy Walton

SDSC CITRIS BANATAO INSTITUTE it²

PRP National-Scale Experimental Distributed Pilot: Using CENIC & Internet2 to Connect Early-Adopter Quilt Regional R&E Networks

See NRP Pilot Monday; Scaling Tuesday

ESnet
CENIC
SDSC
CITRIS BANATAO INSTITUTE
it²
PRP PACIFIC RESEARCH PLATFORM



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

Report on 3-Day FIONA Hands-On Workshop For EPSCoR, MSI & EPSCoR Deep Dive #3 Monday; EPSCoR Talk Tuesday

FIONette—1G, $250





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

Five Racked FIONAs at Calit2:

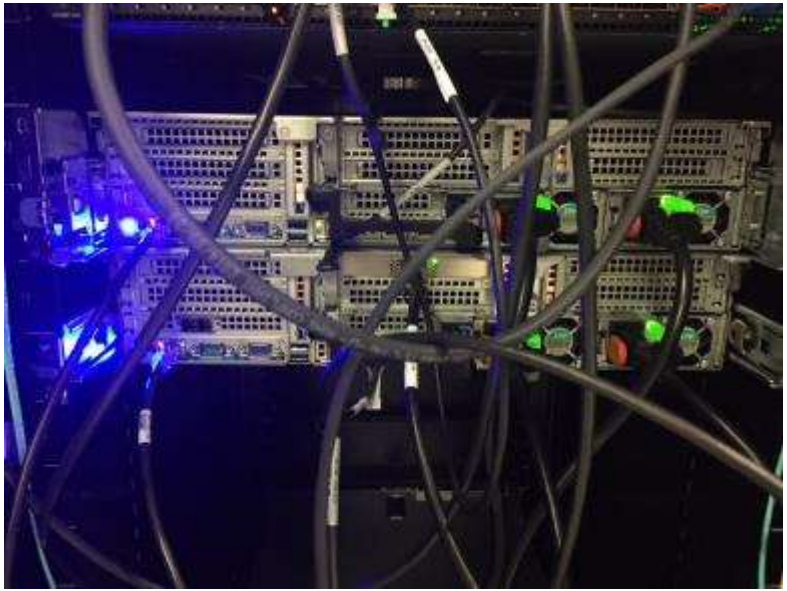
- Each Contains:
  - Dual 12-Core CPUs
  - 96GB RAM
  - 1TB SSD
  - 2 10GbE interfaces
    - Total ~$10,500
  - With 8 GPUs
    - total ~$18,500

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

GPN Becomes the First Multi-State Regional Network to Peer with the PRP

Between the PRP-Contributed PWave DTN in Los Angeles
To GPN FIONA in UMC
Before PRP 0.8 Gbps, In May Seeing 3.7Gbs Over PRP, Now 11 Gbps





See James Deaton NRP Pilot Monday

Source: John Hess, CENIC and George Rob III, UMissouri

Game Changer: Using Kubernetes to Manage Containers Across the PRP

Amazingly, I Didn't Mention Kubernetes Last Year

CADE METZ BUSINESS 06.10.14 01:15 PM

GOOGLE OPEN SOURCES ITS SECRET WEAPON IN CLOUD COMPUTING

WIRED

"Kubernetes is a way of stitching together
a collection of machines into, basically, a big computer,"
--Craig Mcluckie, Google
and now CEO and Founder of Heptio

"Everything at Google runs in a container."
--Joe Beda,Google



Kubernetes Tutorial Sunday

"Kubernetes has emerged as
the container orchestration engine of choice
for many cloud providers including
Google, AWS, Rackspace, and Microsoft,
and is now being used in HPC and Science DMZs.
--John Graham, Calit2/QI UC San Diego

PRP PACIFIC RESEARCH PLATFORM

CLOUD NATIVE COMPUTING FOUNDATION

Rook is Ceph Cloud-Native Object Storage 'Inside' Kubernetes

Kubernetes Tutorial Sunday



Battle-tested, production storage

Rook is based on an embedded version of Ceph, which has 10+ years of production deployments and runs some of the worlds largest clusters.

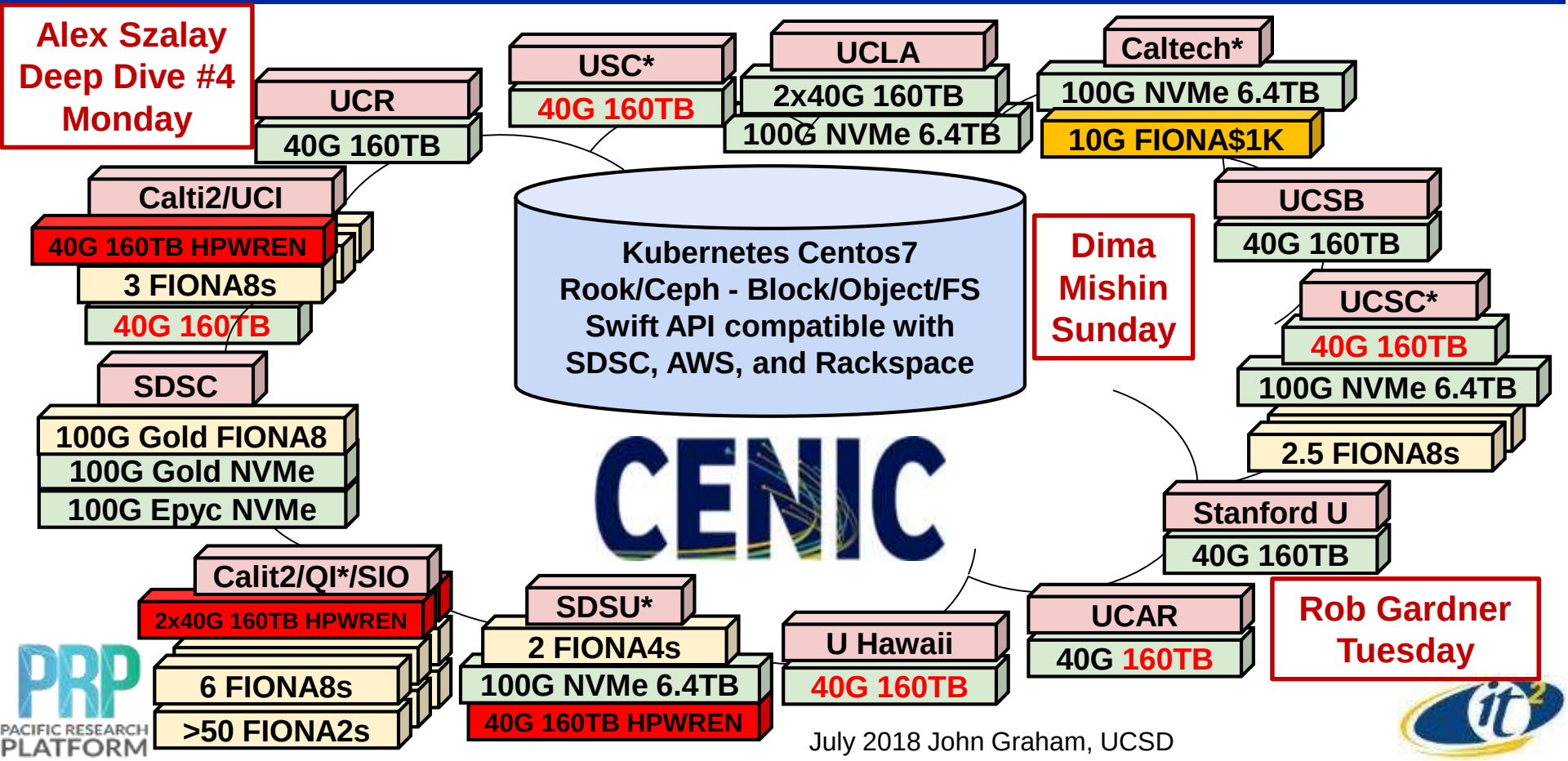
Cloud-native environment integration

Rook runs as a cloud-native service for optimal integration with applications in need of block, object, or file storage.

