“Integrated Optical Fiber/Wireless Systems for Environmental Monitoring”

Invited Keynote
UC San Diego Jacobs School of Engineering
Dean’s Council of Advisors Meeting
UC San Diego
May 12, 2022

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

PACIFIC RESEARCH PLATFORM

2002-2009: The NSF OptIPuter ITR Grant- Can We Make Wide-Area Bandwidth Equal to Cluster Backplane Speeds?

The OptIPuter Exploits a New World in Which the Central Architectural Element is Optical Networking, Not Computers, to Support Data-Intensive Scientific Research and Collaboration

NSF ITR Grant
$13.5M
PI Smarr,
Co-PIs DeFanti, Papadopoulos, Ellisman

A 10Gbps "End-to-End" Global-Scale Research Lightpath Cloud


End User OptIPortal


Instruments




HD/4k Video Cams


Campus Optical Switch

10G Lightpath



HPC

TeraGrid


Data Repositories & Clusters


HD/4k Video Streaming

evl

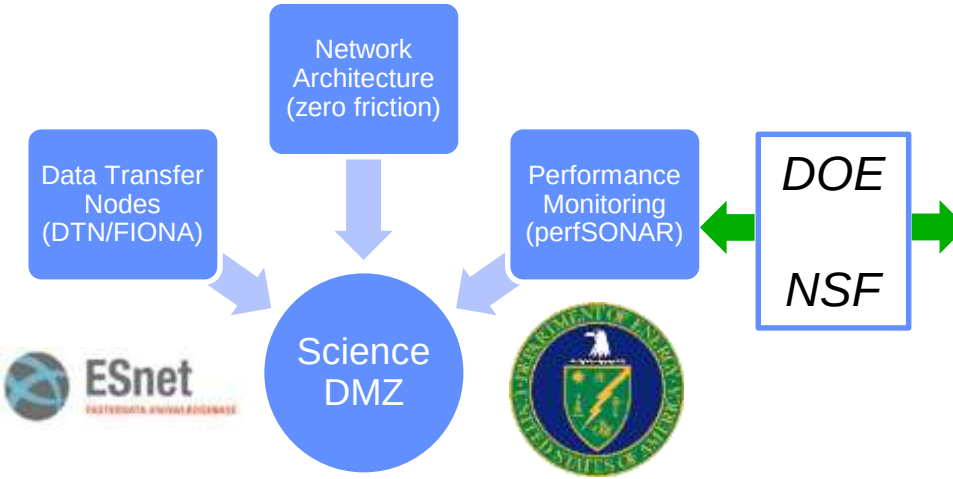
SDSC

it2

PACIFIC RESEARCH PLATFORM

2010-2020:
NSF Adopts the DOE Campus Networking Model For Data-Intensive Research

Science DMZ Coined in 2010 by ESnet



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

Slide Adapted From Inder Monga, ESnet

NSF Campus Cyberinfrastructure Program 2012-2020

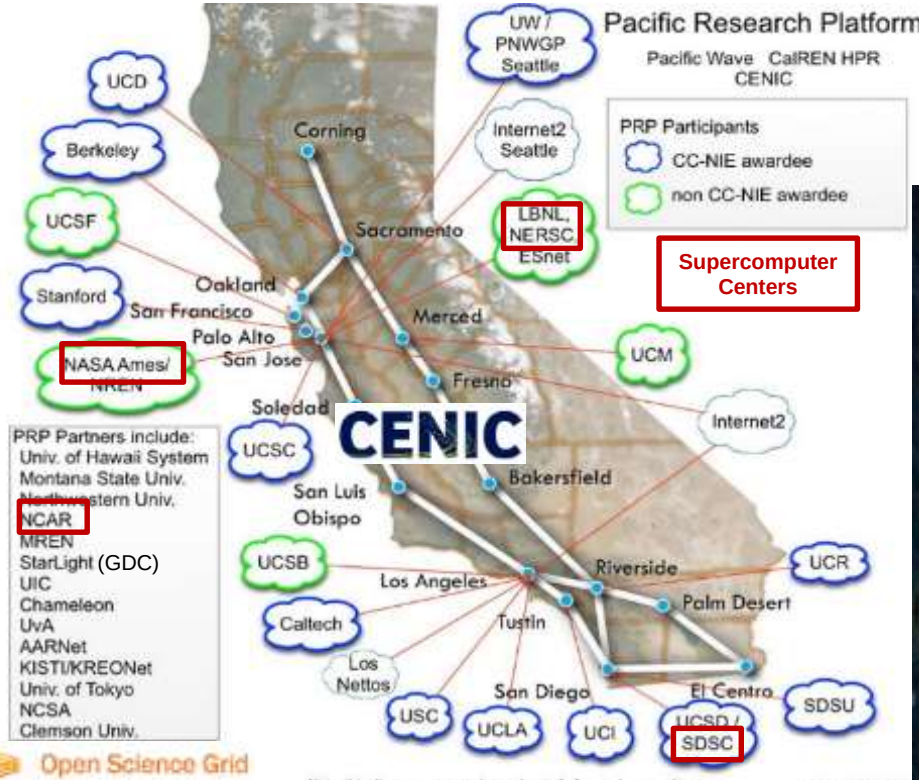


Has Made Over 340 Awards:
Across 50 States and Territories

Slide Adapted From Kevin Thompson, NSF

PACIFIC RESEARCH PLATFORM

2015 Vision: The Pacific Research Platform Will Connect Science DMZs Creating a Regional End-to-End Science-Driven Community Cyberinfrastructure



