“The CENIC-AI Resource”

CENIC 2024:
The Right Connection
March 26, 2024

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, UC San Diego

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Companies Are Facing an AI Workforce Shortage

euronews.next

Next > Tech News

AI is the most promising tech for businesses but a skills shortage stands in the way, studies show

By **Pascale Davies**

Published on 06/02/2024 -

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Universities Must Quickly Ramp Up AI/ML Course Offering

datanami

DATA SCIENCE • AI • ADVANCED ANALYTICS

July 5, 2023

The Demand for AI/ML Skills Is Growing

Mike Loukides

MarketScale

Universities Need AI Skills In the Curriculum to Create Competitive Graduates

Mike Watson

Dec 20, 2023

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The White House Convened a Top Level Task Force

JANUARY 24, 2023

National Artificial Intelligence Research Resource Task Force Releases Final Report

While AI research and development (R&D)

in the United States is advancing rapidly,
opportunities to pursue cutting-edge
AI research and new AI applications
are often inaccessible to researchers.

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The Congress Has Asked NSF to Develop a National AI Research Resource

A widely accessible
AI research cyberinfrastructure
that brings together
computational resources, data,
testbeds, algorithms, software,
services, networks,
and expertise,
as described in this report
would help to democratize
the AI R&D landscape
in the United States
for the benefit of all.



In order to achieve
its vision and goals,
the Task Force estimates
the budget for the NAIRR
as $2.6 billion
over an initial
six-year period.

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First Step: the NAIRR Pilot



NSF News

Democratizing the future of AI R&D: NSF to launch National AI Research Resource pilot

January 24, 2024

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Katie Antypas, Director NSF Office of Advanced Cyberinfrastructure (OAC) Keynotes the 5NRP Conference on NAIRR Pilot

March 20, 2024
Qualcomm Institute, UCSD



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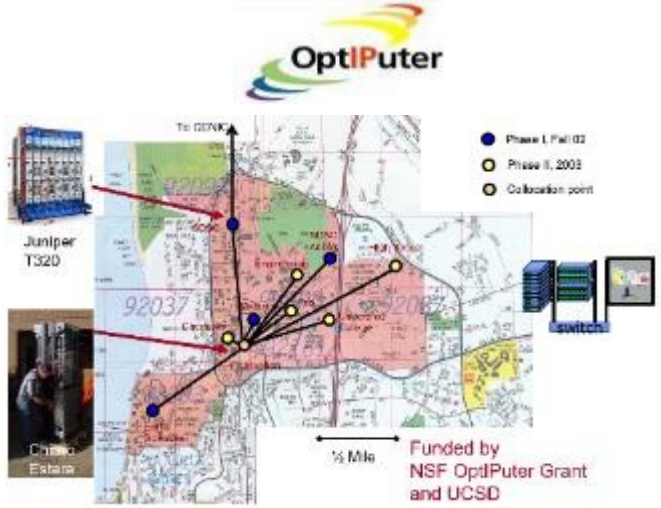
California is On The Path to Provide Leadership for NAIRR

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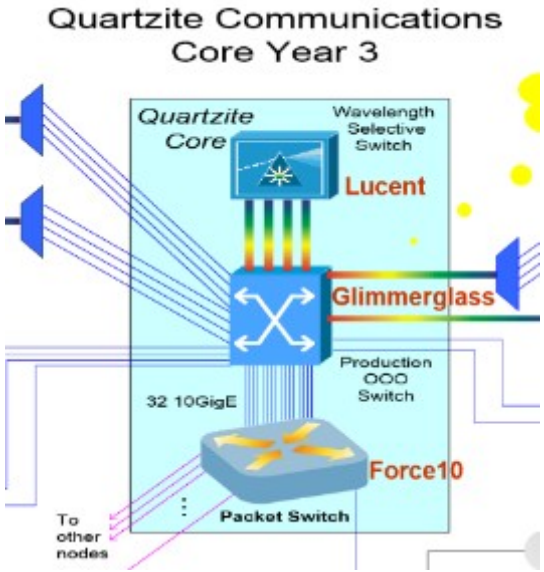
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2002-2015 Using UCSD as a Campus Cyberinfrastructure Testbed: NSF OptIPuter, Quartzite, Prism Awards

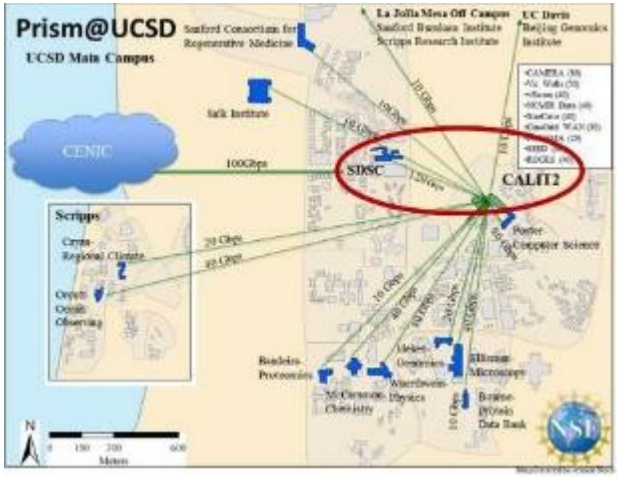


PI Smarr
2002-2009



Goals by 2008:
>= 50 endpoints at 10 GigE
>= 32 Packet switched
>= 32 Switched wavelengths
>= 300 Connected endpoints

PI Papadopoulos
2004-2007



PI Papadopoulos
2013-2015

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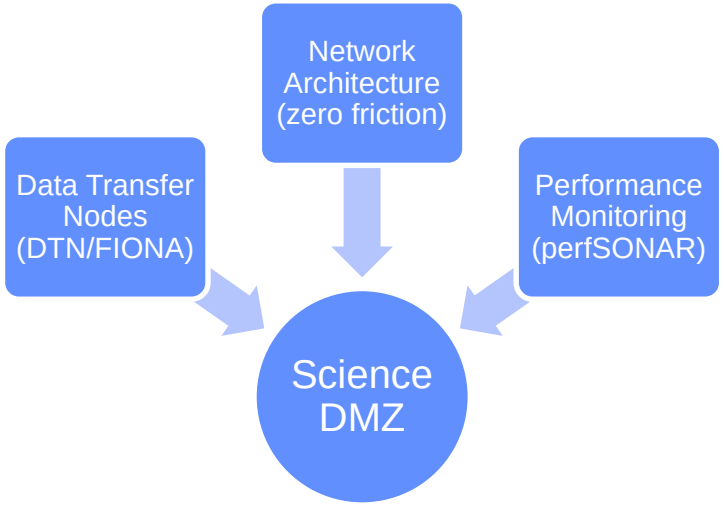
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SDSC

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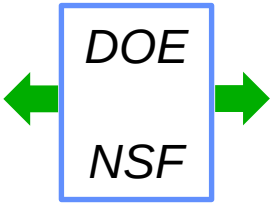
DOE & NSF Partnered on “Science DMZ” Technology Adoption

“Science DMZ” Coined in 2010 by ESnet
Basis of PRP Architecture and Design



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

Slide Adapted From Inder Monga, ESnet



NSF Campus Cyberinfrastructure Program
Has Made Over 385 Awards
Totaling Over $100M Since 2012



