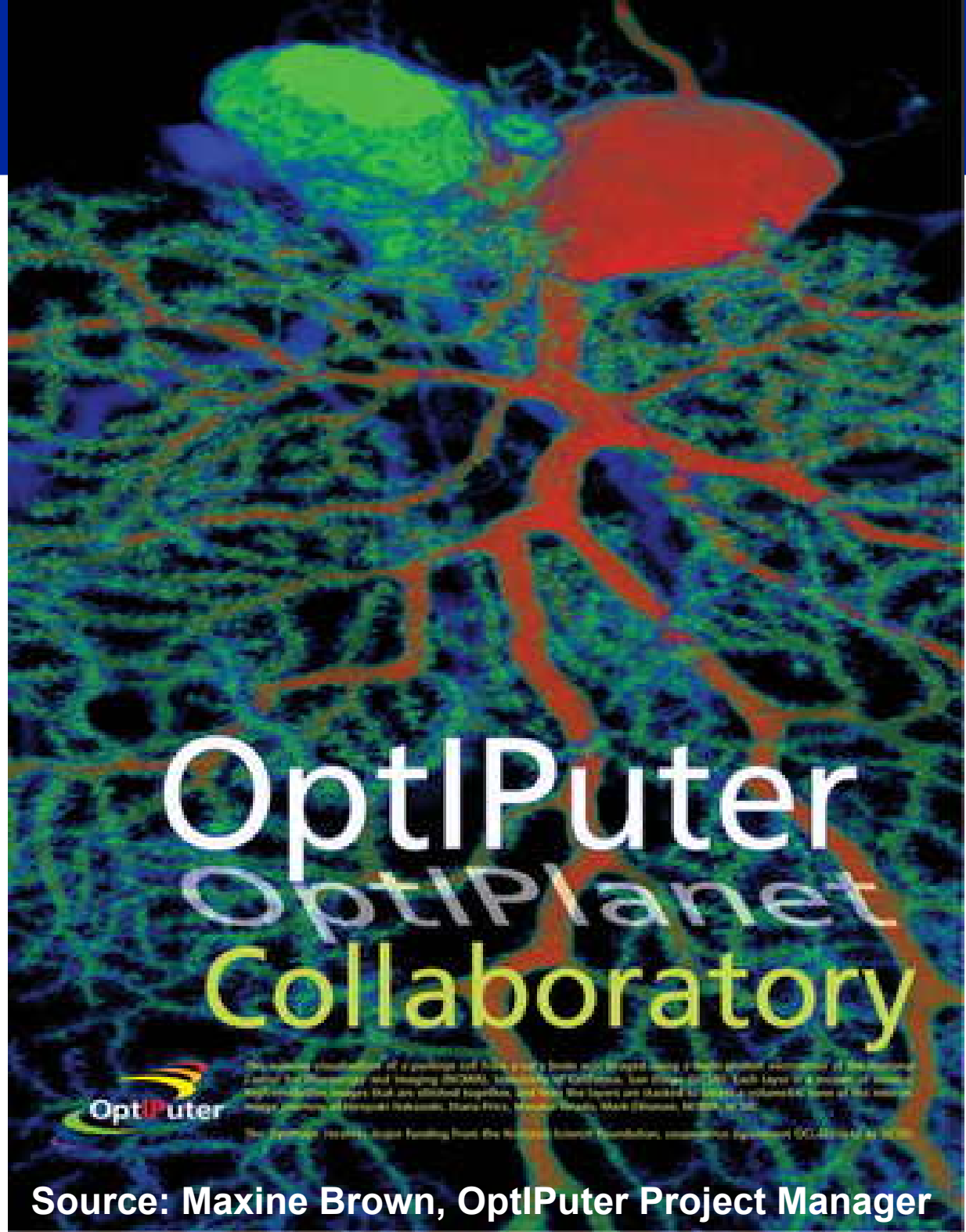
Creating a Planetary Scale OptIPuter

Invited Talk-Calit2 Booth
Supercomputing '07
Convention Center, Reno, NV
November 13, 2007