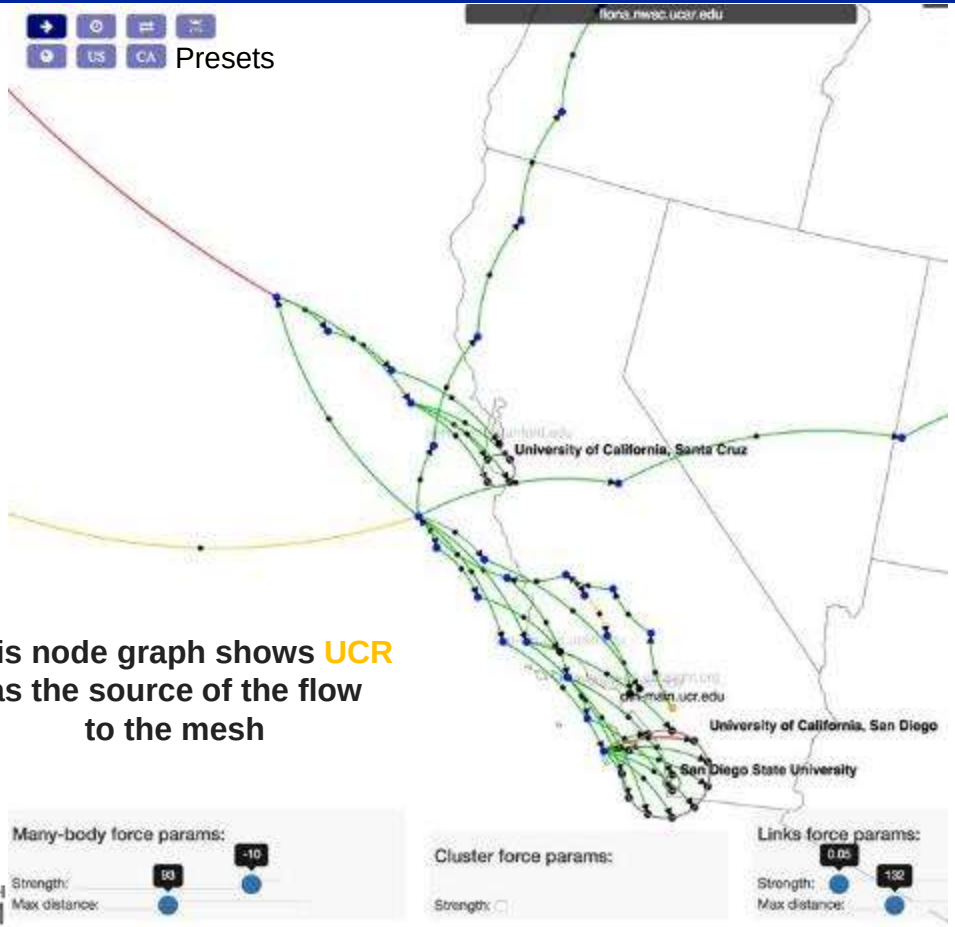
PACIFIC RESEARCH PLATFORM

Source: John Graham, Calit2/QI

PRP is Deploying Distributed Petabytes of Storage for Posting/Staging Data at $10/TB per Year by Leveraging our Base of Installed FIONAs

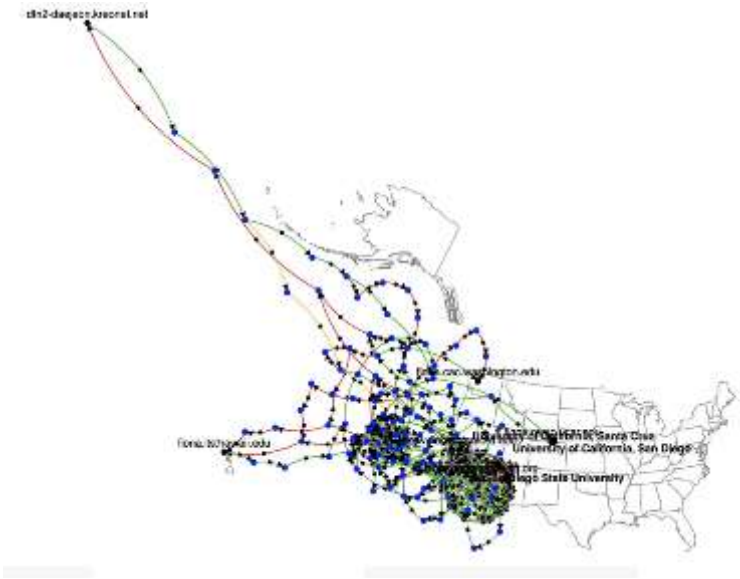


Operational Metrics: Containerized Trace Route Tool Allows Realtime Visualization of Status of Network Links



This node graph shows UCR as the source of the flow to the mesh

Source: Dmitry Mishin(SDSC), John Graham (Calit2)