NSF CC*DNI Grant
$6.3M 10/2015-10/2020
In Year 7 Now



PRP PACIFIC RESEARCH PLATFORM

https://pacificresearchplatform.org/

CITRIS BANATAO INSTITUTE

SDSC

it²

2015-2021: UCSD Designs PRP Data Transfer Nodes (DTNs) -- Flash I/O Network Appliances (FIONAs)

FIONAs Solved the Disk-to-Disk Data Transfer Problem at Near Full Speed on Best-Effort 10G, 40G and 100G

FIONA

(Flash Input/Output Network Appliance) FIONAs are rack-mounted PCs designed by our PRP team. They are Science DMZ Data Transfer Nodes (DTNs), optimized for 10-100Gbps data transfers and large data storage, and are also capable of holding up to eight GPUs or FPGA add-in boards or up to 256TB of disk each.

Software Specifications

Installation Instructions

Hardware Specifications

2021 – 2020 – 2019 – 2018 – 2017 – 2016 – 2015

www.pacificresearchplatform.org



Add Up to 8 Nvidia GPUs Per 2U FIONA
To Add Machine Learning Capability

Up to 192 TB Rotating Storage

PRP PACIFIC RESEARCH PLATFORM

NSF

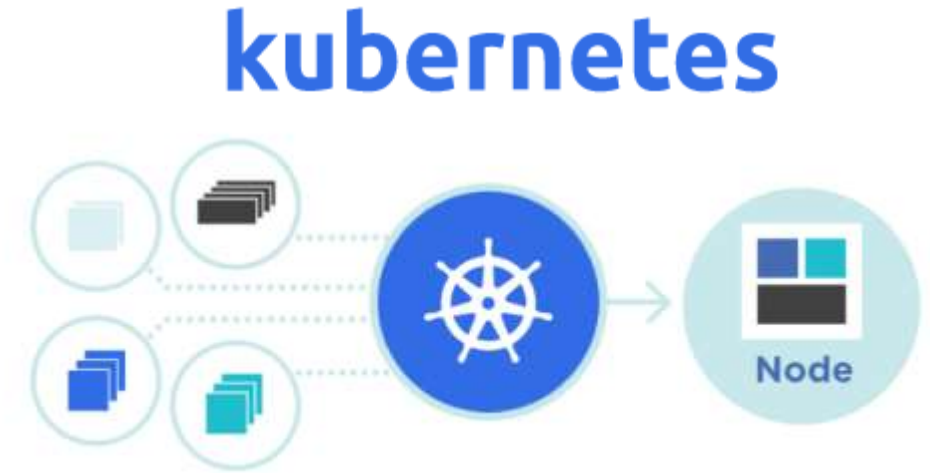
FIONAs Designed by UCSD's Phil Papadopoulos, John Graham, Joe Keefe, and Tom DeFanti

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20 YEARS QUALCOMM INSTITUTE

2018/2019: PRP Game Changer!
Using Google's Kubernetes to Orchestrate Containers Across the PRP

User Applications



Containers

PRP PACIFIC RESEARCH PLATFORM

Clouds

PRP PACIFIC RESEARCH PLATFORM

CLOUD NATIVE COMPUTING FOUNDATION

PRP's Nautilus Hypercluster Adopted Kubernetes to Orchestrate Software Containers and Manage Distributed Storage

Nautilus

kubernetes

Kubernetes (K8s) is an open-source system for automating deployment, scaling, and management of containerized applications.



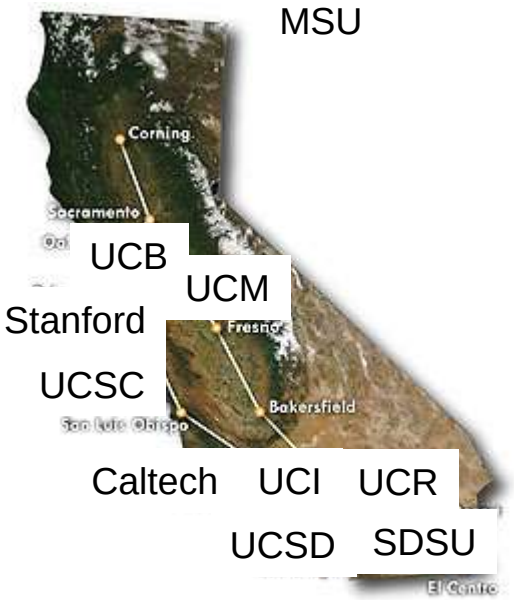
Planet Scale

Designed on the same principles that allows Google to run billions of containers a week, Kubernetes can scale without increasing your ops team.