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

UCSD
UCIrvine

it²



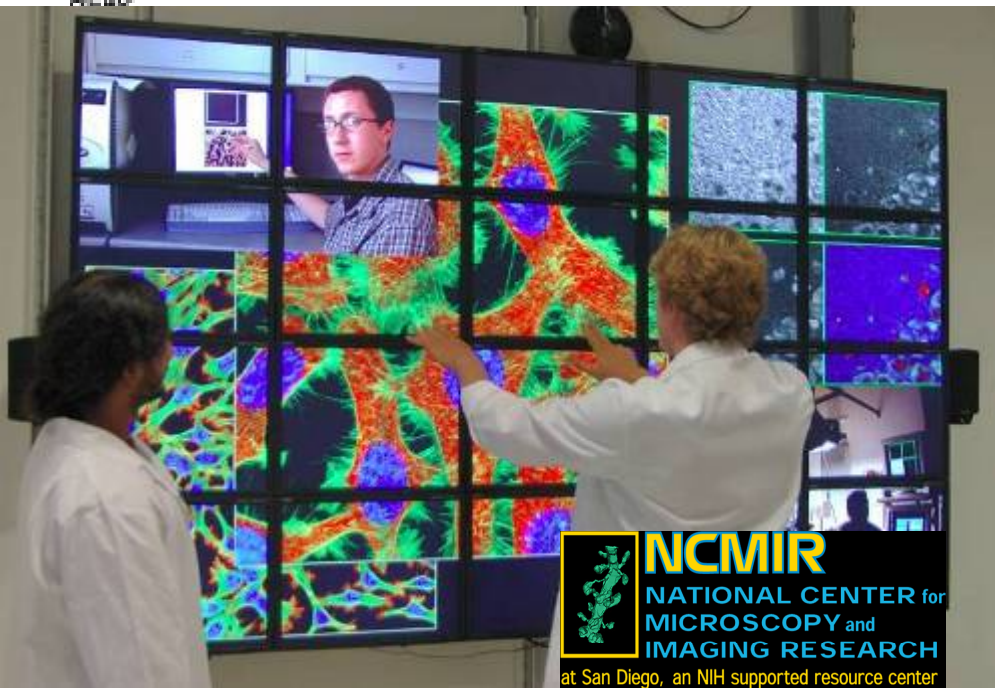
Source: Maxine Brown, OptIPuter Project Manager

UCSD
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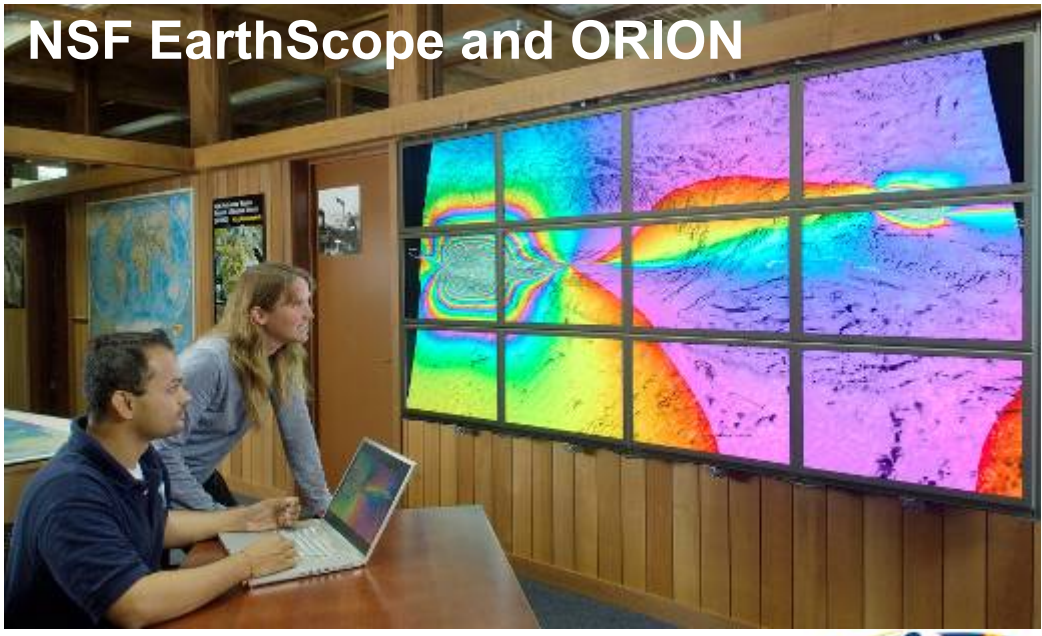
The OptIPuter Project – Creating High Resolution Portals Over Dedicated Optical Channels to Global Science Data

- **NSF Large Information Technology Research Proposal**
  - Calit2 (UCSD, UCI) and UIC Lead Campuses—Larry Smarr PI
  - Partnering Campuses: SDSC, USC, SDSU, NCSA, NW, TA&M, UvA, SARA, NASA Goddard, KISTI, AIST, CRC(Canada), CICESE (Mexico)
- **Engaged Industrial Partners:**
  - IBM, Sun, Telcordia, Chiaro, Calient, Glimmerglass, Lucent
- **$13.5 Million Over Five Years—Now In the Six and Final Yea..**

NIH Biomedical Informatics Research Network



NSF EarthScope and ORION



SCRIPPS INSTITUTION OF OCEANOGRAPHY

My OptIPortal™ – Affordable Termination Device for the OptIPuter Global Backplane

- 20 Dual CPU Nodes, 20 24” Monitors, ~$50,000
- 1/4 Teraflop, 5 Terabyte Storage, 45 Mega Pixels--Nice PC!
- Scalable Adaptive Graphics Environment (SAGE) Jason Leigh, EVL-UIC

evl electronic visualization laboratory





UCSD UCIrvine

Powered by Rocks ROCKS

Source: Phil Papadopoulos SDSC, Calit2

it²

CAMERA: Community Cyberinfrastructure for Advanced Marine Microbial Ecology Research and Analysis



Paul Gilna Ex. Dir.