Source: Kevin Thompson, NSF

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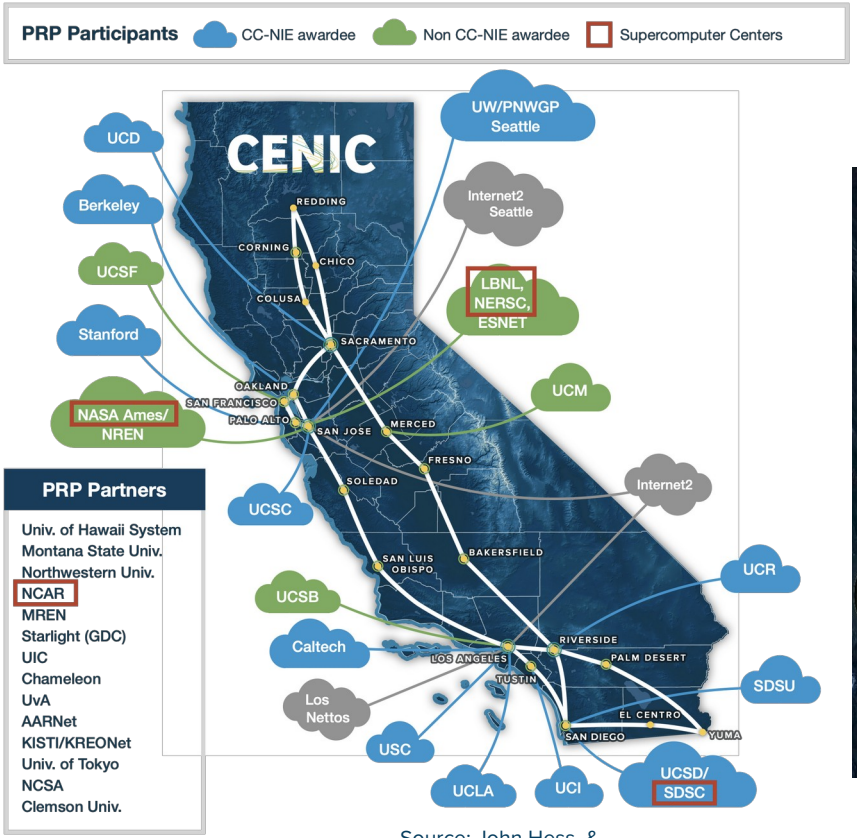
ESnet FASTERDATA KNOWLEDGEBASE

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NSF

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2015 Vision: The Pacific Research Platform Will Build on CENIC to Connect Science DMZs Creating a Regional Community Cyberinfrastructure



Source: John Hess, & Hunter Hadaway, CENIC

NSF CC*DNI Grant
$6.3M 10/2015-10/2020
Extended – Ended Year 7 in Oct 2022



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Machine Learning, Artificial Intelligence, and Data Science Research Applications Need Access to GPUs

"Graphics processing units (GPUs), originally developed for accelerating graphics processing, can dramatically speed up computational processes for deep learning. They are an essential part of a modern artificial intelligence infrastructure and new GPUs have been developed and optimized specifically for deep learning."

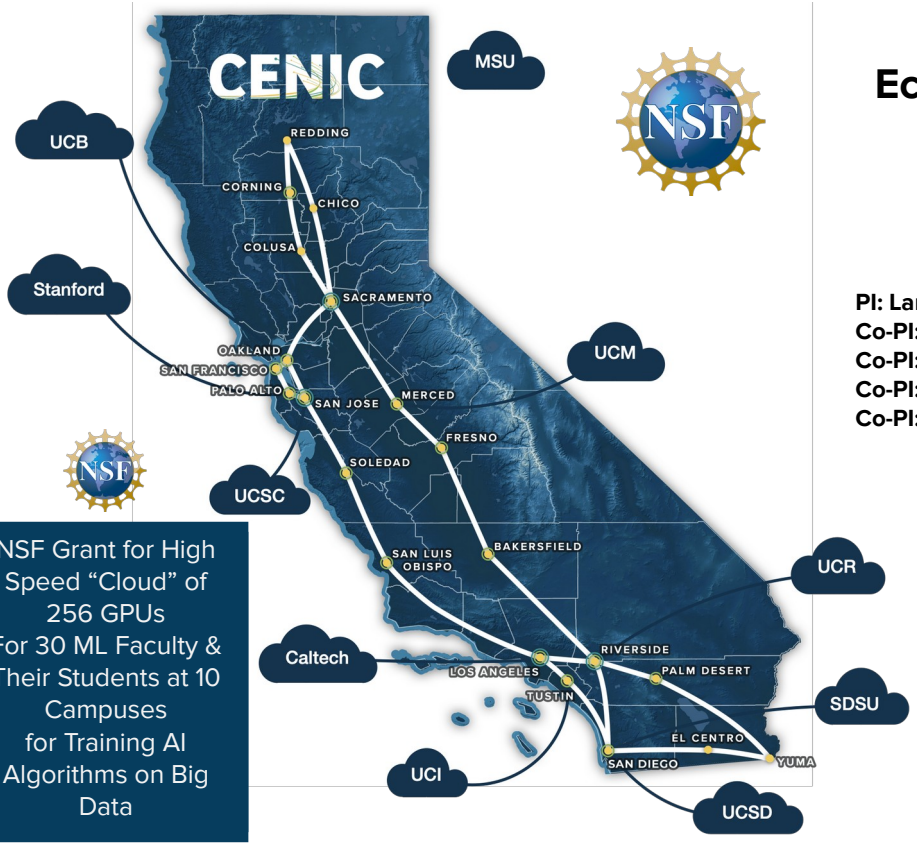
run:ai www.run.ai/guides/gpu-deep-learning

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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 21, 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

JACOBS SCHOOL OF ENGINEERING
SDSC UC San Diego QUALCOMM INSTITUTE

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Data Transfer Nodes (DTNs) Terminate CENIC's Fiber Optics on Campuses: 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



Add Up to 8 Nvidia GPUs Per 2U FIONA
To Add Machine Learning Capability
Up to 240TB Storage



FIONAs Are Rack Mounted

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

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Installing Community Shared FIONA CPU/GPU/Storage Systems on CENIC-Connected Campuses