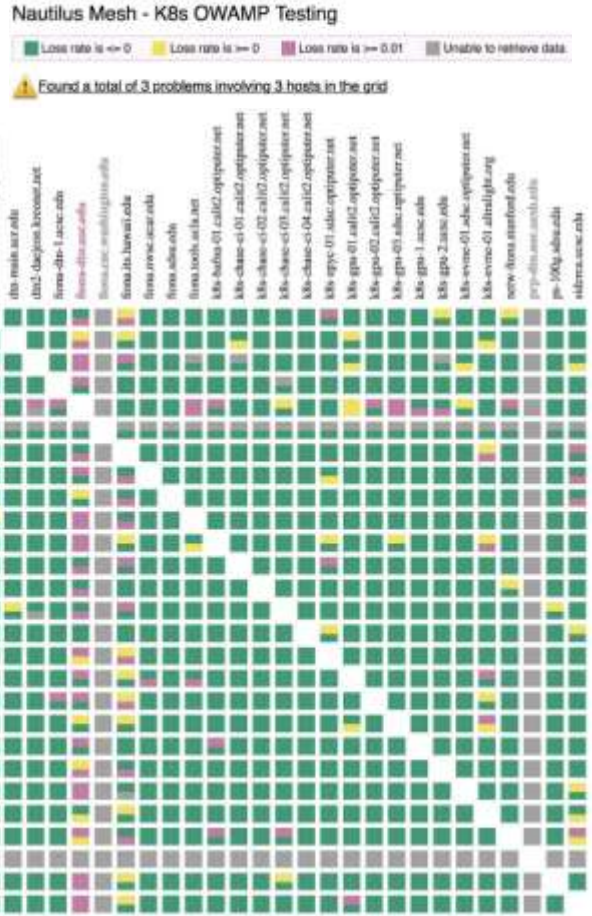
All Kubernetes Nodes on PRP

PACIFIC RESEARCH PLATFORM

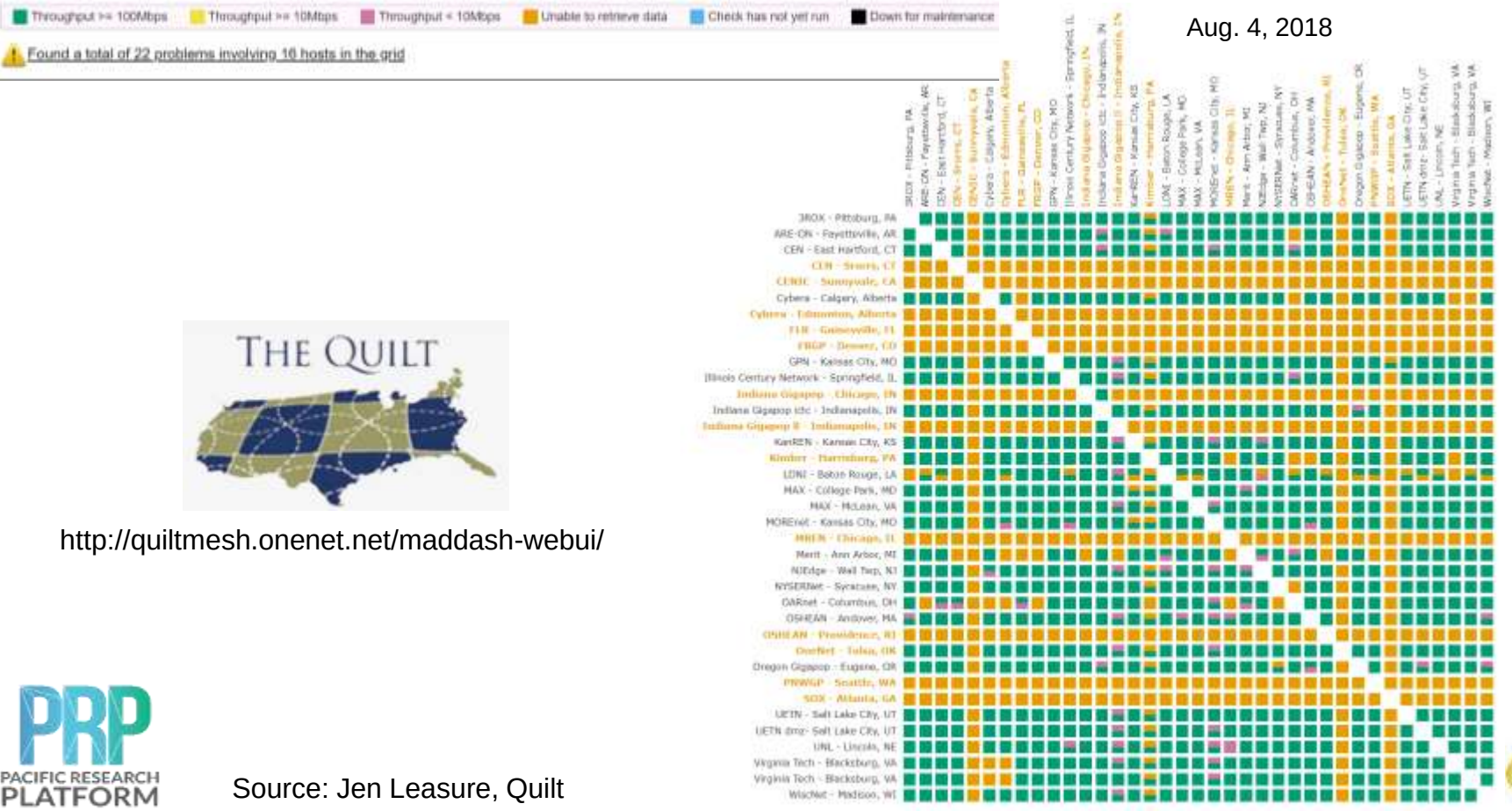
Operational Metrics: Containerized perfSONAR MaDDash Dashboards For Realtime Measurements of PRP Number of Paths and Packet Loss



Source: Dmitry Mishin(SDSC), John Graham (Calit2)



Quilt Members Have Built Their Own perfSONAR MaDDash Inspired by PRP



THE QUILT

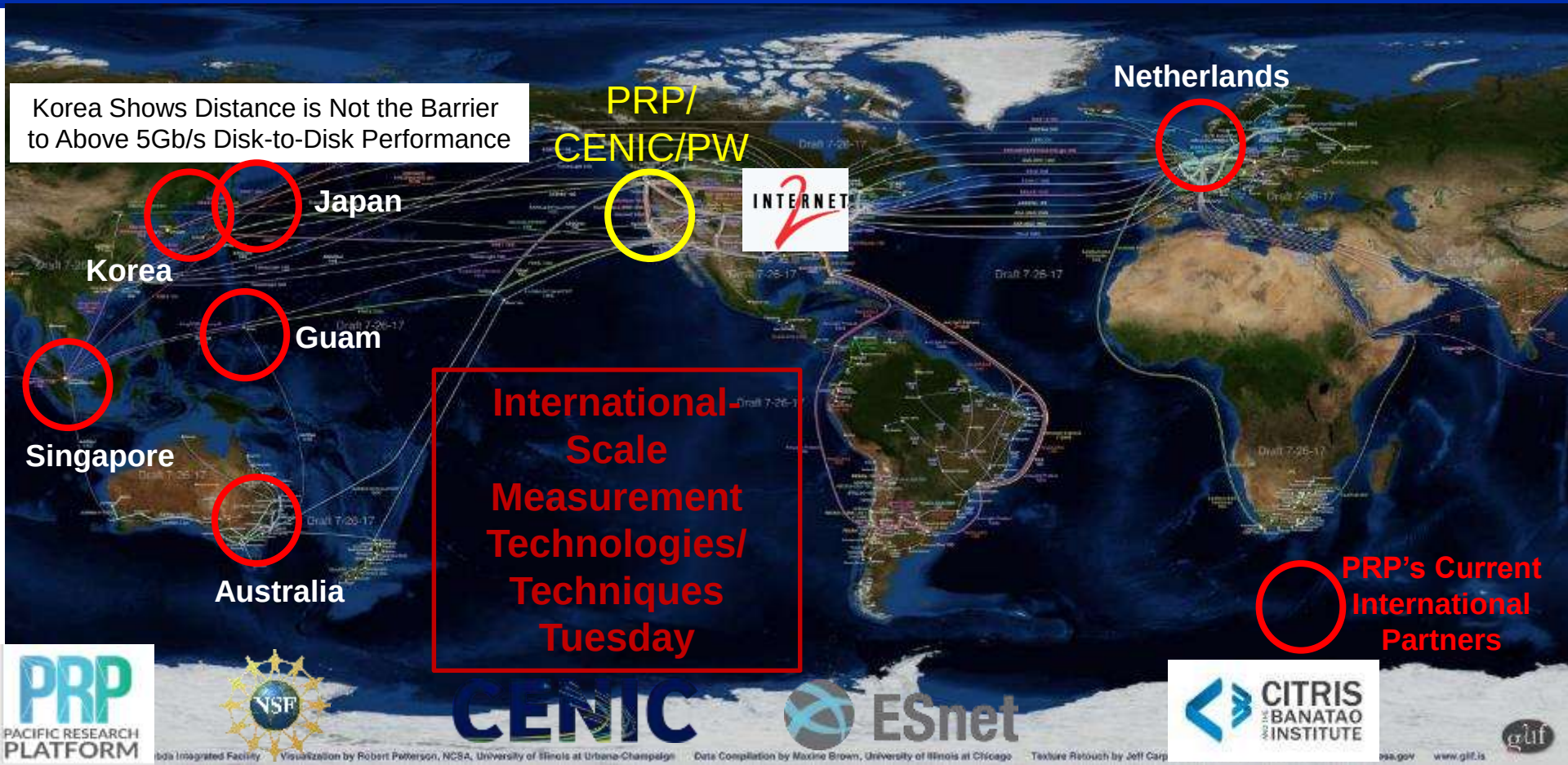
http://quiltmesh.onenet.net/maddash-webui/