National LambdaRail Direct Connect Computation and Storage Complex

PI Larry Smarr

Funded by: Gordon and Betty Moore Foundation

Joint Partnership of:

camera
Marine Microbial Ecology

Announced January 17, 2006
$24.5M Over Seven Years

Building On Centers of Excellence and Achievement









Powered by Rocks



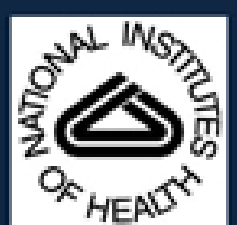






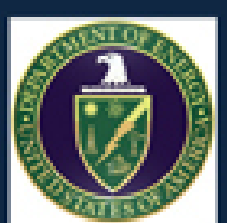
The Scripps Genome Center

Supported by:















Marine Genome Sequencing Project – Measuring the Genetic Diversity of Ocean Microbes



MARINE MICROBIOLOGY INITIATIVE

Gordon and Betty MOORE FOUNDATION

Sorcerer II Data Will Double Number of Proteins in GenBank!

UCSD
UCIrvine

J. Craig Venter INSTITUTE

it²

Enormous Increase in Scale of Known Genes Over Last Decade

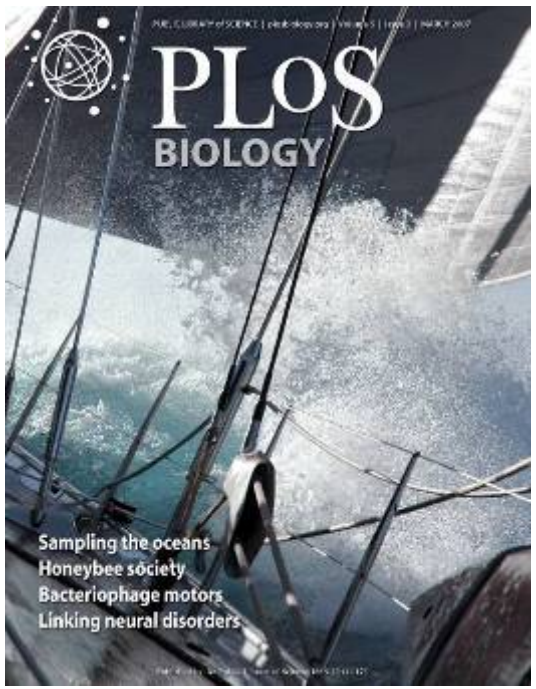
1995
First Microbe Genome



1.8 Million Bases
1749 Genes

J. Craig Venter
INSTITUTE

2007
Ocean Microbial Metagenomics



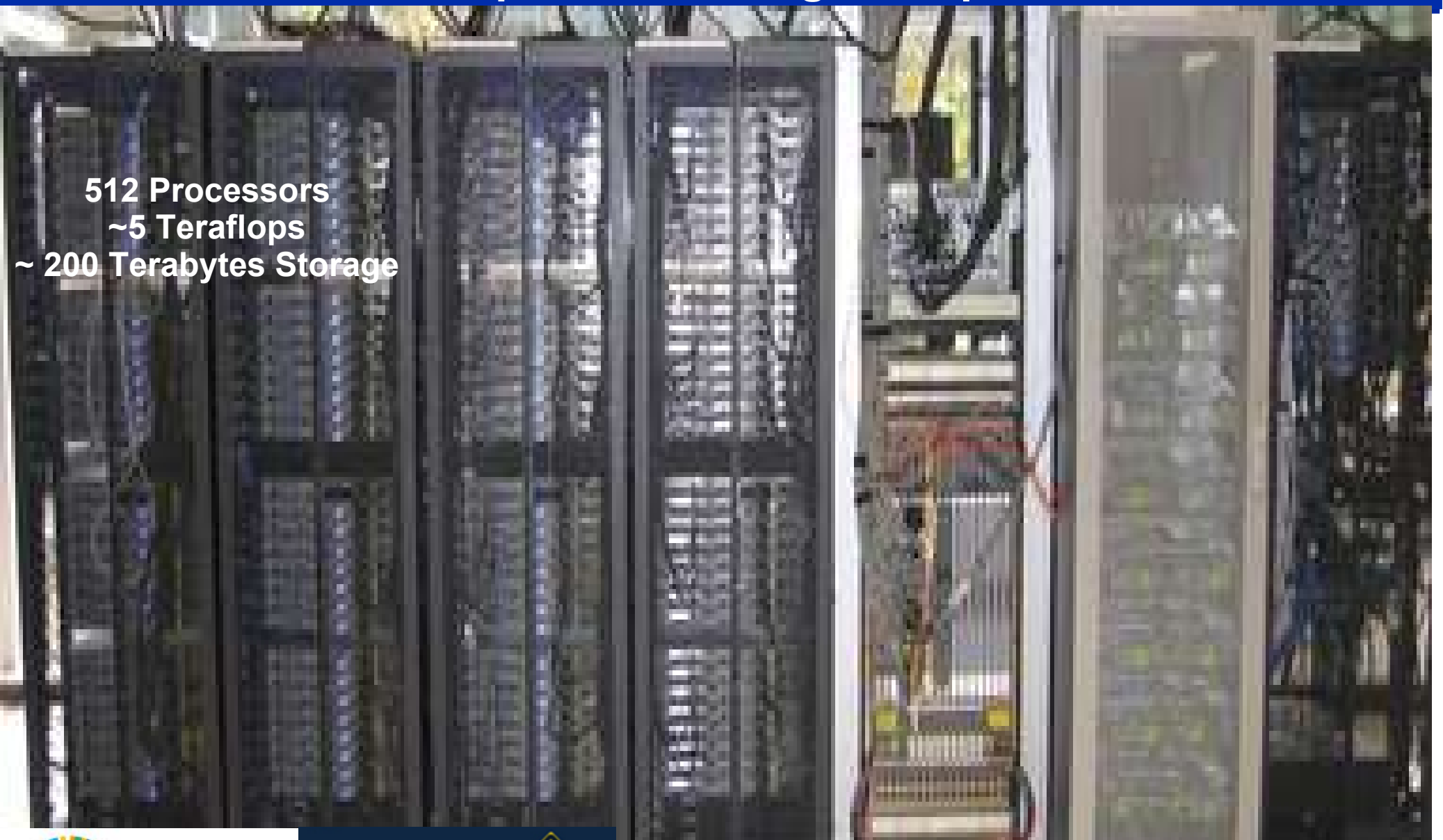
6.3 Billion Bases
5.6 Million Genes

~3300x

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Calit2 Community Cyberinfrastructure for Advanced Marine Microbial Ecology Research and Analysis (CAMERA) Compute and Storage Complex



camera
Marine Microbial Ecology

Powered by Rocks

ROCKS

Source: Phil Papadopoulos, SDSC, Calit2

it2

Calit2's Direct Access Core Architecture Will Create Next Generation Metagenomics Server

Gordon and Betty MOORE FOUNDATION

Sargasso Sea Data

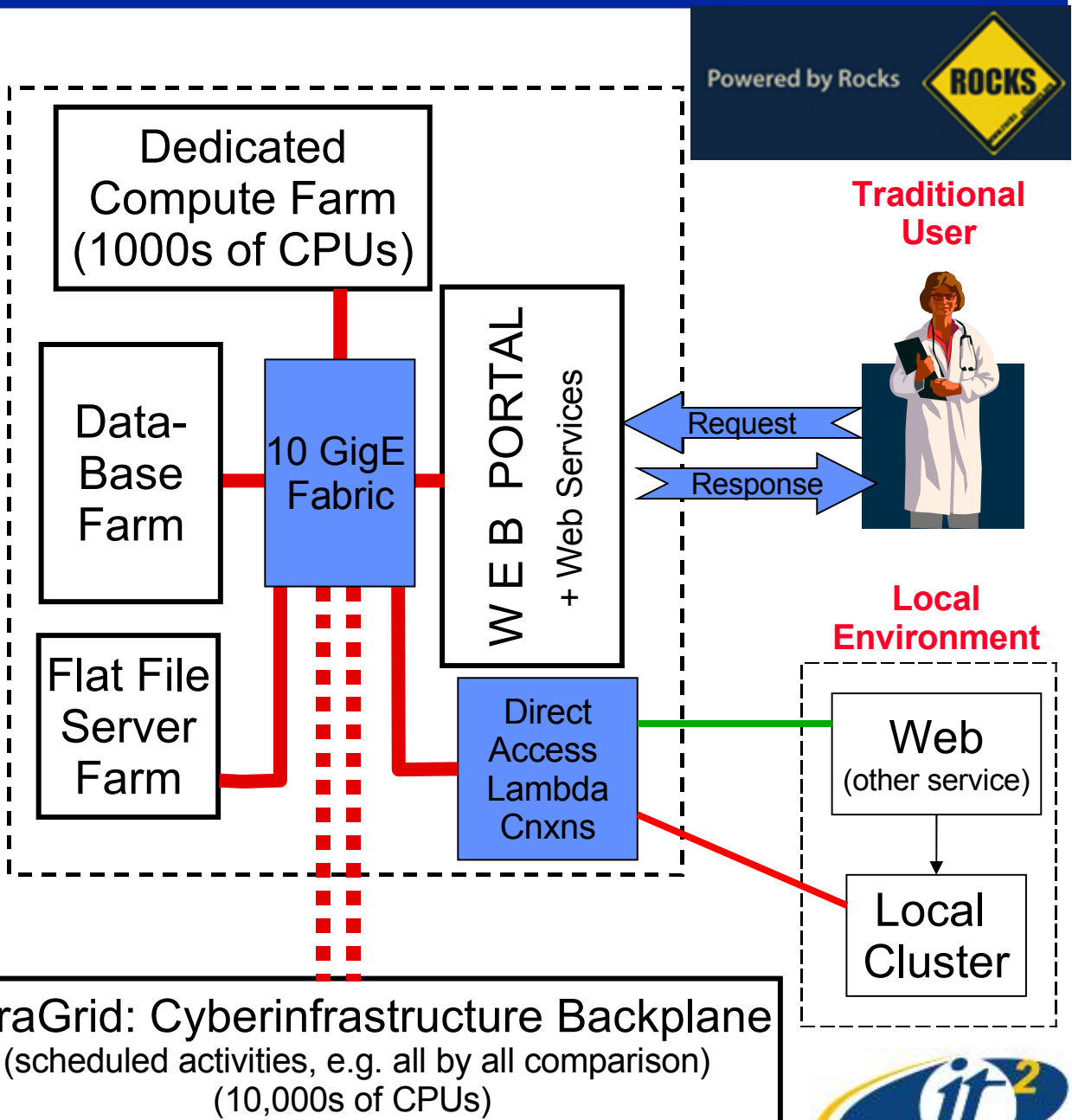
Sorcerer II Expedition (GOS)