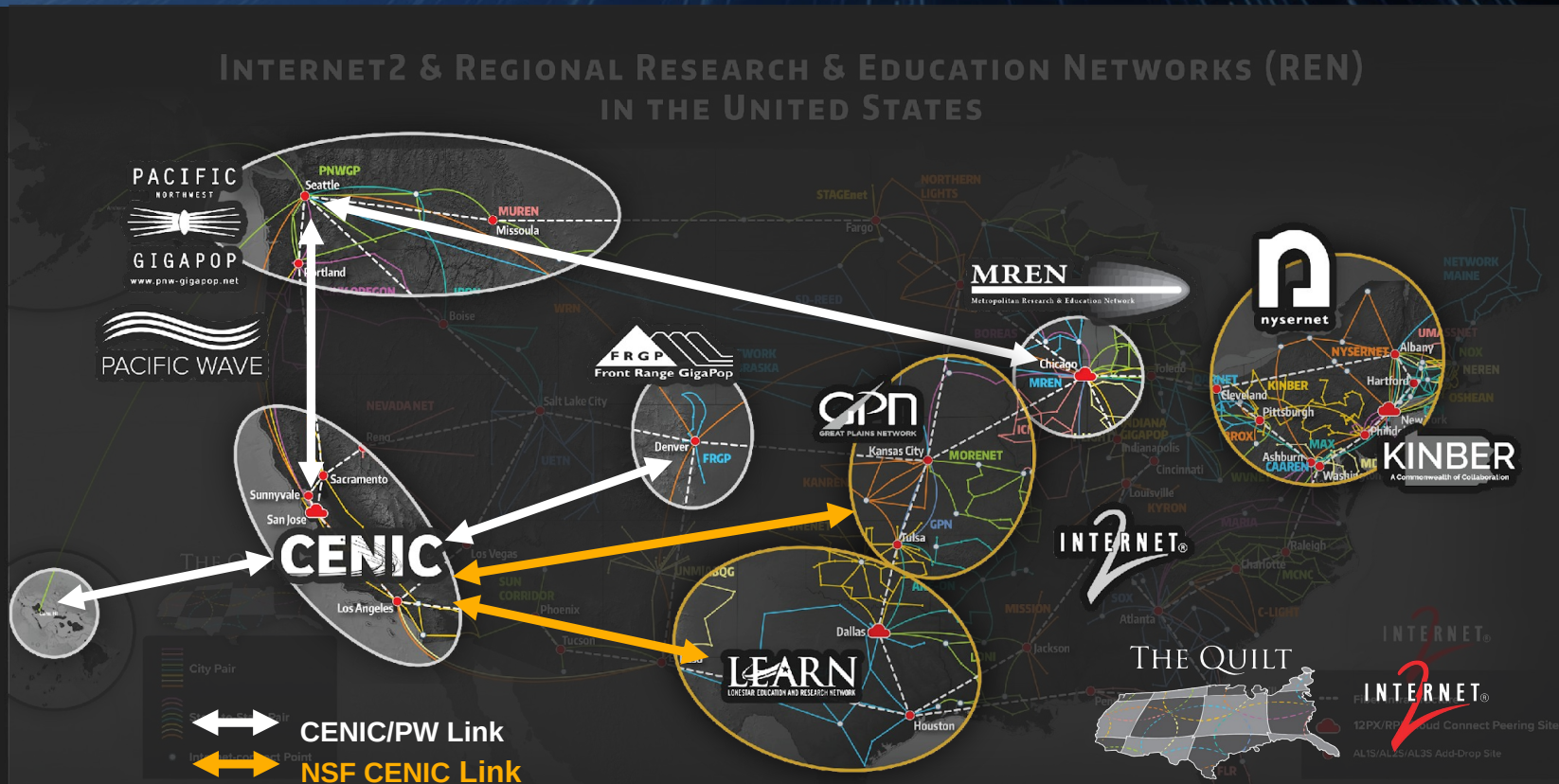




2018-2021: Toward the National Research Platform (NRP) - Using CENIC & Internet2 to Connect Quilt Regional R&E Networks

"Towards The NRP"
3-Year Grant Funded By
NSF $2.5M
October 2018

PI Smarr
Co-PIs Altintas
Papadopoulos
Wuerthwein
Rosing
DeFanti



SDSC

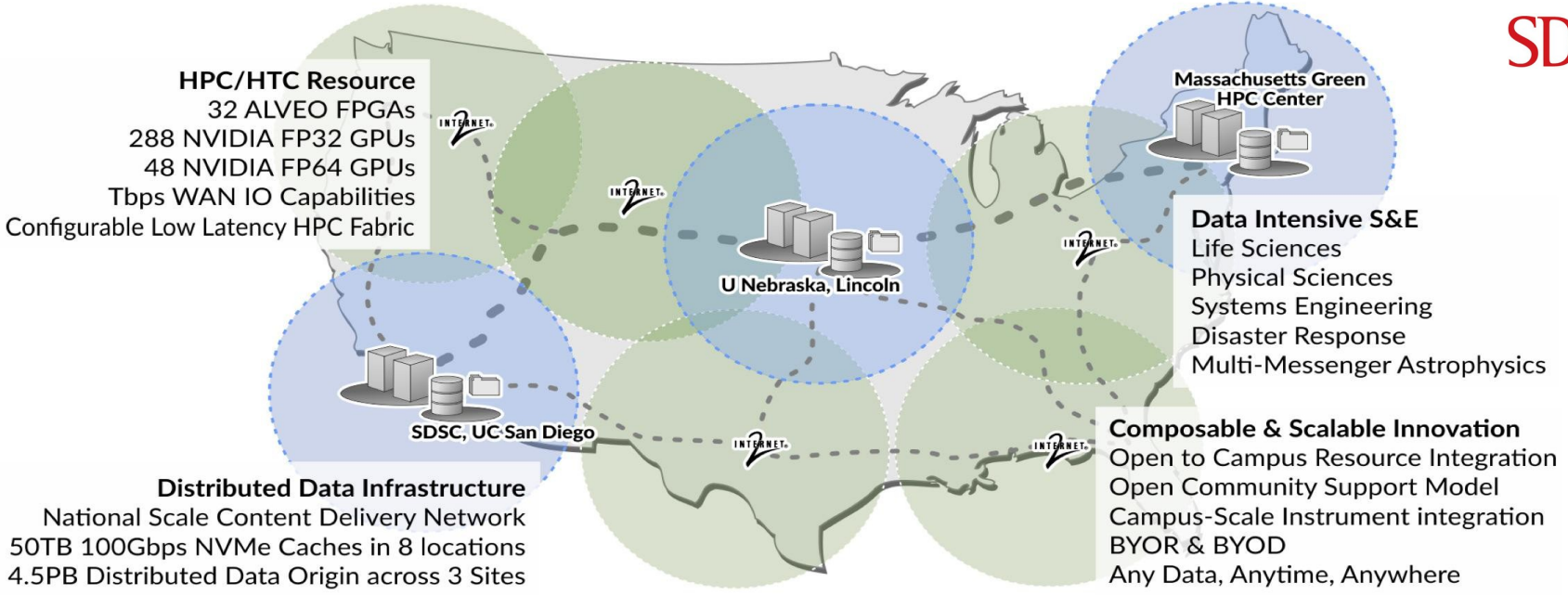
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2021-2026: PRP Federates with NSF-Funded *Prototype National Research Platform*

SDSC



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)

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2023 - The National Research Platform Emerges As a Unification of 22 Years of NSF Cyberinfrastructure Grants

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NEWS GRANTS TECHNOLOGY COMMUNITY JOIN / CONTACT



Professor Frank Würthwein

- Director - SDSC
- Distributed High-Throughput Computing Lead - SDSC

Designed for Growth and Inclusion

The National Research Platform (NRP) is a partnership of more than 50 institutions, led by researchers and cyberinfrastructure professionals at UC San Diego, supported in part by awards from the National Science Foundation.

https://nationalresearchplatform.org/

How it works

Nautilus is NRP's Multi-Institution Hypercluster Which Creates a Community Owned and Operated "AI Resource"

Feb 20, 2024

Nautilus NSF

~200 FIONAs on 27 Partner Campuses
Networked Together at 10-100Gbps

Installed GPUs	Installed CPU Cores	Rotating Storage
1231	20,973	7000 TB

CENIC THE QUILT INTERNET2

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NRP's *Nautilus* Hypercluster Adopted Open-Source Kubernetes and Rook to Orchestrate Software Containers and Manage Distributed Storage