"Kubernetes with Rook/Ceph Allows Us to Manage Petabytes of Distributed Storage and GPUs for Data Science, While We Measure and Monitor Network Use."
--John Graham, Calit2/QI UC San Diego

PRP
PACIFIC RESEARCH PLATFORM

2017-2020: NSF CHASE-CI Grant Adds a Machine Learning Layer Built on Top of the Pacific Research Platform



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

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
Co-PIs:

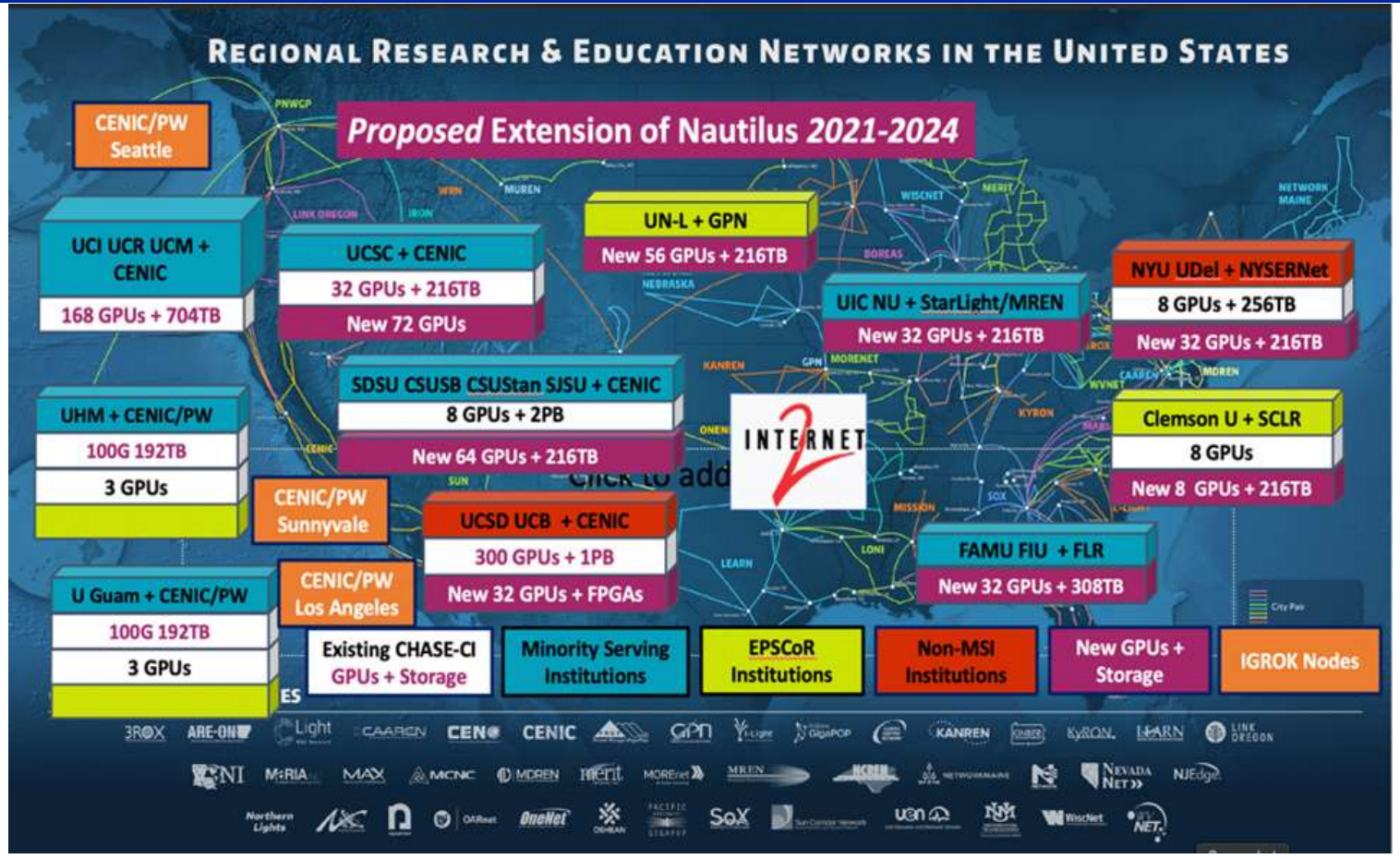
- Tajana Rosing
- Ken Kreutz-Delgado
- Ilkay Altintas
- Tom DeFanti

JACOBS SCHOOL OF ENGINEERING

SDSC UC San Diego

PRP
PACIFIC RESEARCH PLATFORM

2021-2024: Two CHASE-CI Follow-On Awards Will Spread GPUs and Storage Across the USA