PRP PACIFIC RESEARCH PLATFORM

Source: Jen Leasure, Quilt

it²

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



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



CMS

Particle Physics

Biomedical 'omics



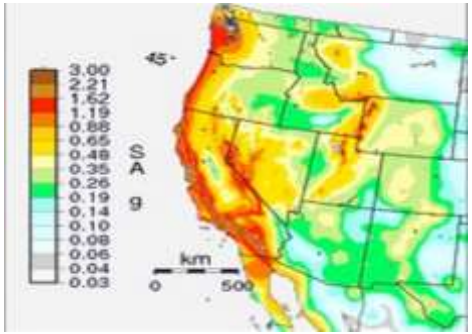
NSF



INTERMEDIATE PALOMAR TRANSIENT FACTORY

Telescope Surveys

Earth Sciences



See Following Panel: Science Drivers for NRP

Visualization, Virtual Reality, Collaboration



CITRIS THE BANATAO INSTITUTE

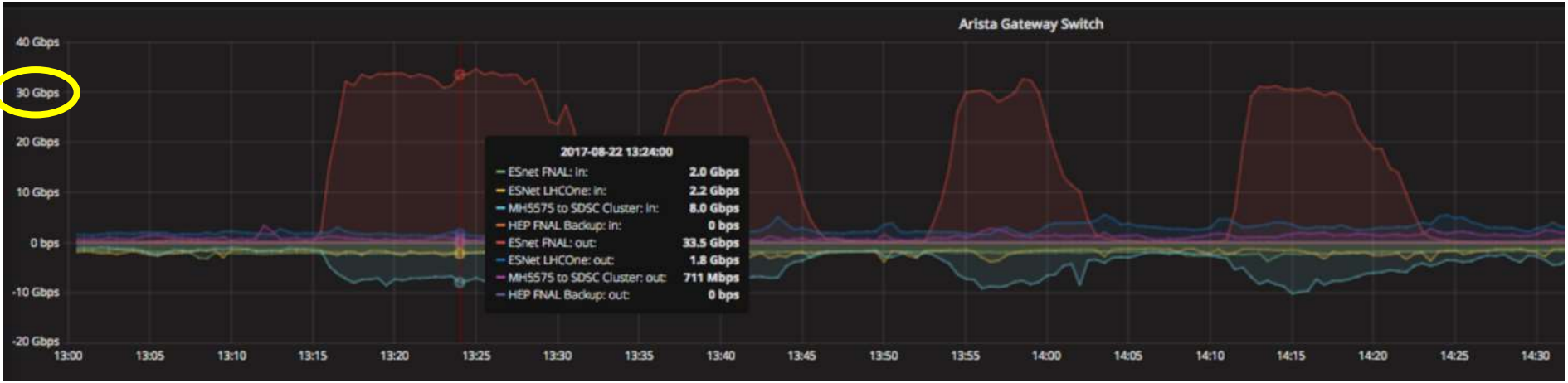
SDSC it²

PRP Science Application Class #1:
Providing High Performance Access to Distributed Data Analysis

PACIFIC RESEARCH PLATFORM

Data Transfer Rates From 40 Gbps DTN in UCSD Physics Building, Across Campus on PRISM DMZ, Then to Chicago's Fermilab Over CENIC/ESnet

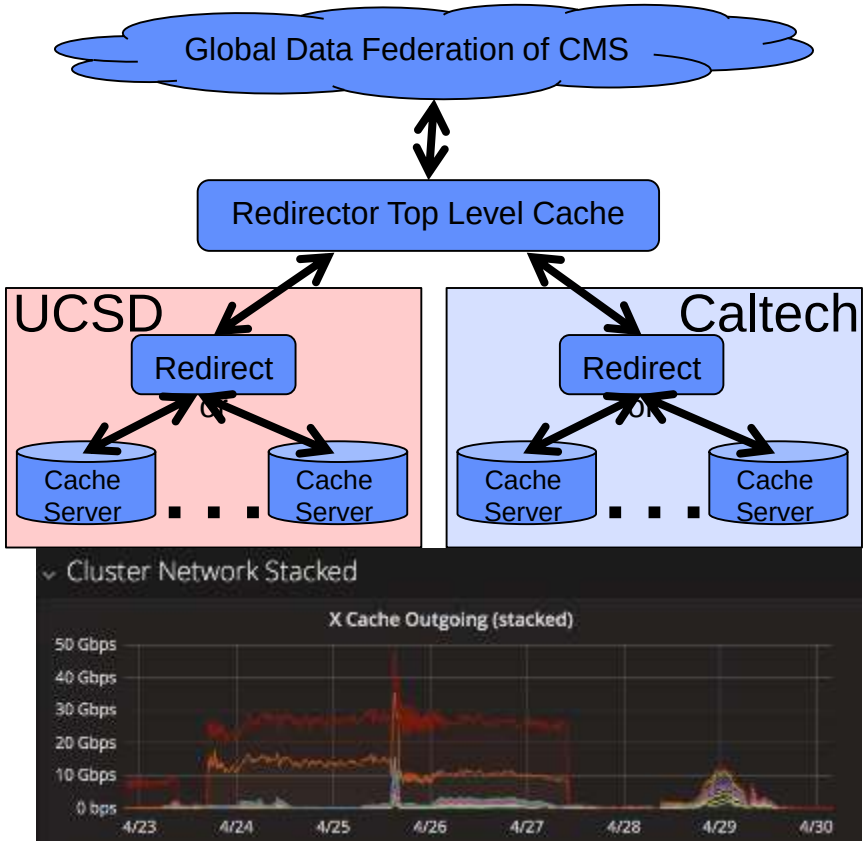
Based on This Success,
Würthwein Will Upgrade 40G DTN to 100G
For Bandwidth Tests & Kubernetes Integration
With OSG, Caltech, and UCSC



Source: Frank Würthwein, OSG, UCSD/SDSC, PRP

PRP PACIFIC RESEARCH PLATFORM NSF CENIC ESnet SDSC CITRIS BANATAO INSTITUTE it²

PRP Distributed Tier-2 Cache
Across Caltech & UCSD-Thousands of Flows Sustaining >10Gbps!



Provisioned pilot systems:

PRP UCSD: 9 x 12 SATA Disk of 2TB
@ 10Gbps for Each System

PRP Caltech: 2 x 30 SATA Disk of 6TB
@ 40Gbps for Each System

Source: Frank Würthwein, OSG, UCSD/SDSC, PRP; Havey Newman, Caltech

Collaboration Opportunity with OSG/PRP/I2 on Distributed Storage



Total data volume pulled last year is dominated by 4 caches.

OSG Is Operating a Distributed Caching CI. At Present, 4 Caches Provide Significant Use

PRP Kubernetes Infrastructure Could Either Grow Existing Caches by Adding Servers, or by Adding Additional Locations

Source: Frank Würthwein, OSG, UCSD/SDSC, PRP

Open Science Grid

INTERNET 2

See Talk on OSG/PRP/I2 Tuesday

StashCache Users include:

LIGO





DES

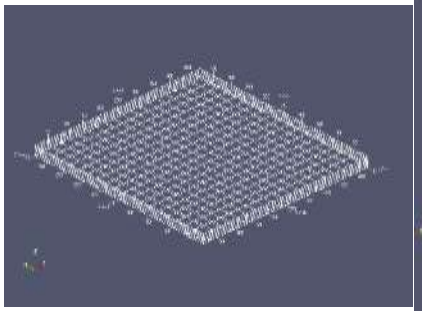
PRP Science Application Class #2:
Providing High Performance Access to Remote Supercomputers