Production-Grade Container Orchestration



kubernetes



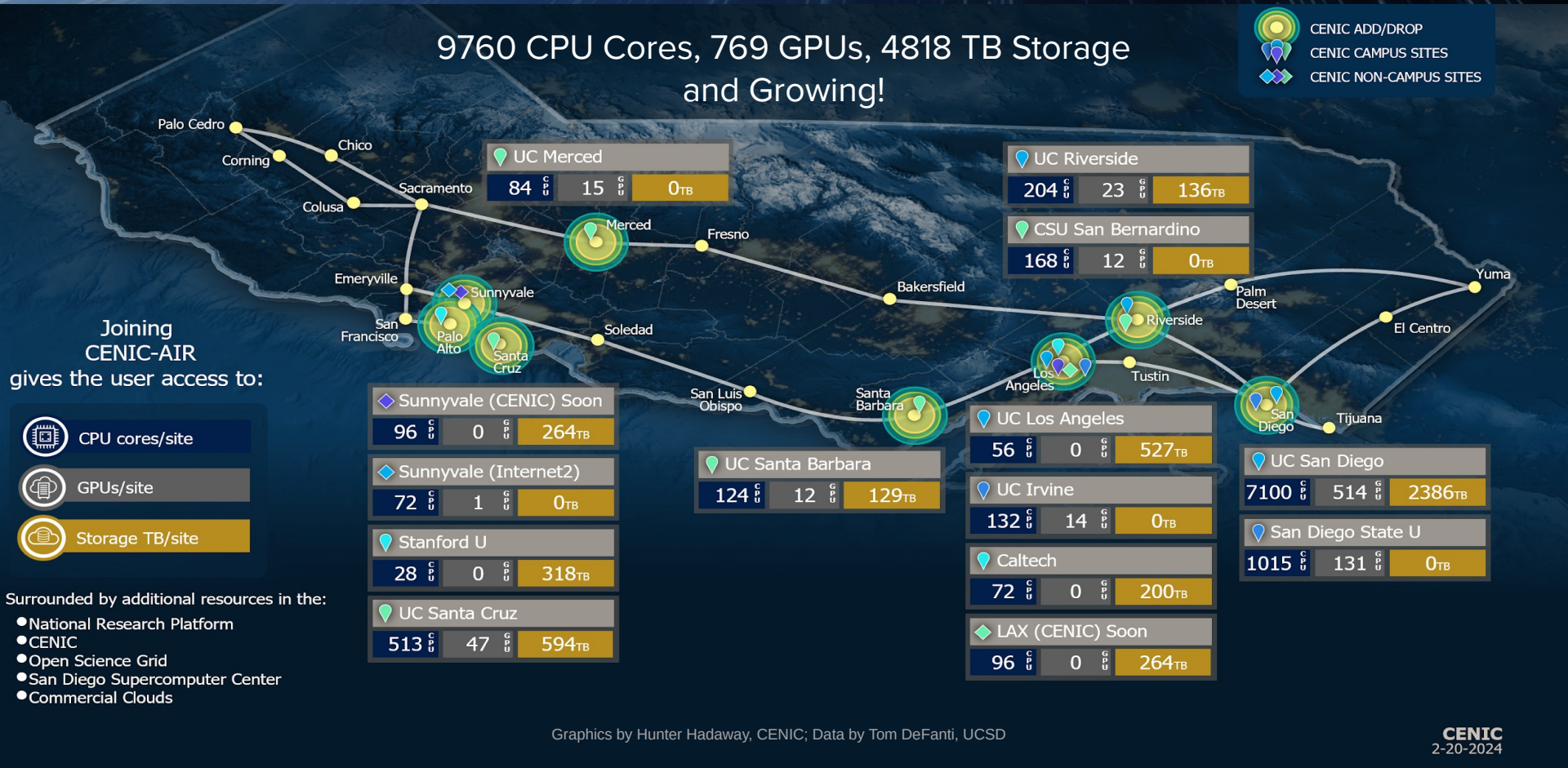


Open source file, block & object storage for your cloud-native environment

"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, UC San Diego

The Majority of *Nautilus* GPUs Reside in the CENIC AI Resource (CENIC-AIR): Hosted by and Available to CENIC Members



Graphics by Hunter Hadaway, CENIC; Data by Tom DeFanti, UCSD

CENIC
2-20-2024

CENIC-AIR Users Can Burst into the Larger NRP

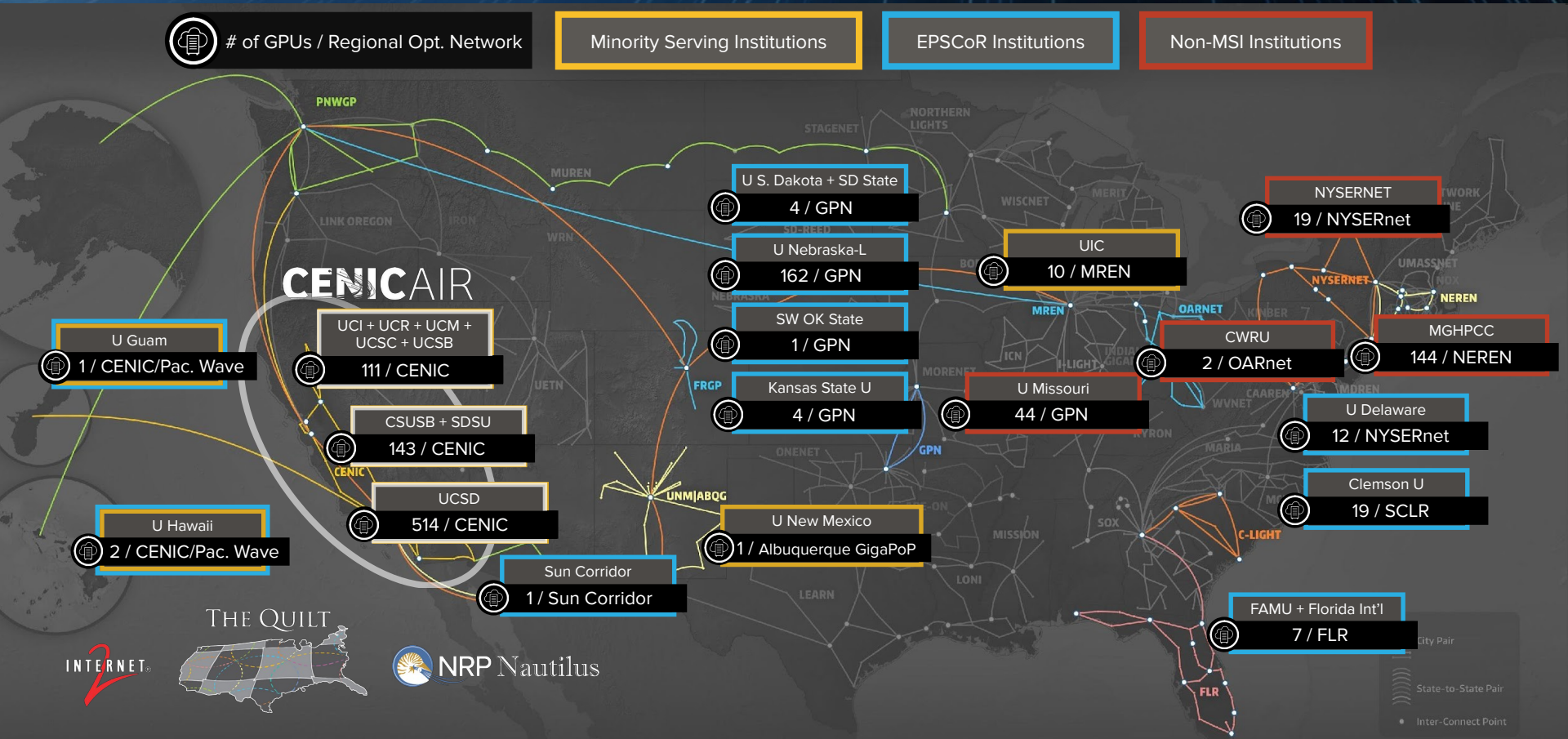
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NRP Nautilus