JGI Community Sequencing Project

Moore Marine Microbial Project

NASA and NOAA Satellite Data

Community Microbial Metagenomics Data



Source: Phil Papadopoulos, SDSC, Calit2

CENTER FOR EARTH OBSERVATIONS & APPLICATIONS

SCRIPPS INSTITUTION OF OCEANOGRAPHY

SDSC SAN DIEGO SUPERCOMPUTER CENTER

UCSD UCIrvine

J. Craig Venter INSTITUTE

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“Instant” Global Microbial Metagenomics CyberCommunity

Over 1500 Registered Users From 50 Countries



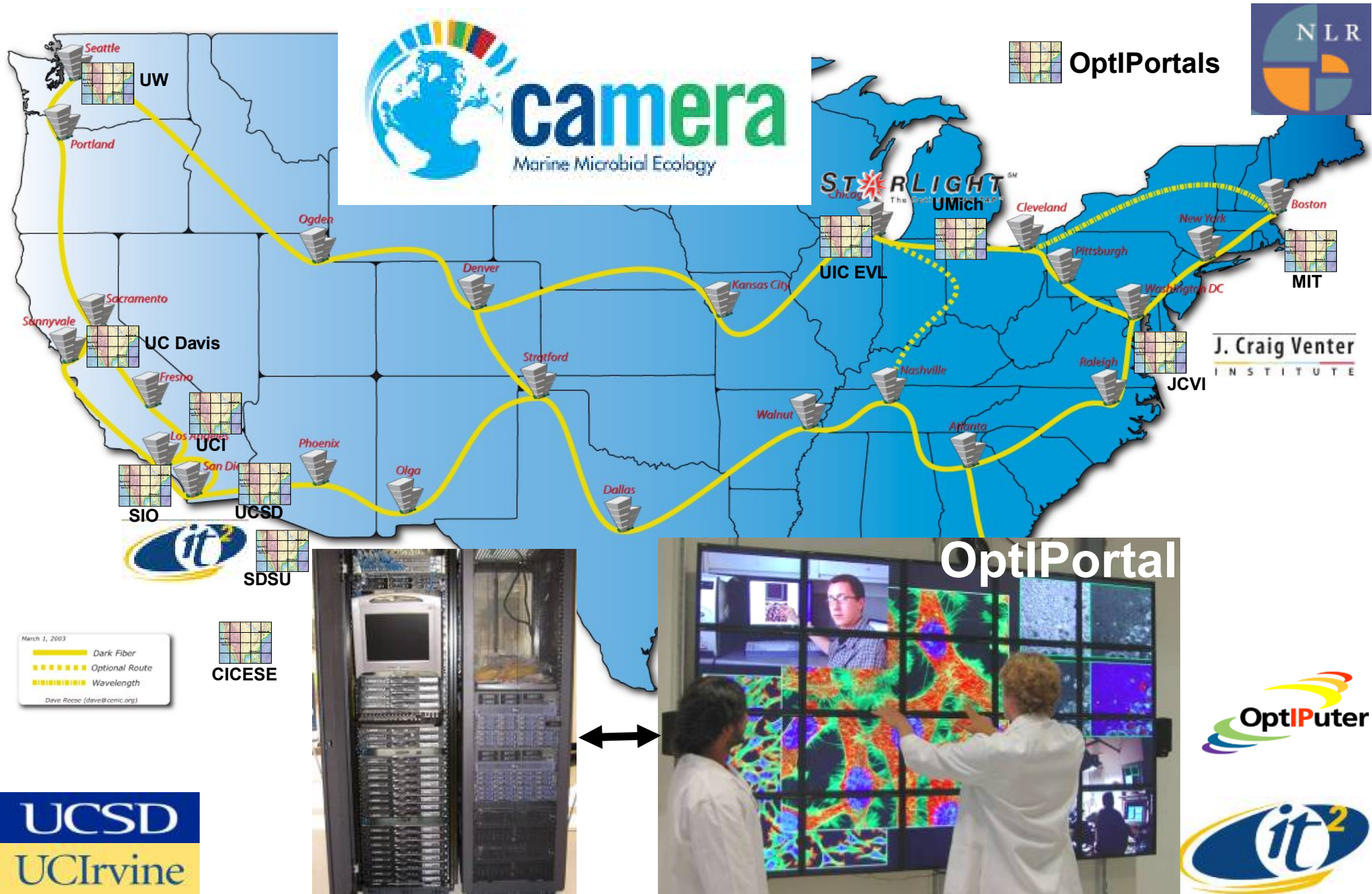
USA	761
United Kingdom	64
Germany	54
Canada	46
France	44
Brazil	33