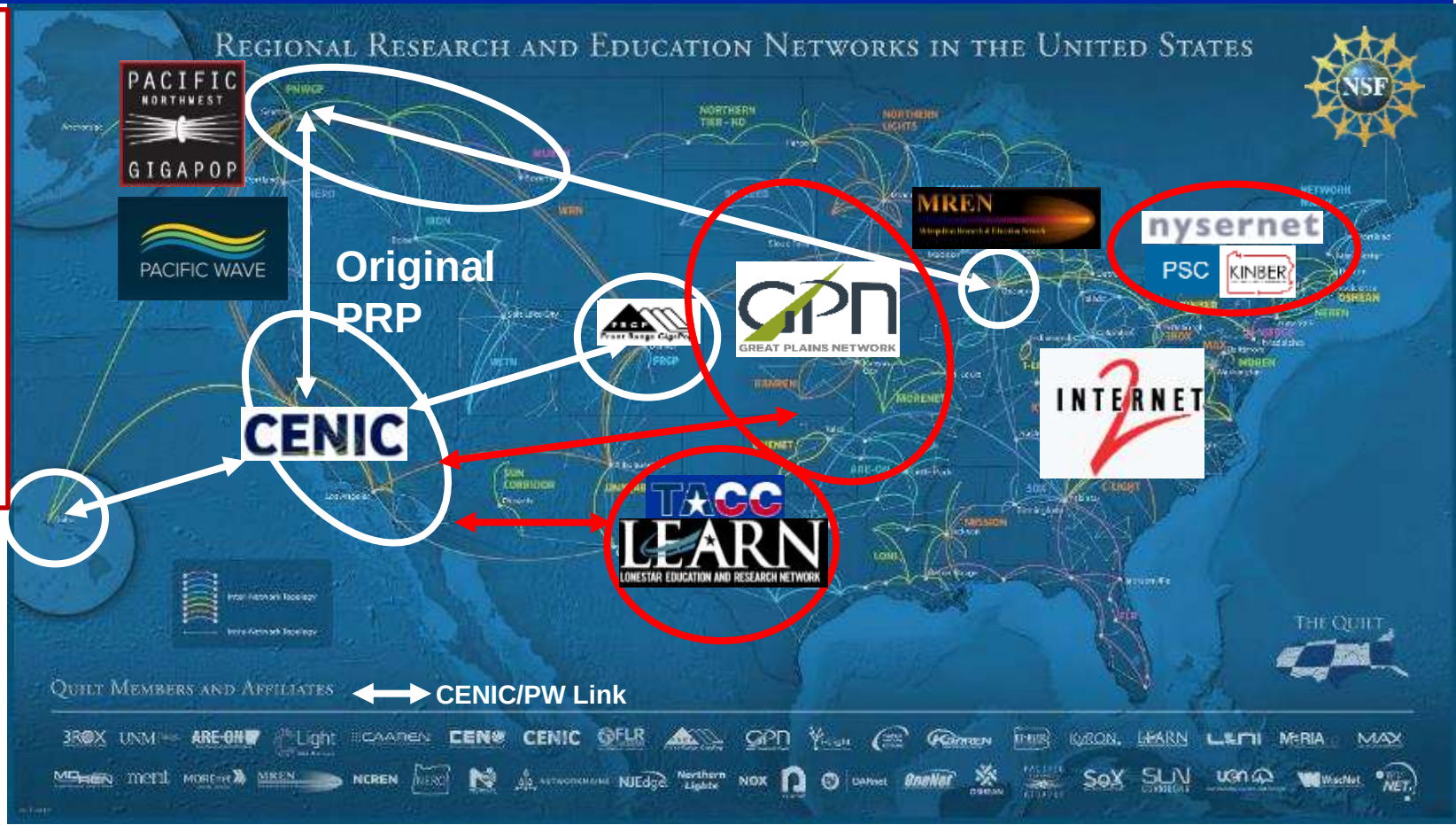


PACIFIC RESEARCH PLATFORM

2018-2021: Toward the National Research Platform (TNRP) - Using CENIC & Internet2 to Connect Regional Optical Fiber R&E Networks

"Towards The NRP"
3-Year Grant Funded by NSF
$2.5M
October 2018
Award #1826967

PI Smarr
Co-PIs Altintas, Papadopoulos, Wuerthwein, Rosing



PACIFIC RESEARCH PLATFORM

PRP's Nautilus is a Multi-Institution Hypercluster Connected by Optical Networks

Nautilus

~200 FIONAs on 25 Partner Campuses Networked Together at 10-100Gbps

Installed CPUs	Installed GPUs	Rotating Storage
7870	549	4000 TB

PRP PACIFIC RESEARCH PLATFORM

CENIC

THE QUILT

INTERNET2

20 YEARS QUALCOMM INSTITUTE

The New Pacific Research Platform Video Highlights 3 Different Applications Out of 600 Nautilus Namespace Projects