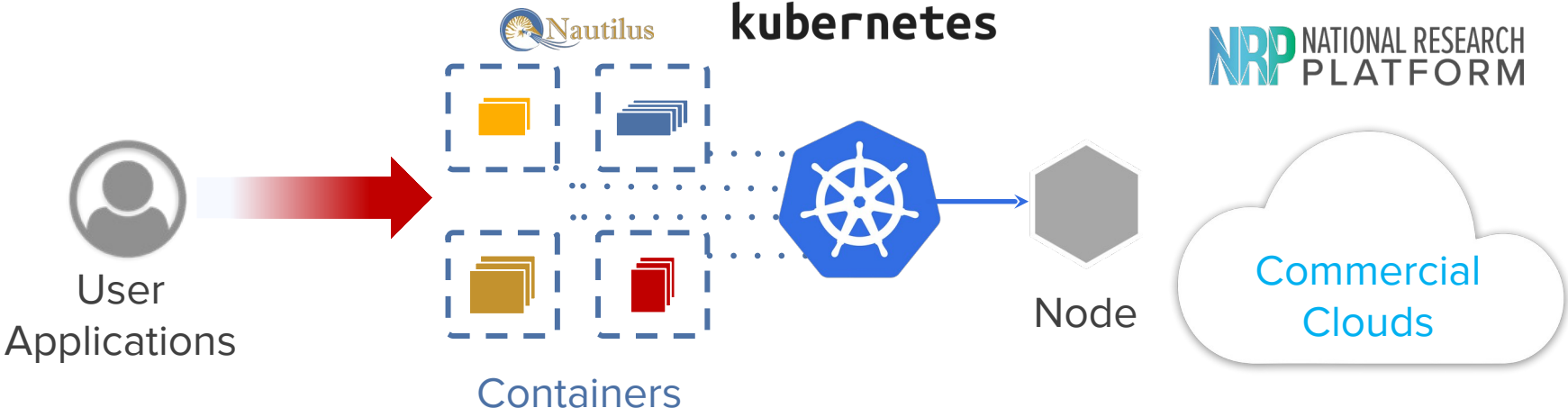
The Users of the CENIC-AIR Can Burst into NRP's Nautilus Hypercluster Outside of California

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The Users of the CENIC-AIR Can Also Burst Into the Commerical Clouds

Nautilus Containerized Applications Are "Cloud Ready"



CLOUD NATIVE COMPUTING FOUNDATION

Use the NRP Web Site to Get Started and Find Expert *Community* Support

nationalresearchplatform.org

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Contact Us

Join the NRP mailing list

Get Quick Access

Matrix Chat Has Over 1000 Members

Nautilus Documentation

Getting Started with Nautilus

Matrix Chat

Who is Using It?

CENIC-Connected Campuses Are Major Users of NRP Resources

Last 6 Months

- **University of California**
  - UC Berkeley
  - UC Irvine
  - UC Los Angeles
  - UC Merced
  - UC Riverside
  - UC Santa Cruz
  - UC San Diego
- **California State Universities**
  - Cal Poly Humboldt
  - CSU Northridge
  - CSU San Bernardino
  - San Diego State U
- **Private Universities**
  - Caltech
  - Stanford U
  - USC

Broadening Inclusion in California: The NRP is Increasingly Being Used by the California State University System



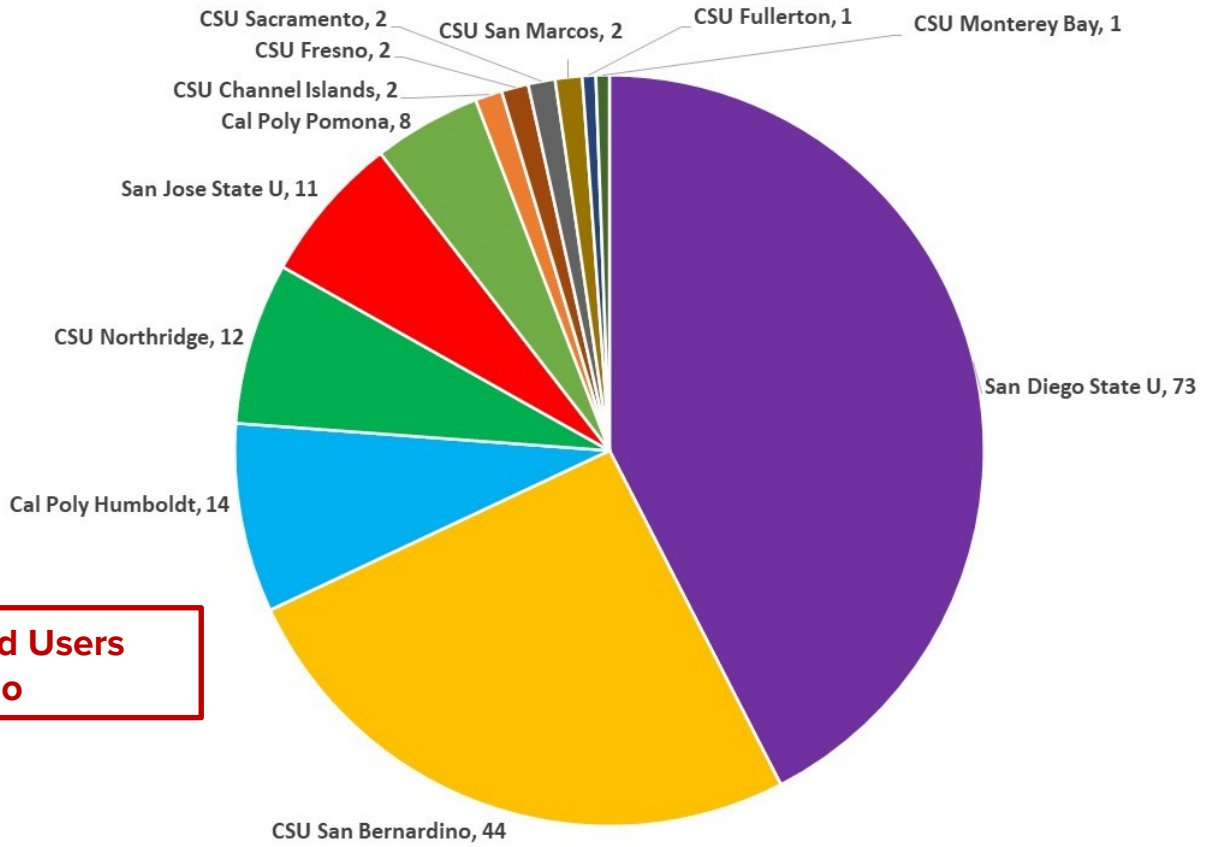
CSU The California State University

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NRP Nautilus

12 of 23 CSU Campuses (Up From 8 Six Months Ago) Have 1 or More Users Who Have Registered With NRP's Nautilus