camera
Marine Microbial Ecology

J. Craig Venter
INSTITUTE

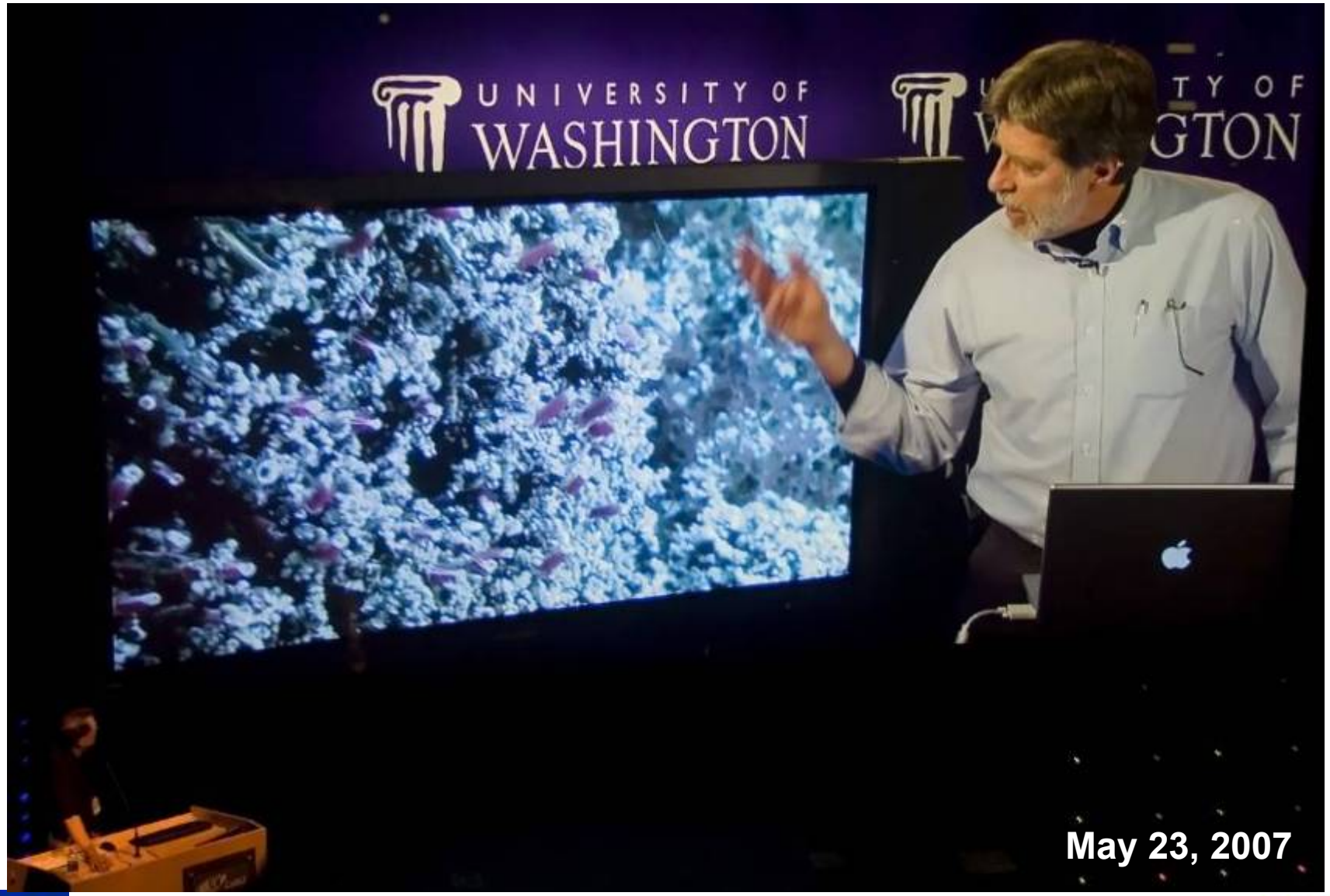
it2

An Emerging High Performance Collaboratory for Microbial Metagenomics



e-Science Collaboratory Without Walls Enabled by Uncompressed HD Telepresence

1500 Mbits/sec Calit2 to UW Research Channel Over NLR

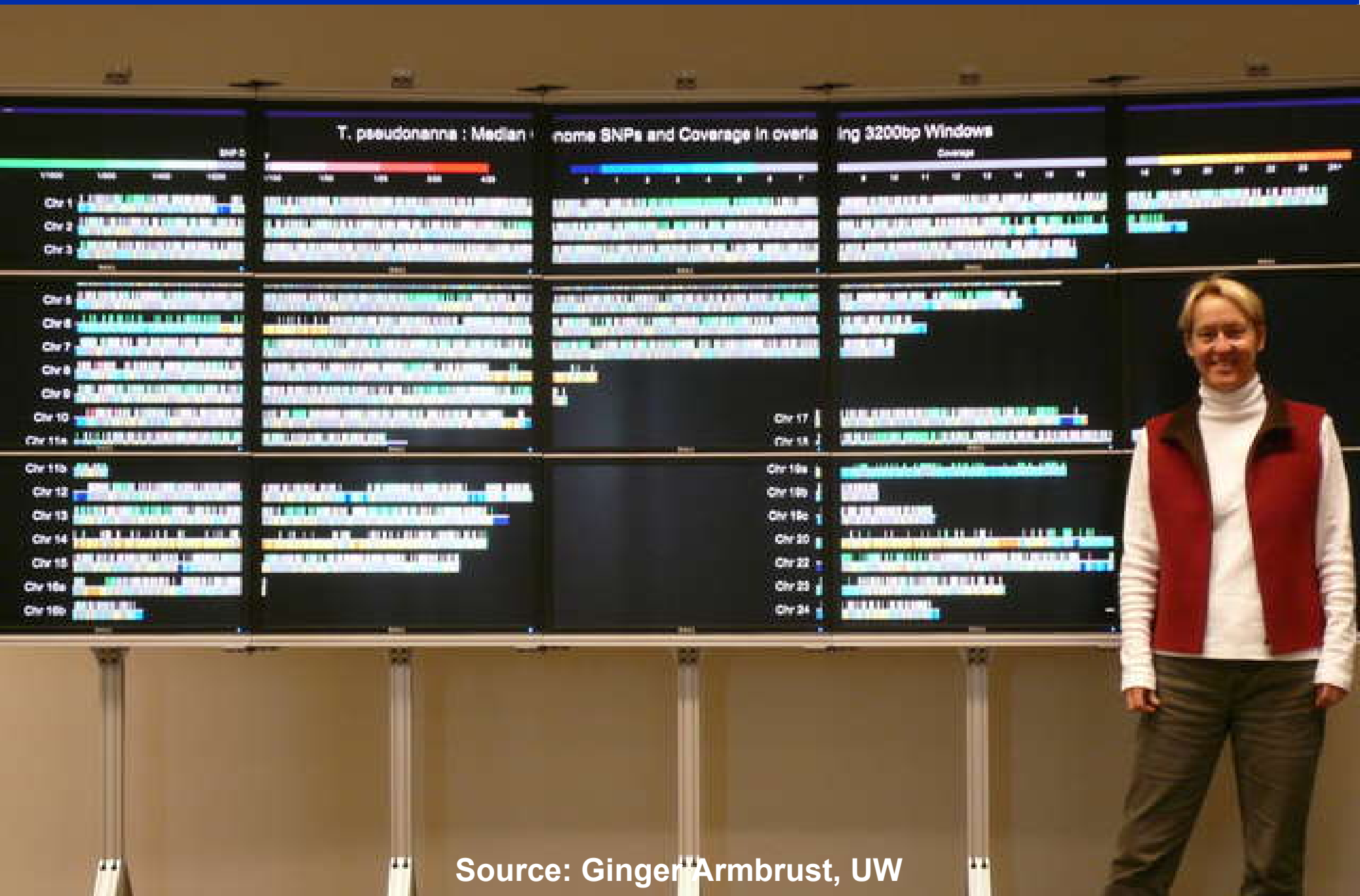


John Delaney, PI LOOKING, Neptune

Photo: Harry Ammons, SDSC

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UCIrvine

New Genome Wall at UWashington
Chromosomes of Marine Diatom Thallasiosira Pseudonanna