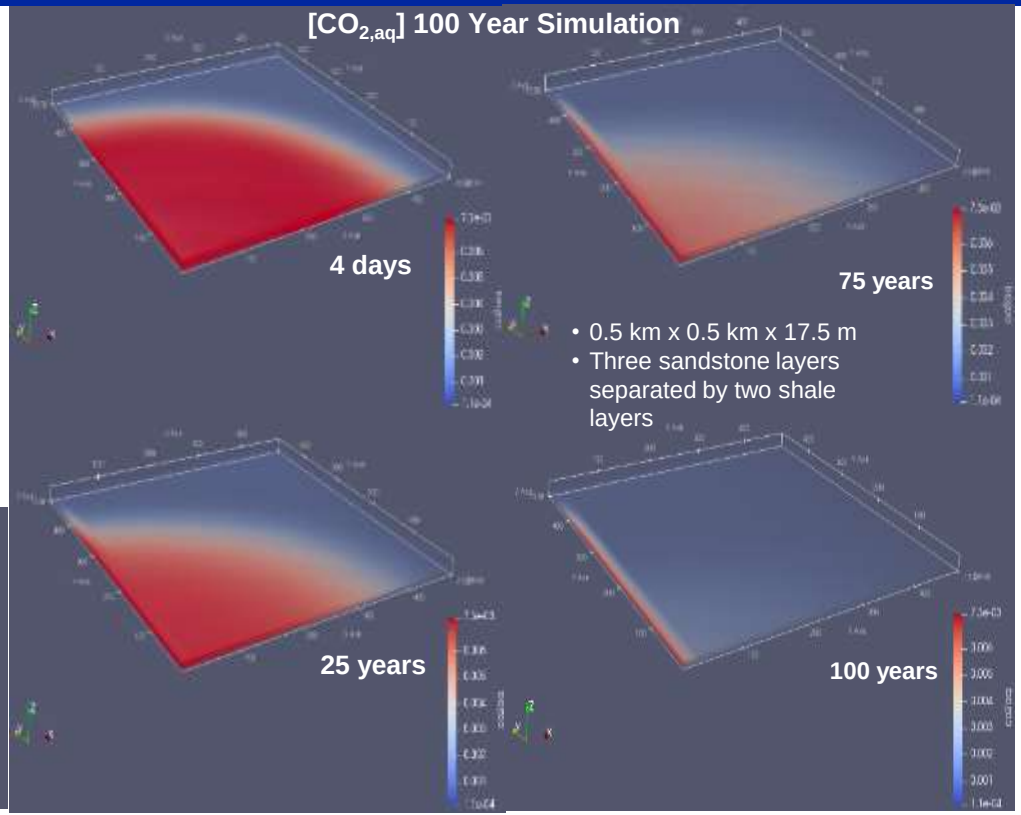
PACIFIC RESEARCH PLATFORM

Distributed Computation on PRP
Coupling SDSU Cluster and SDSC Comet Using Kubernetes Containers

Simulating the Injection of CO_2 in Brine-Saturated Reservoirs: Poroelastic & Pressure-Velocity Fields Solved In Parallel With MPI Using Domain Decomposition Across Containers

See Talk by Chris Paolini Sunday





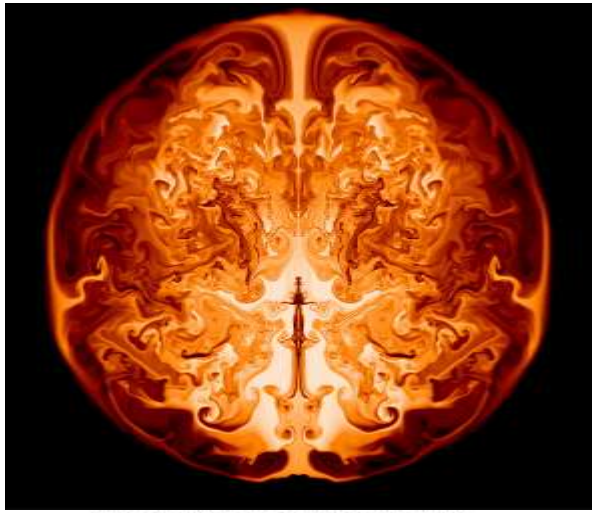
Developed and executed MPI-based PRP Kubernetes Cluster execution

Source: Chris Paolini and Jose Castillo, SDSU

PRP PACIFIC RESEARCH PLATFORM

it²

Speeding Downloads Using 100 Gbps PRP Link Over CENIC Couples UC Santa Cruz Astrophysics Cluster to LBNL NERSC Supercomputer



A 2D superluminous supernova simulation generated with the CASTRO code. (Image: Ken Chen, National Astronomical Observatory of Japan)

K. Chen, S. Woolsey, T. Sukhbold, The Astrophysical Journal, 832, 1, Nov. 2016

NERSC Project PI:
S. Woolsey, UC Santa Cruz

CENIC



NSF-Funded Cyberengineer
Shaw Dong @UCSC
Receiving FIONA
Feb 7, 2017

CENIC 2018 Innovations in Networking Award for Research Applications

PRP PACIFIC RESEARCH PLATFORM

BERKELEY LAB Bringing Science Solutions to the World

NERSC

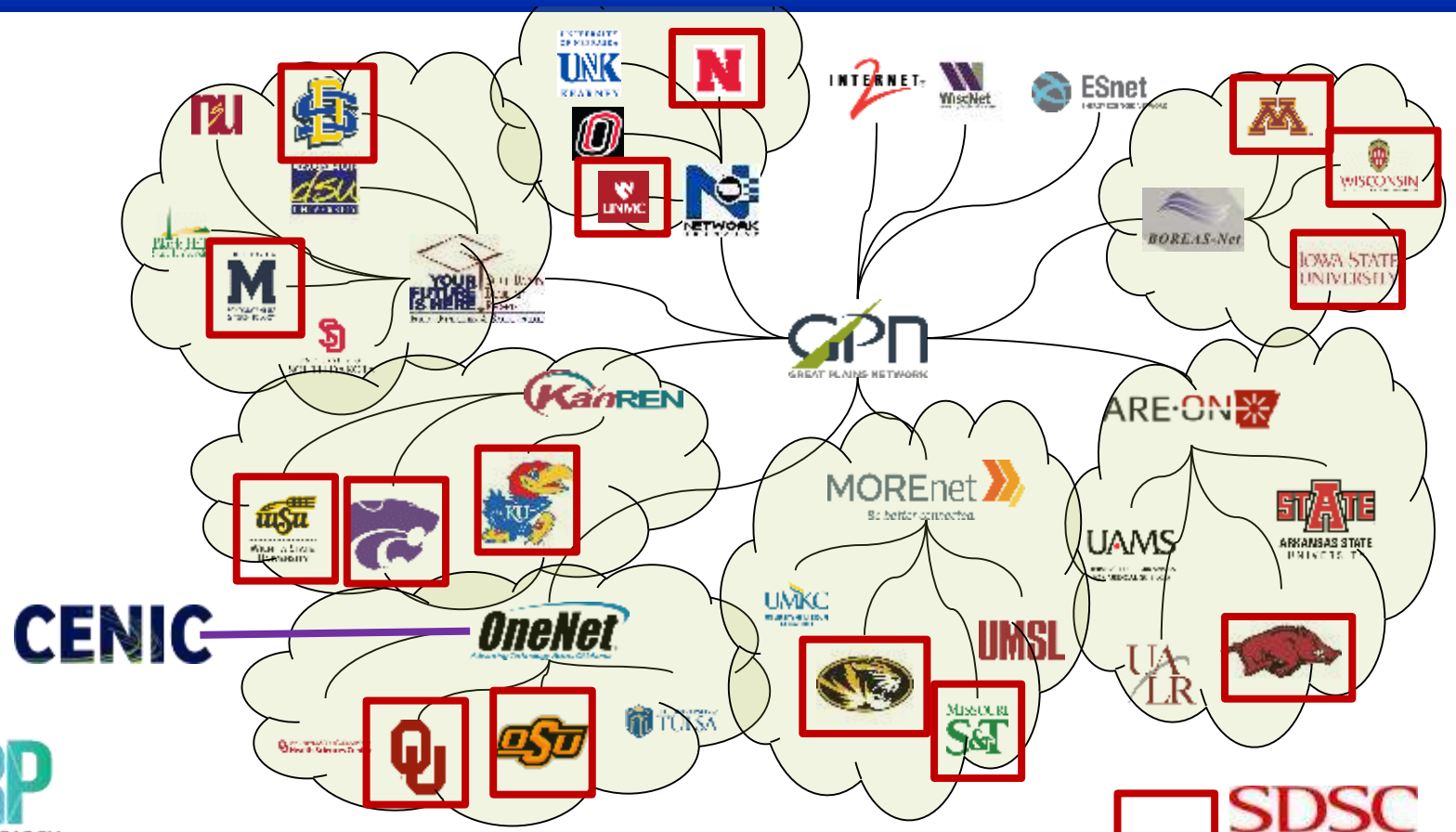
ESnet

SDSC

CITRIS BANATAO INSTITUTE

it²

The Great Plains Network
Has Many Campuses With Active Projects at SDSC



PRP
PACIFIC RESEARCH PLATFORM

GPN Map Source: James Deaton, GPN

SDSC
Shawn Strande, SDSC

it²

PRP Science Application Class #3:
Providing High Perf. Access to SensorNets Coupled to Realtime Computing