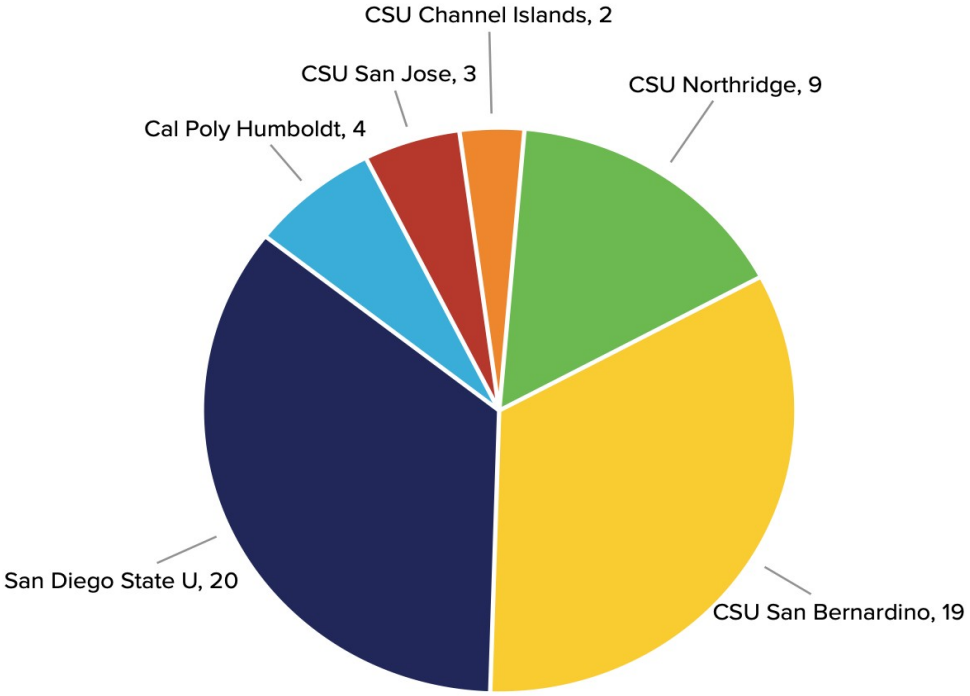
Total: 173 CSU Nautilus Registered Users
Up From 80 Six Months Ago

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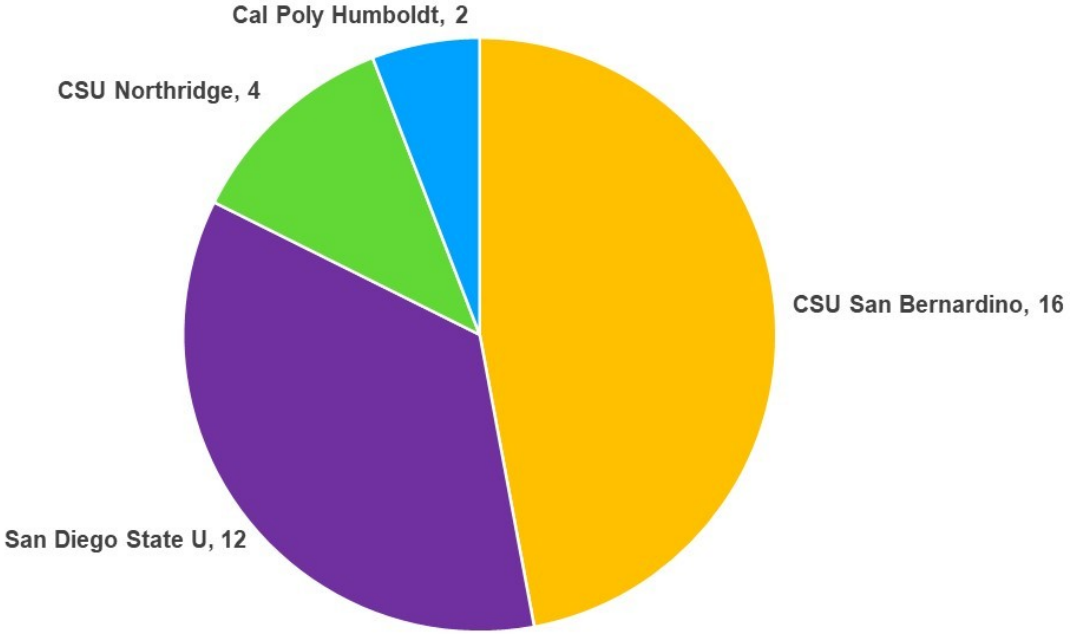
NRP Nautilus

5 of 23 CSU Campuses Have Created 1 or More Nautilus Projects (Namespaces)



Total: 57 CSU Nautilus Namespaces

4 of 23 CSU Campuses
Have Used Nautilus GPU and/or CPUs in the Last 6 Months



48,750 GPU-Hrs **1,087,000 CPU-Hrs**

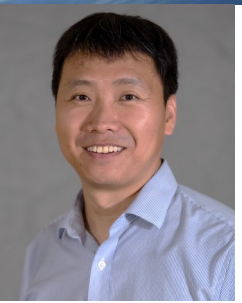
Total: 35 CSU Active Nautilus Namespaces

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CSUN Prof. Bingbing Li
Machine Learning Research Projects Utilizing Nautilus



CSUN Prof.
Bingbing Li

CSUN | ARCS Astronomy Research Center for STEAHM

- **Energy Disaggregation for Manufacturing Plant**
  - Faculty Lead: Dr. Bingbing Li (CSUN), Dr. Richard Donovan (UCI)
  - **DNNs: Long Short-Term Memory (LSTM) RNN, PyTorch**
- **Graph Representation Learning for Material Prediction and Recommendation in CAD Automation**
  - Faculty Lead: Dr. Bingbing Li (CSUN)
  - Collaborator: Dr. Daniele Grandi @ Autodesk and Dr. Thomas Lu @JPL
  - **DNNs: UV-Net Graph Neural Networks (GNN), PyTorch**
- **Knowledge Graph Construction Through the Potential of Large Language Models within Manufacturing**
  - Faculty Lead: Dr. Bingbing Li (CSUN)
  - Collaborator: Dr. Jerry Fuh & Senthil Kumar @ National University of Singapore
  - **DNNs: LLMs (ChatGPT & LLaMa), Tensorflow**
- **Multi-Domain AI for Future Manufacturing**
  - Faculty Lead: Dr. Bingbing Li (CSUN)
  - Collaborator: Dr. Edward Chow & Dr. Thomas Lu @JPL
  - **DNNs: LLMs (ChatGPT & LLaMa), Tensorflow**
- **Medical Image Restoration through Optical & CT Scanning**
  - Faculty Lead: Dr. Xiyi Hang & Dr. Bingbing Li (CSUN)
  - Collaborator: Dr. Ye Pu and Prof. Demetri Psaltis @ Swiss Federal Institute of Technology Lausanne
  - **DNNs: Large-Kernel CNN, Tensorflow**

TensorFlow

PyTorch

LLM
LARGE LANGUAGE MODEL

ChatGPT

Meta

California State University San Bernardino is an Excellent Example of How to Help Your Faculty and Students Learn How to Use CENIC-AIR



CENIC 2024 Innovations in Networking Award

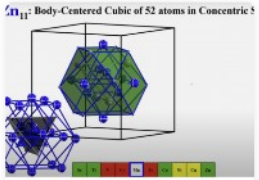
Their Campus HPC Program
Enabled CSUSB Faculty & Students
to Use More NRP GPU-Hours
In the Last 6 Months
Than 8 of the 10 UC Campuses!