Source: Ginger Armbrust, UW

Goal for SC'07
iHDTV Integrated into OptIPortal

SC07 is the International Conference for High Performance Computing, Networking, Storage and Analysis

11am Thursday

Moving from Compressed HD to Uncompressed iHDTV Reno to UW in Seattle





Source: Michael Wellings
Research Channel
Univ. Washington

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UCIrvine

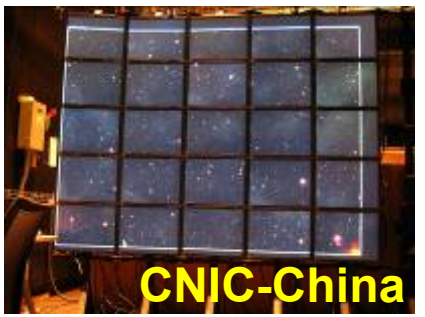
it²

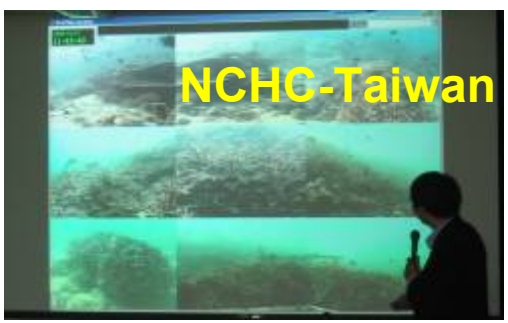
Rocks / SAGE OptIPortals Are Being Adopted Globally—Connecting at 10G via GLIF