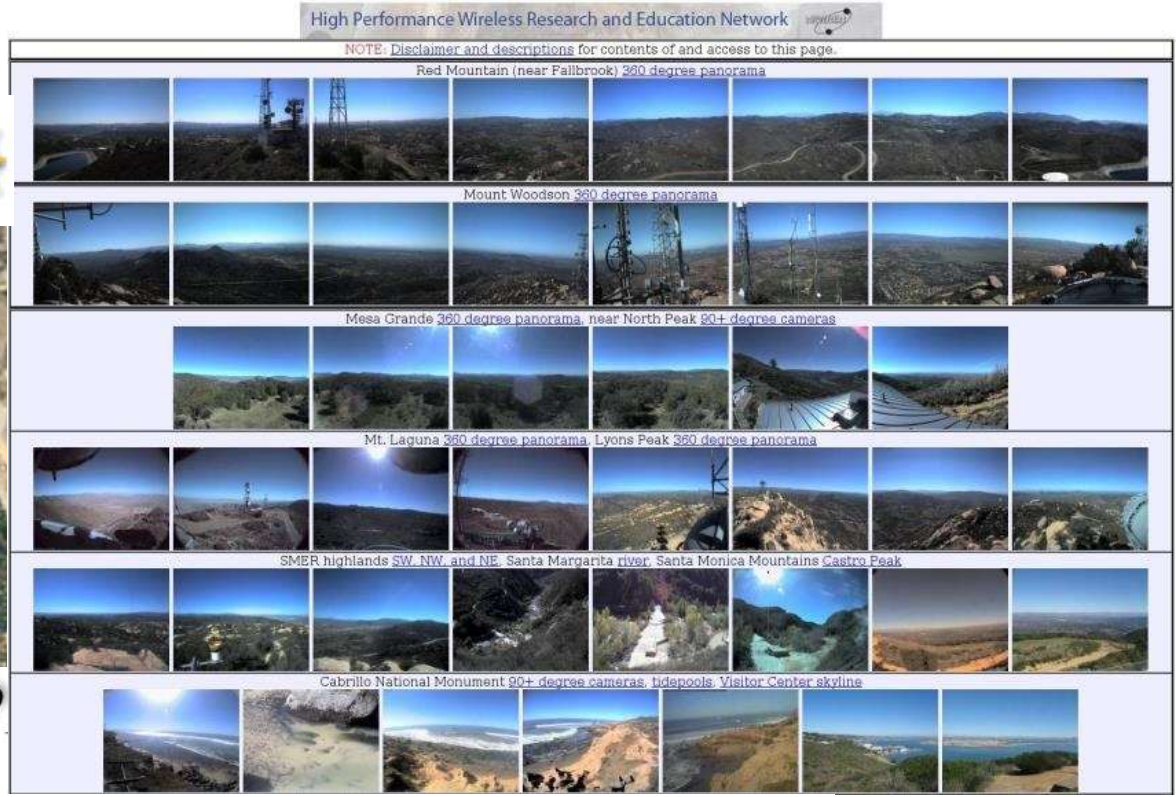


Pacific Research Platform Video:
https://pacificresearchplatform.org/media/pacific-research-platform-video/

2000-2012: HPWREN: NSF-Funded High-Bandwidth Wireless Network Cameras and Meteorological Sensors on Top of San Diego Mountains for Environmental Observations

Source: Hans Werner Braun, High Performance Wireless Research and Education Network (HPWREN) PI





PRP PACIFIC RESEARCH PLATFORM

UC San Diego

SDSC SAN DIEGO SUPERCOMPUTER CENTER

SCRIPPS INSTITUTION OF OCEANOGRAPHY

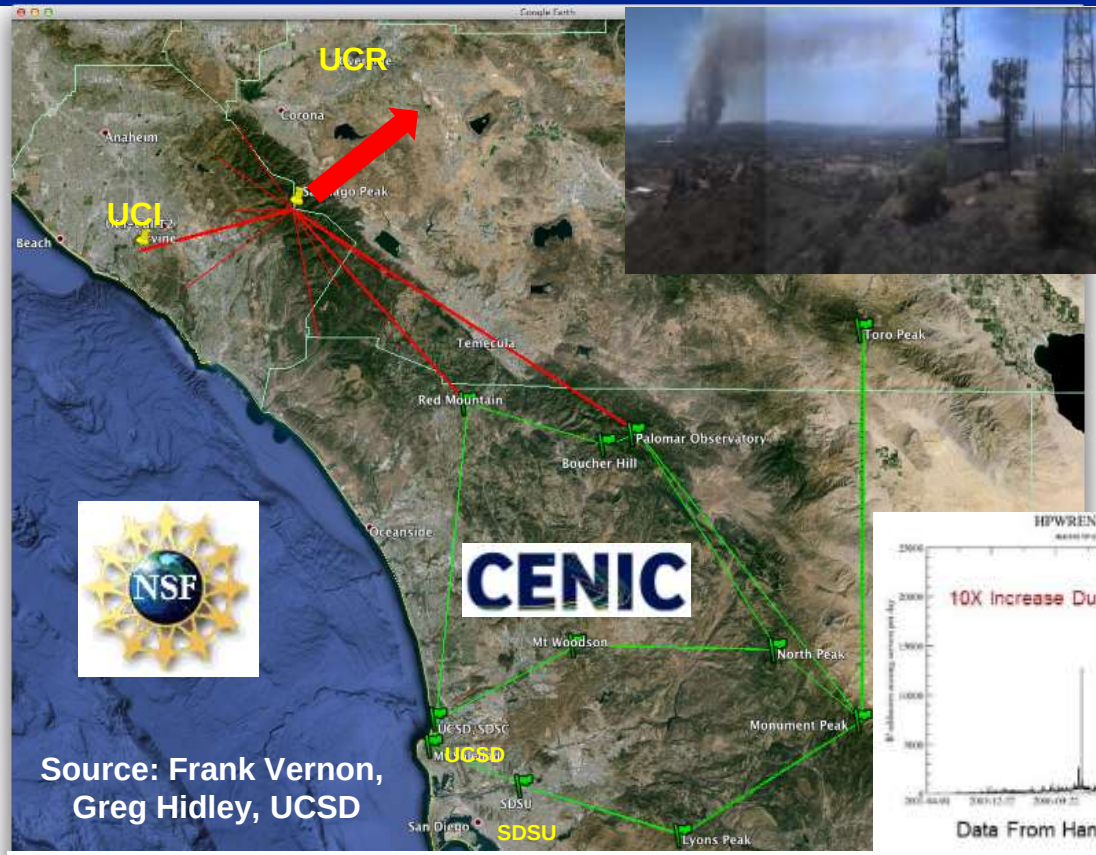
SAN DIEGO STATE UNIVERSITY

2016-2022: PRP Upgrades HPWREN Data Servers, Connects Them With CENIC/PRP Optical Fiber Backbone