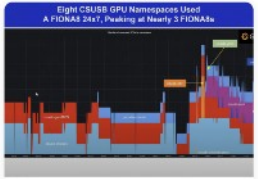


JupyterHub, NRP



ACCESS


Projects


2023 Faculty Showcase

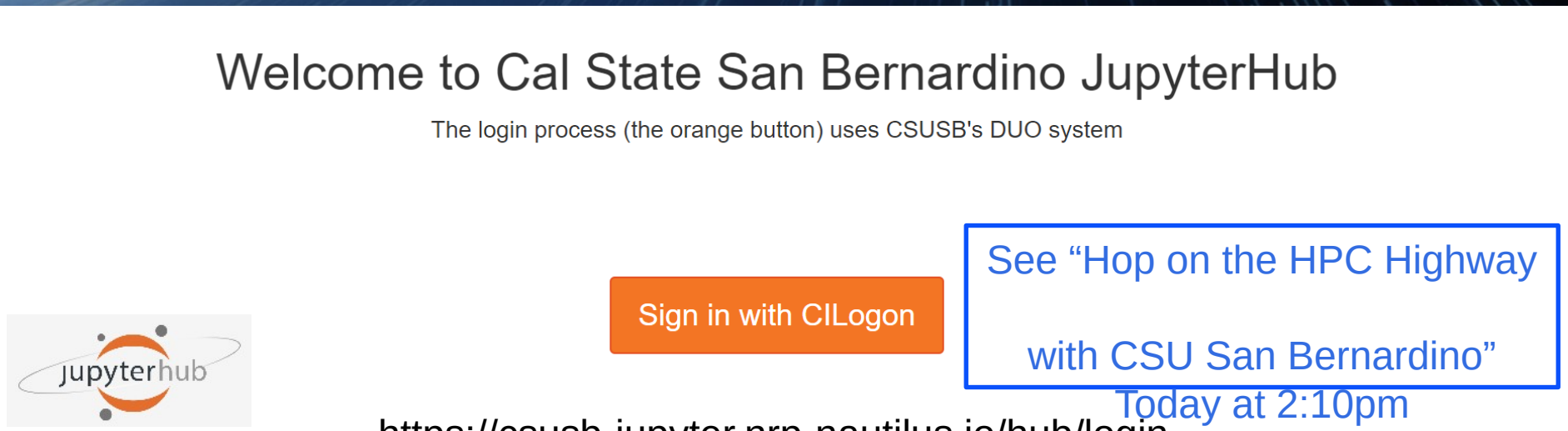
www.csusb.edu/academic-technologies-innovation/xreal-lab-and-high-performance-computing/high-performance-computing

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A Key Reason CSUSB Has The Largest CSU Nautilus Usage: They Installed and Publicized the JupyterHub “Easy Button”

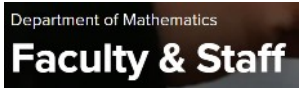


See “Hop on the HPC Highway with CSU San Bernardino” Today at 2:10pm

https://csusb-jupyter.nrp-nautilus.io/hub/login

Over 450 Total Users
Tripled in the Last Six Months!

Slide Adapted from Prof. Youngsu Kim



CSUSB WE DEFINE THE Future

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SDSU Is the Lead Campus for the New CENIC-Connected Technology Infrastructure for Data Exploration (TIDE) NSF Grant

SDSU San Diego State University · Cal Poly Humboldt · CSUN California State University Northridge · SDSC · CENIC · California State University San Bernardino · California State University San Marcos · Channel Islands California State University · Stanislaus California State University

- **A CSU Resource for Research & Education:**
  - **NSF CC* Regional Computing Award for ~$1M**
    - **$800 for a New Computational Core**
    - **$200 for Students to Help Onboard and Support Users**
  - **Federated with NRP Nautilus**
  - **First New NSF Resource in CENIC-AIR**



616 CPU Cores · 73 GPUs · 14.592 TB RAM

CENIC 2024 Innovations in Networking Award

NRP National Research Platform · CENIC AIR CENIC Artificial Intelligence Resource

Source: Jerry Sheehan, TIDE PI

NRP Nautilus

Accelerating the Development of California's AI/ML Workforce By Using CENIC-AIR for Campus Courses

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UCSD's Information Technology Services Has Adapted NRP FIONA8s To Support Students in Data Science (DS) & Machine Learning (ML) Courses



SDSC Racked FIONAs:

- 132 32-bit GPUs (10% NRP)
- 1024 CPU-cores
- 10/100G Networking
- Not Federated With NRP

Software Used By Students

TensorFlow, PyTorch, Caffe, jupyter, ANACONDA, NumPy, NVIDIA CUDA, kubernetes, docker

- **Student-Focused Platform For:**
  - Undergraduate & Graduate Coursework
  - For-Credit Independent Study
  - Thesis/Dissertation Research
  - Capstones & Projects
- **Research-Driven Architecture**
- **Managed by UCSD IT Services**

Source: Adam Tilghman, UCSD ITS
Data Science/ML Platform - 2/2024 Update

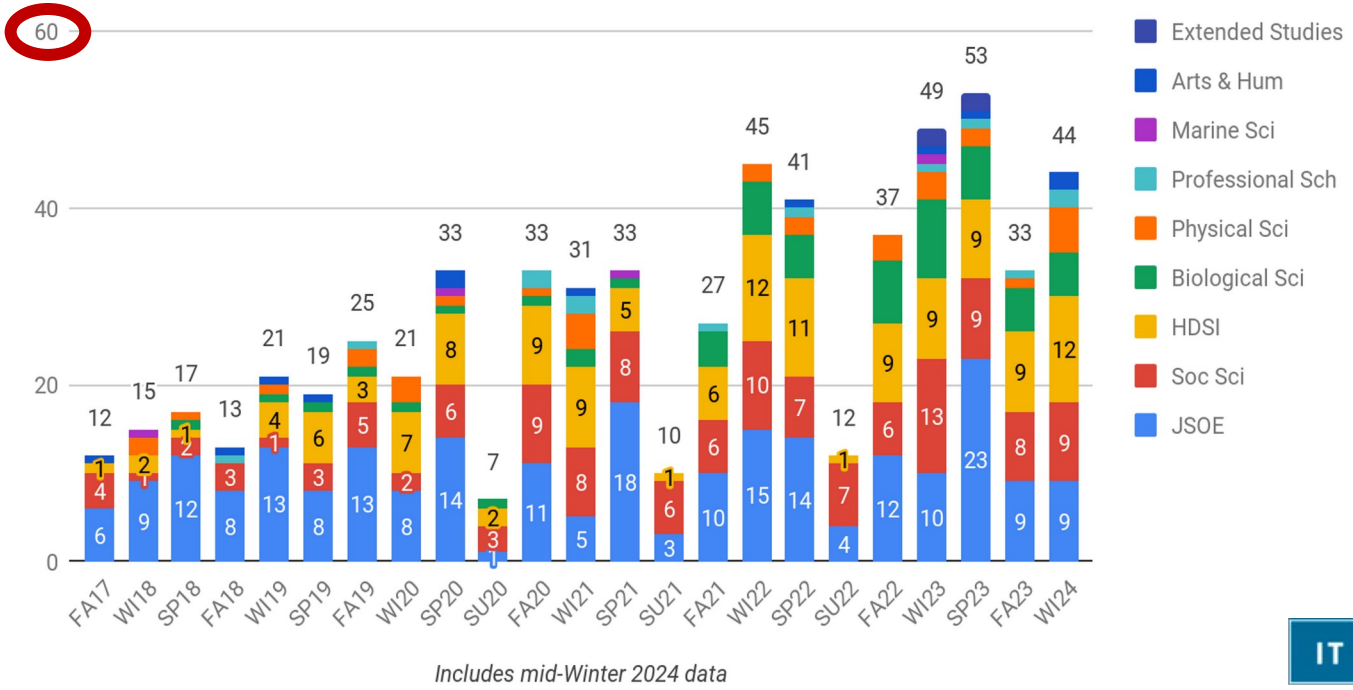
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IT SERVICES
UC San Diego