PACIFIC RESEARCH PLATFORM

New PRP Application:
Coupling Wireless Wildfire Sensors to Computing

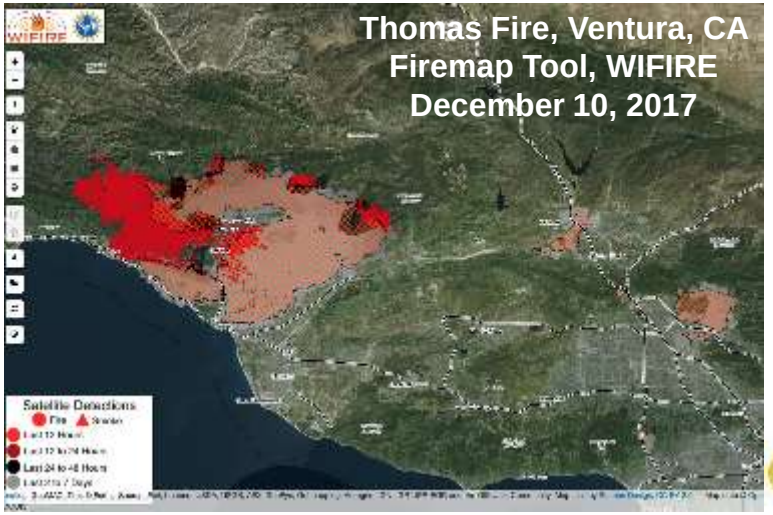
Technology Projects to Combat California Wildfires Are Recognized with CENIC Innovation Award

WIFIRE · HPWREN · Nevada Seismological Laboratory, Mackay School of Earth Sciences & Engineering

See HPWREN Deep Dive #1 Tuesday

CENIC 2018
Innovations in Networking Award for Experimental Applications





PRP PACIFIC RESEARCH PLATFORM

it²

Once a Wildfire is Spotted, PRP Brings High-Resolution Weather Data to Fire Modeling Workflows in WIFIRE



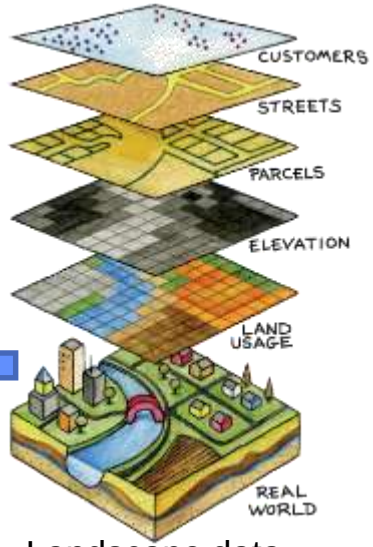
Real-Time Meteorological Sensors



Source: Ilkay Altintas, SDSC

WIFIRE

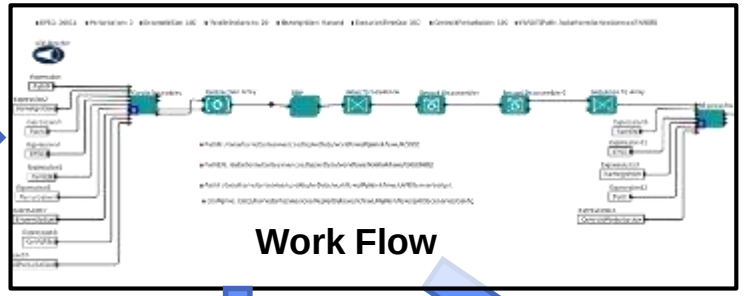




Landscape data

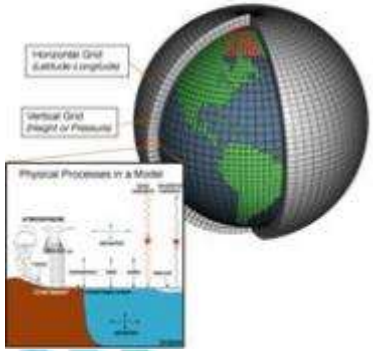
PRP





Work Flow

Weather Forecast





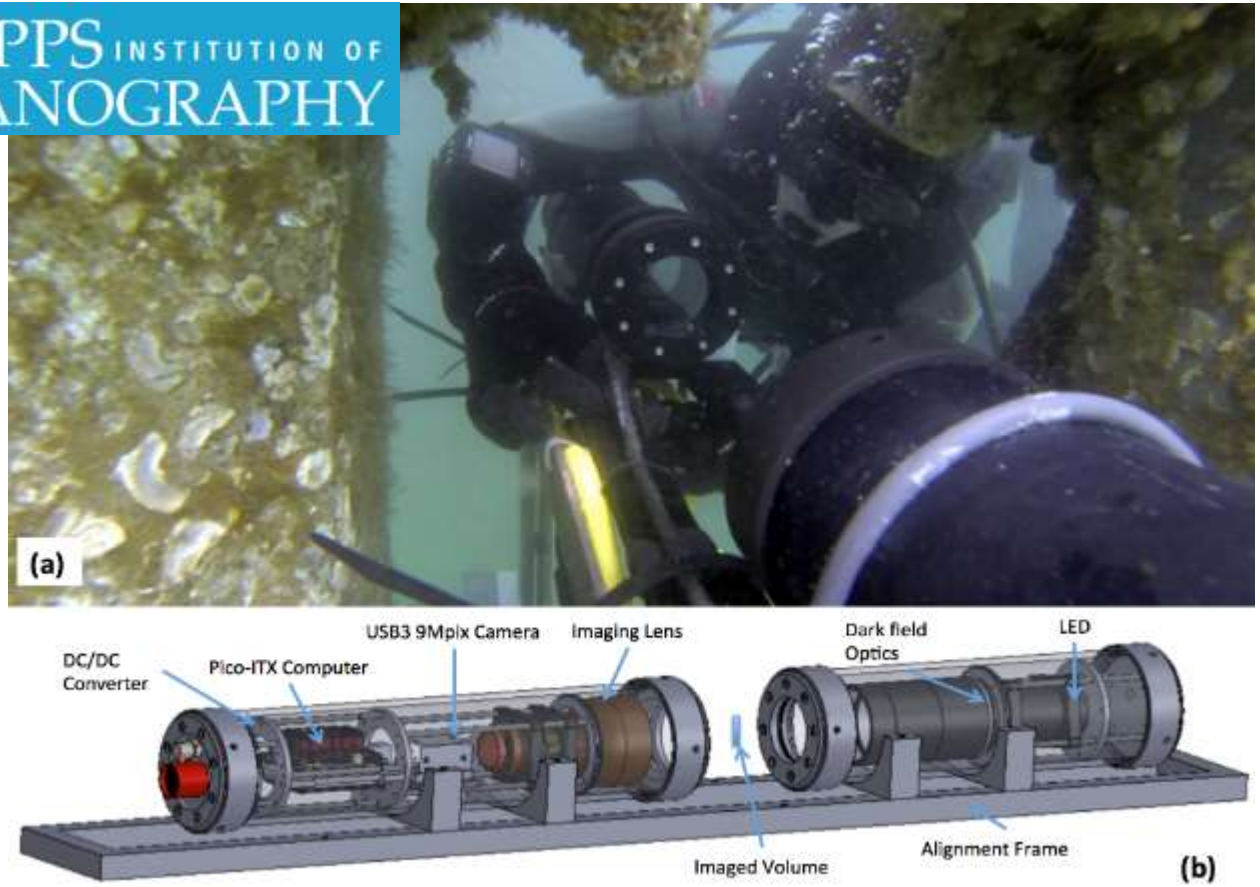




PRP
PACIFIC RESEARCH PLATFORM

Fiber Optic Network Streams Images From UC San Diego Jaffe Lab (SIO) Scripps Plankton Microscope Camera