- **CENIC/PRP Connects UCSD and SDSU**
  - Data Redundancy
  - Disaster Recovery
  - High Availability
- **CENIC Extension to UCI & UCR**
  - Data Replication Sites



UCI Antenna Dedicated
June 27, 2017
Vint Cerf, Louis Fox, Ramesh Rao
Frank Vernon, Larry Smarr



PRP PACIFIC RESEARCH PLATFORM

UC San Diego · SDSC San Diego Supercomputer Center · Scripps Institution of Oceanography · Calit2 · San Diego State University

PRP, HPWREN, and WIFIRE are Partnering With NSF-Funded SAGE to Create Smart Cameras for Early Wildfire Detection



A Software-Defined National Cyberinfrastructure for Distributed Sensing: Moving Artificial Intelligence to the Edge

Pete Beckman, Eugene Kelly, Charlie Catlett, Ilkay Altintas, Scott Collis, Nicola Ferrier, Raj Sankaran, Jim Olds, Valerie Taylor, Dan Reed, Frank Vernon, Joe Swantek, Mike Papka, Bill Miller, Aaron Packman, Irene Qualters, and many more…

NSF · Northwestern University · The University of Chicago · Northern Illinois University · Argonne National Laboratory · Colorado State University · UC San Diego · George Mason University · DPI Discovery Partners Institute · Array of Things · ARM · neon National Ecological Observatory Network · HPWREN · SDSC San Diego Supercomputer Center · Lincoln Park Zoo For Wildlife. For All. · OHAZ

PRP Pacific Research Platform

Source: Charlie Catlett, Pete Beckman, Argonne National Lab

Using NSF-Funded SAGE Technology to Bring ML/AI to the Edge For Smoke Plume Detection



Using Deep Learning Models
to Extract Spatio-temporal Information
from Stored Camera Imagery
and Deploy on the Edge
to Detect Smoke Plumes In Real Time



Building atop standard community software:

TensorFlow · TensorRT · PYTORCH · TensorFlow Lite · OpenCV · docker · NVIDIA CUDA · K3S · ROS

HPWREN · ALERTWildfire · SDSC · NSF · Sage · Nautilus · PRP PACIFIC RESEARCH PLATFORM

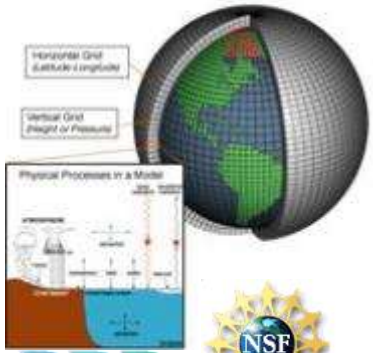
Source: Charlie Catlett, Pete Beckman, Argonne National Lab