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UC San Diego's DS/ML Platform Has Supported Up To Nearly 60 Courses Over the Last Six Years



Includes mid-Winter 2024 data

Source: Adam Tilghman, UCSD ITS
Data Science/ML Platform - 2/2024 Update

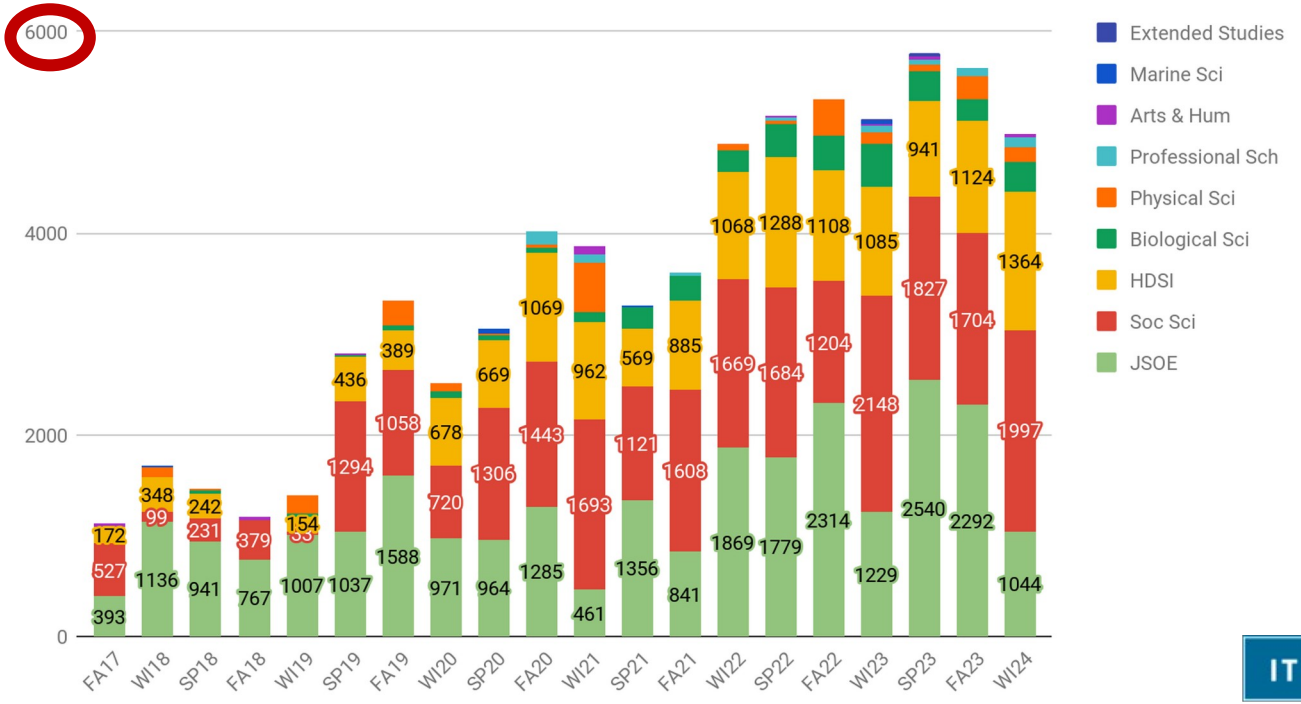
IT SERVICES
UC San Diego

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UC San Diego's DS/ML Platform
Has Supported Up To 6,000 Students Per Quarter Over the Last Six Years



Source: Adam Tilghman, UCSD ITS
Data Science/ML Platform - 2/2024 Update

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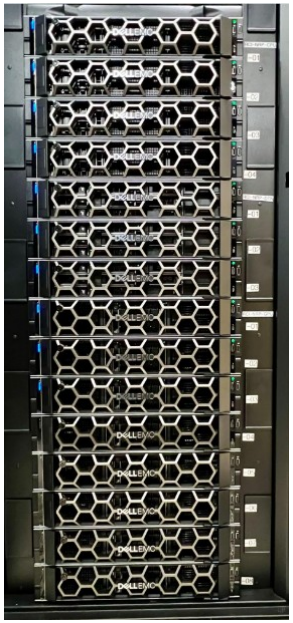
Selected Courses, Spring 2023

- Advanced Computer Vision
- Bioinformatics for Immunologists
- Computational Physics: Probabilistic Models/Sim.
- Data Analysis/Design for Biologists
- Data Science/Spatial Analysis
- Deep Learning and Applications
- Intro to Causal Inference
- Neural Networks/Pattern Recognition
- Numerical Analysis for Multiscale Biology
- Robot Manipulation and Control

Source: Adam Tilghman, UCSD ITS
Data Science/ML Platform - 2/2024 Update

SDSU's VERNE Expands UCSD's Instructional Model by Federating with NRP: Visionary, Education, Research, Network, Ecosystem

SDSU Information Technology Division



CENIC

NVIDIA. docker kubernetes jupyter PyTorch TensorFlow MATLAB RStudio

- **Dell PowerEdge Cluster for Instructional Use:**
  - 15 Nodes with:
    - 32 A100 GPUs (can bemanaged as 232 independent GPUs)
    - 768 CPU cores
    - 960 TB Storage
  - A Learning Resource that Surges for Research and Instruction
  - System Administration as a Service from the NRP
- **Growth in Both SDSU Courses and Students Using VERNE**
  - Spring Quarter 2024
    - 14 Courses
    - 300 Students

Slide courtesy of Jerry Sheehan and Mike Farley

NRP NATIONAL RESEARCH PLATFORM

CENIC AIR CENIC ARTIFICIAL INTELLIGENCE RESOURCE

NRP Nautilus

Next Talk:
Christopher Bruton
CENIC Network Architect

Join in Using the CENIC-AIR

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NRP Nautilus