SCRIPPS INSTITUTION OF OCEANOGRAPHY

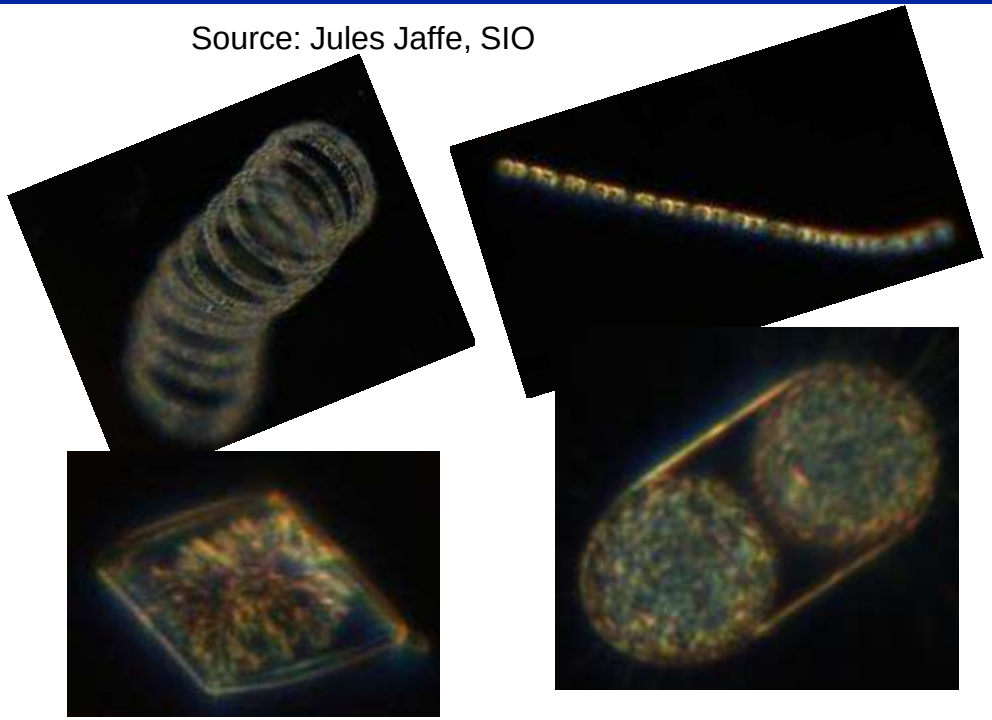


PRP PACIFIC RESEARCH PLATFORM

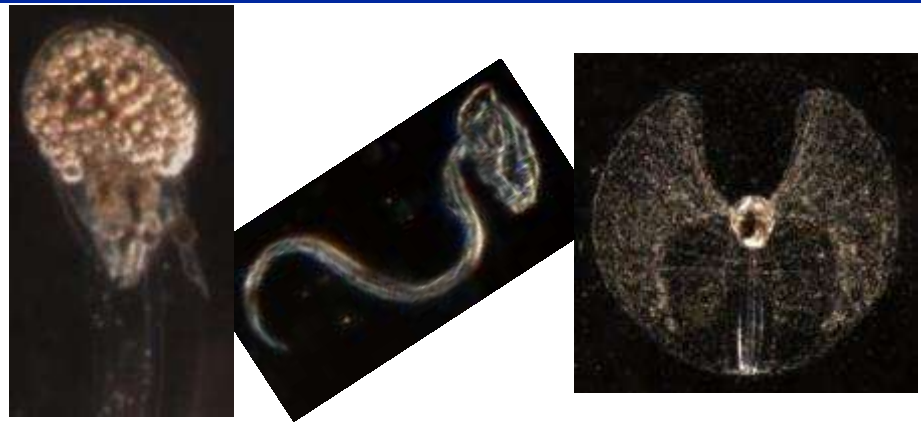
it²

Over 1 Billion Images So Far!
Requires Machine Learning for Automated Image Analysis and Classification