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



Real-Time Meteorological Sensors

Weather Forecast



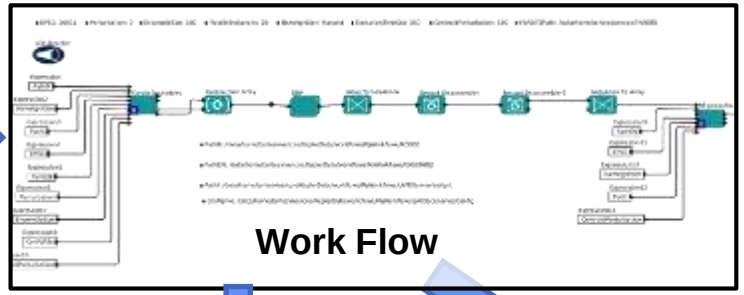
PRP

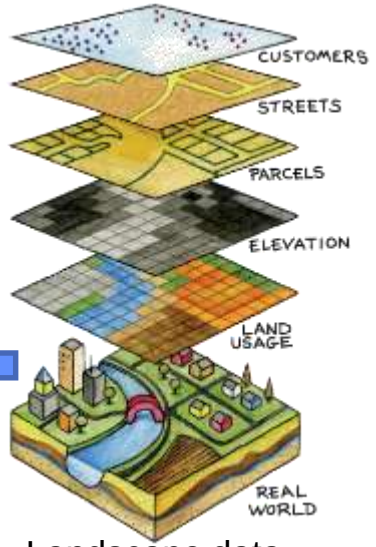




Source: Ilkay Altintas, SDSC







Landscape data



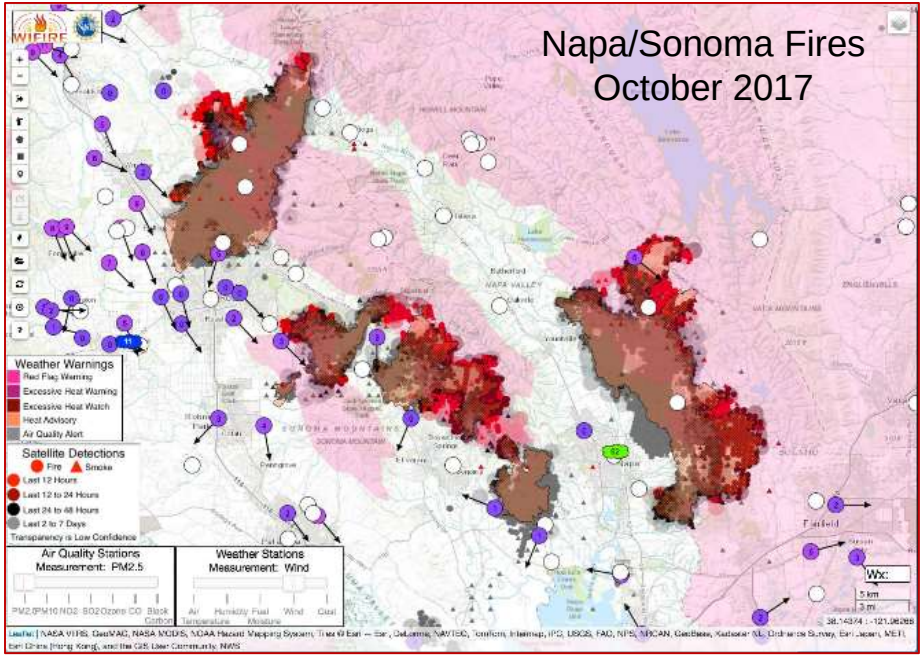




PACIFIC RESEARCH PLATFORM

WIFIRE's Firemap Was Heavily Used by Public For California Wildfires October 2017 through December 2017

800K+ unique visitors and 8M+ hits





PACIFIC RESEARCH PLATFORM

http://firemap.sdsc.edu

WIFIRE NSF

Ilkay Altintas, SDSC WIFIRE PI

Can We Extend the Open Source Kubernetes PRP/NRP to Include Open Interface Wireless Systems?

EURECOM
Sophia Antipolis

5G Direct Access:
Real-time implementation on
OpenAirInterface (OAI)

Fraunhofer IIS

OPEN AIR INTERFACE

O-RAN ALLIANCE

kubernetes

CLOUD NATIVE COMPUTING FOUNDATION

PRP
PACIFIC RESEARCH PLATFORM

XCOM 5G Open RAN System





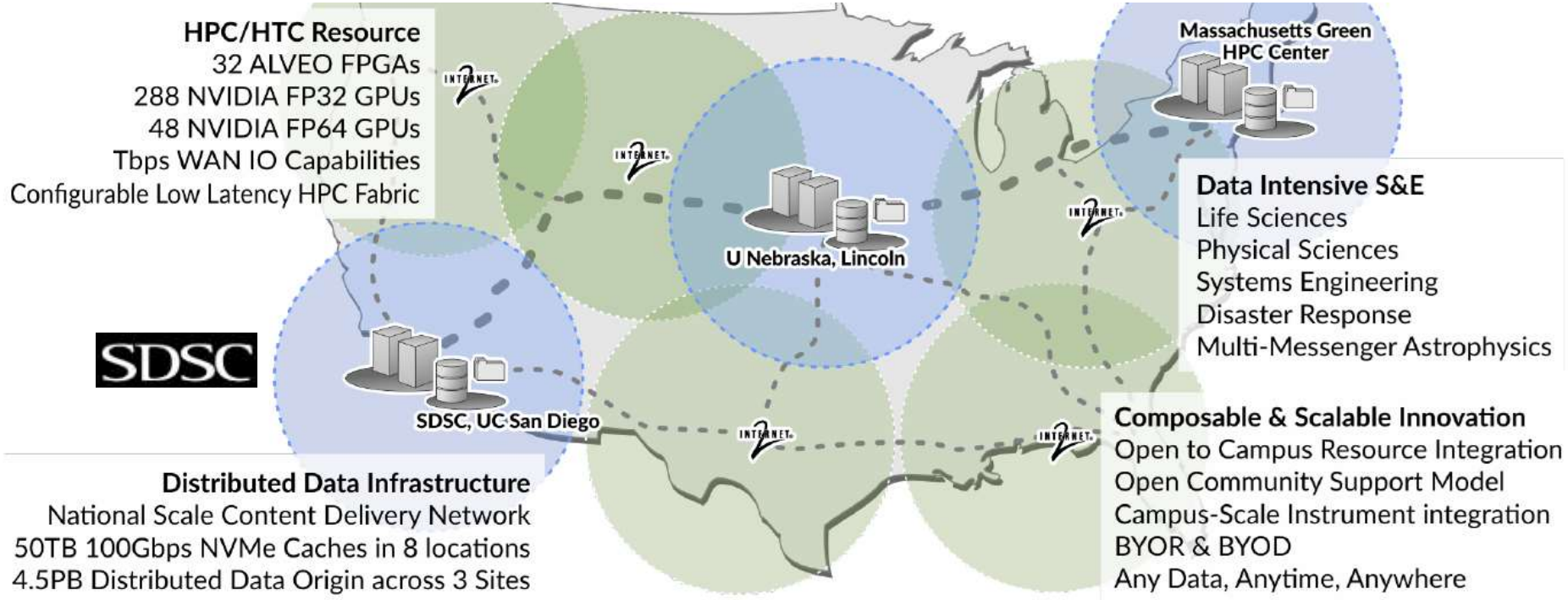


Plus Many Other Companies…

As future wireless technologies move towards terahertz frequency, we see much higher capacity, but lesser coverage, which leads network densification with fronthaul and backhaul, that requires fiber based links connect radio units (Physical layer) to distributed units (MAC/R:C and baseband layers) to centra units (where PDCP/IP routing combined with AI/ML algorithms run for data analytics). Network Densification and Network Disaggregation is going to drive interesting architecture for coupling optical fiber platforms into future wireless.

PACIFIC RESEARCH PLATFORM

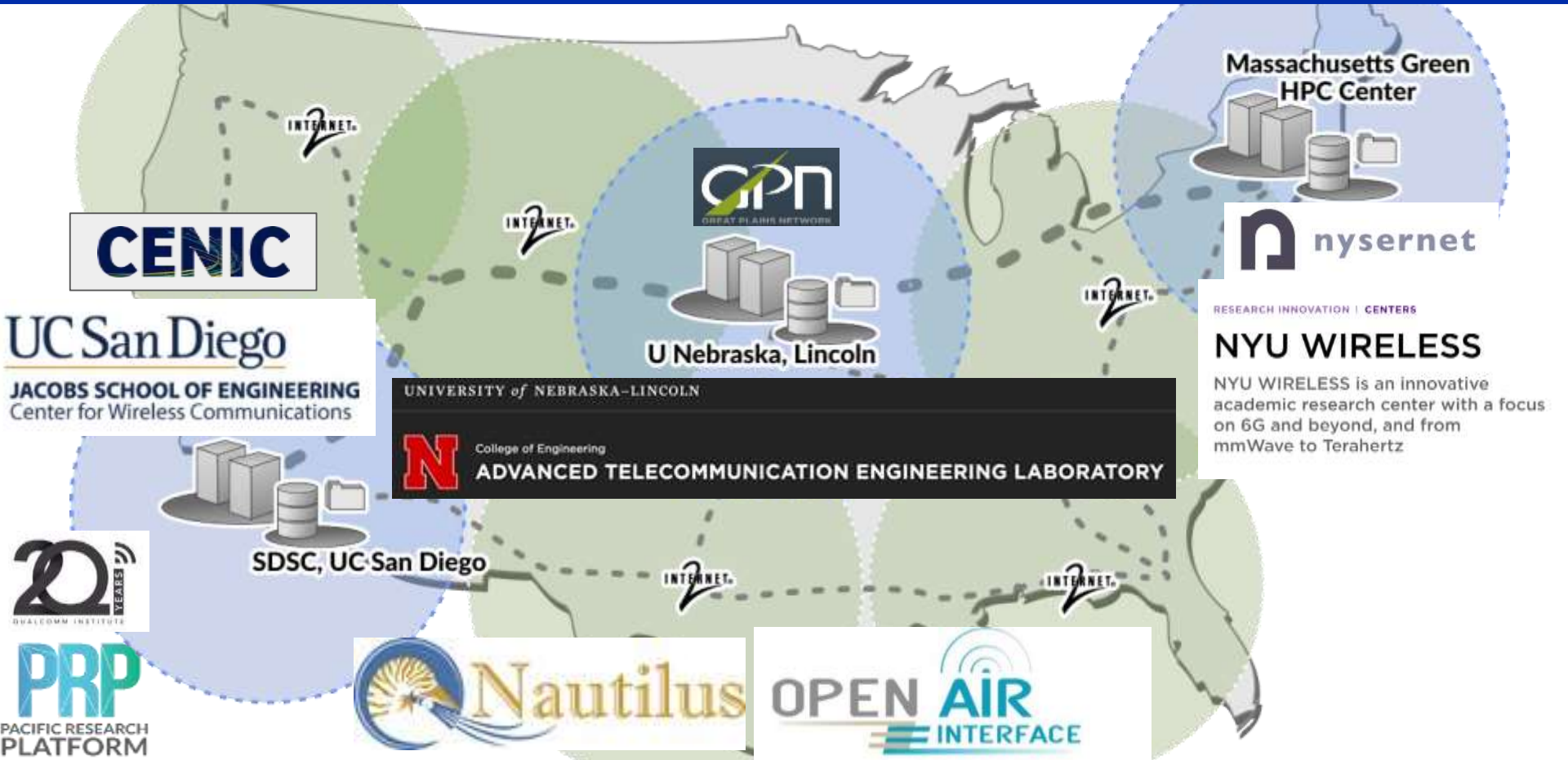
2021-2026 NRP Future: PRP Federates with NSF-Funded *Prototype National Research Platform*



PRP PACIFIC RESEARCH PLATFORM

NSF Award OAC #2112167 (June 2021) [$5M Over 5 Years]
PI Frank Wuerthwein (UCSD, SDSC)
Co-PIs Tajana Rosing (UCSD), Thomas DeFanti (UCSD), Mahidhar Tatineni (SDSC), Derek Weitzel (UNL)

Proposed PRP/NRP – OpenAirInterface 5G/6G End-to-End National-Scale Optical Fiber / "Future Wireless" Testbed



PRP/TNRP/CHASE-CI Support and Community:

- US National Science Foundation (NSF) awards to UCSD, NU, and SDSC
  - CNS-1456638, CNS-1730158, CNS-2100237, CNS-2120019, ACI-1540112, ACI-1541349, OAC-1826967, OAC-2112167
  - OAC 1450871 (NU) and OAC-1659169 (SDSU)
- UC Office of the President, Calit2 and Calit2's UCSD 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 & Wyoming Supercomputing Center, AWS, Google, Microsoft, Cisco

PACIFIC RESEARCH PLATFORM