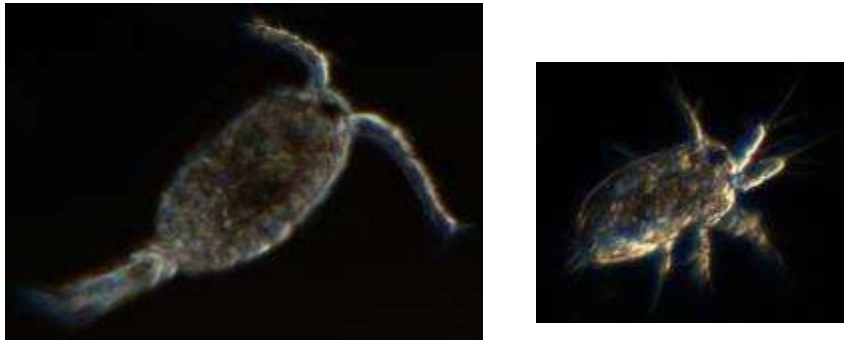
Source: Jules Jaffe, SIO



Phytoplankton: Diatoms



Zooplankton: Larvaceans



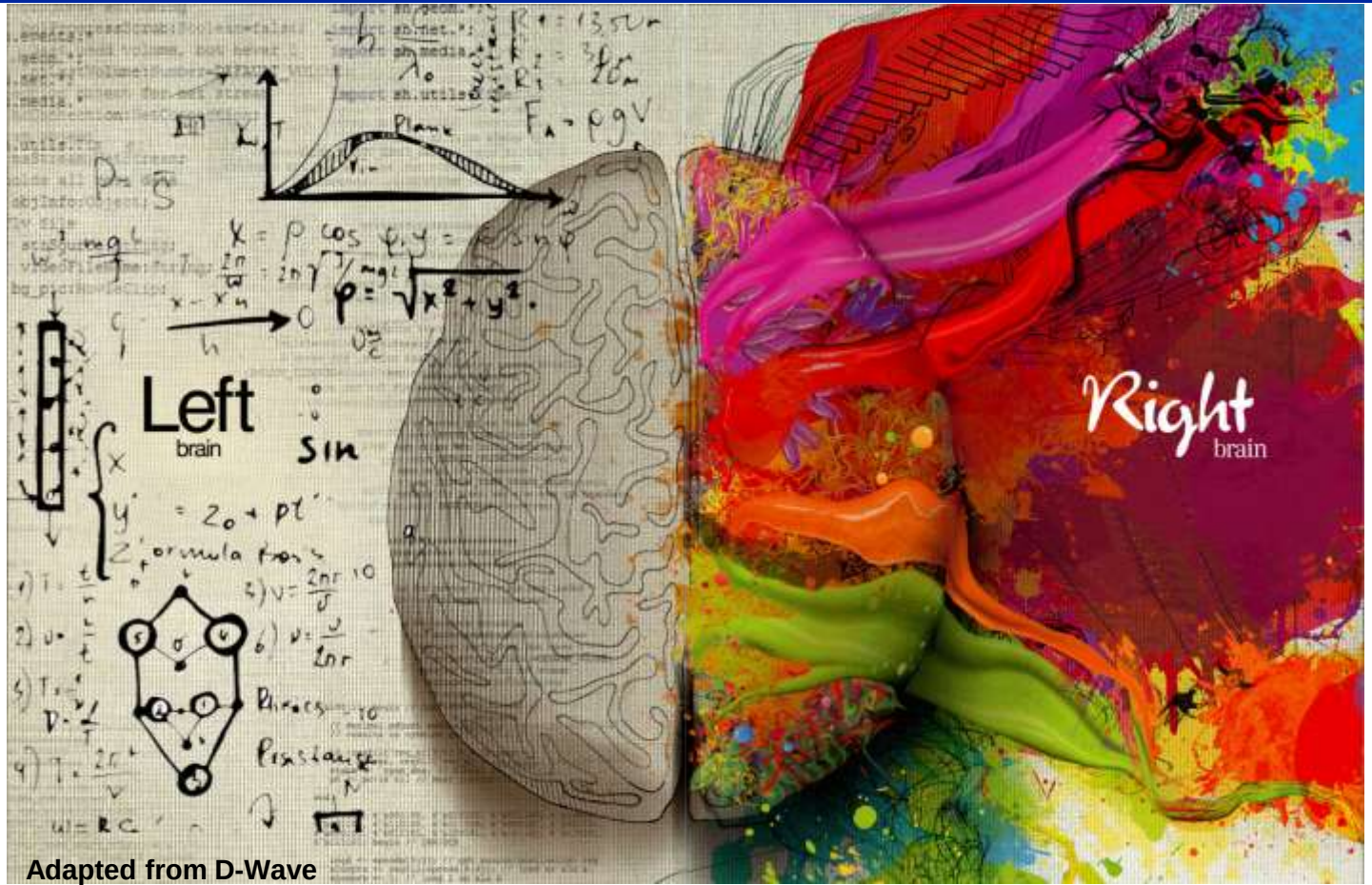
Zooplankton: Copepods

PACIFIC RESEARCH PLATFORM

”We are using the FIONAs for image processing... this includes doing Particle Tracking Velocimetry that is very computationally intense.”-Jules Jaffe

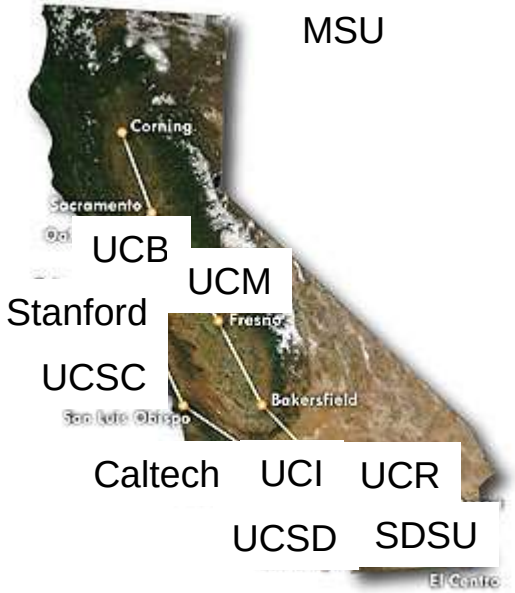
it²

Adding Machine Learning to PRP:
Left & Right Brain Computing: Arithmetic vs. Pattern Recognition



Adapted from D-Wave

New NSF CHASE-CI Grant Creates a Community Cyberinfrastructure: Adding a Machine Learning Layer Built on Top of the Pacific Research Platform



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 ML Faculty & Their Students at 10 Campuses
for Training AI Algorithms on Big Data

See Venkat Vishwanath, Deep Dive #4 Tuesday

PRP PACIFIC RESEARCH PLATFORM

JACOBS SCHOOL OF ENGINEERING
SDSC UC San Diego it²

FIONA8: Adding GPUs to FIONAs
Supports Data Science Machine Learning



Multi-Tenant Containerized GPU JupyterHub
Running Kubernetes / CoreOS
Eight Nvidia GTX-1080 Ti GPUs

~$13K

32GB RAM, 3TB SSD, 40G & Dual 10G ports

Source: John Graham, Calit2

PACIFIC RESEARCH PLATFORM

UCSD Adding >350 Game GPUs to Data Sciences Cyberinfrastructure - Devoted to Data Analytics and Machine Learning

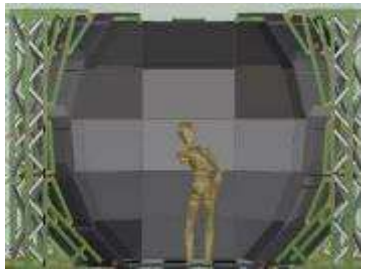
UC San Diego

IT SERVICES

95 GPUs
for Students

Open Science Grid

48 GPUs for
OSG Applications



SunCAVE 70 GPUs
WAVE + Vroom 48 GPUs

UCSD Cognitive Science

JACOBS SCHOOL OF ENGINEERING

SDSC it²



Plus 288 64-bit GPUs
On SDSC's Comet

QUALCOMM INSTITUTE



FIONA with
8-Game GPUs

CHASE-CI Grant Provides
96 GPUs at UCSD
for Training AI Algorithms on Big Data

PRP
PACIFIC RESEARCH PLATFORM

it²

Next Step: Using Kubernetes to Surround the PRP Machine Learning Platform With Clouds of CPUs, GPUs and Non-Von Neumann Processors

IBM



64-TrueNorth Cluster

IBM Cloud

IBM Watson

PATTERN COMPUTER.

See Talks by NSF Clouds, Google, Amazon

Google's First Machine Learning Chip (TPU) Is 30x Faster Than CPUs And GPUs

64-bit GPUs

XSEDE

Extreme Science and Engineering Discovery Environment

NSF





MSU



CHASE-CI

PRP PACIFIC RESEARCH PLATFORM

NSF

CloudLab

Chameleon

BUILDING AN AI CHIP SAVED GOOGLE FROM BUILDING A DOZEN NEW DATA CENTERS

WIRED



Google

Microsoft Installs Altera FPGAs into Bing Servers & 384 into TACC for Academic Access

Project Catapult

Established: February 2, 2015

Microsoft

TACC

SEP 30, 2016 @ 07:39 PM 3,606

Marco Chiappetta,

Forbes / Tech

Amazon Boosts Cloud-Computing Performance With New, GPU-Accelerated AWS Instances

amazon web services

Japan plans to build the fastest deep learning supercomputer

AIST ADVANCED INDUSTRIAL SCIENCE AND TECHNOLOGY (AIST)

4352x NVIDIA Tesla V100 GPUs

it²

Calit2 Has Established Labs On Both UC San Diego and UC Irvine Campuses For Exploring Machine Learning on von Neumann and NvN Processors



Ken Kreutz Delgado, Director

Data ThinkTank @ CALIT2

UCI University of California, Irvine

Charless Fowlkes, Director

PRP PACIFIC RESEARCH PLATFORM

it²

Our Support:

- US National Science Foundation (NSF) awards
  - CNS 0821155, CNS-1338192, CNS-1456638, CNS-1730158, ACI-1540112, & ACI-1541349



- University of California Office of the President CIO
- UCSD Chancellor's Integrated Digital Infrastructure Program
- UCSD Next Generation Networking initiative
- Calit2 and Calit2 Qualcomm Institute
- CENIC, PacificWave and StarLight
- DOE ESnet

PRP
PACIFIC RESEARCH PLATFORM

it²