AIST-Japan


KISTI-Korea


UZurich


CNIC-China


NCHC-Taiwan


Osaka U-Japan

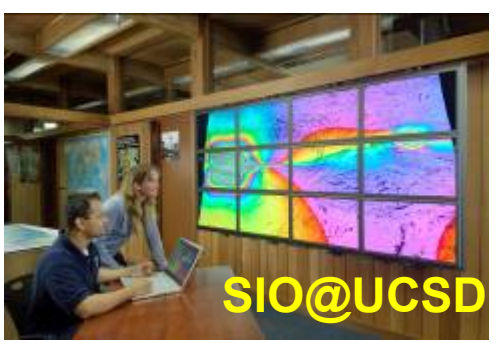

NCSA & TRECC


UIC


Calit2@UCI


Calit2@UCSD


NCMIR@UCSD


SIO@UCSD

UCSD
UCIrvine

Powered by Rocks ROCKS

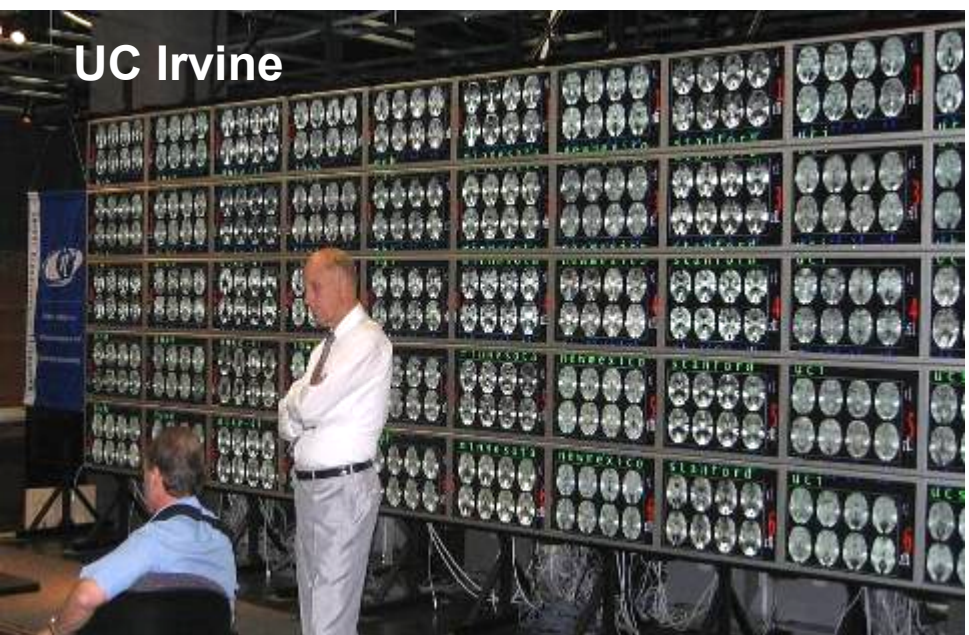
evl electronic visualization laboratory

it2

Nearly One Half Billion Pixels in Calit2 Extreme Visualization Project!

Connected at 2,000 Megabits/s!







UCI HIPerWall Analyzing Pre- and Post- Katrina

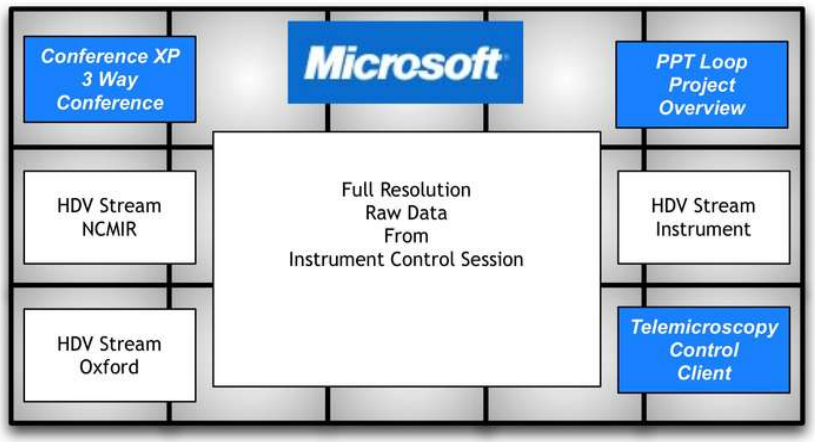
UCSD
UCIrvine

Falko Kuester, UCSD; Steven Jenks, UCI

Intercontinental Telemicroscopy over Lambda Network

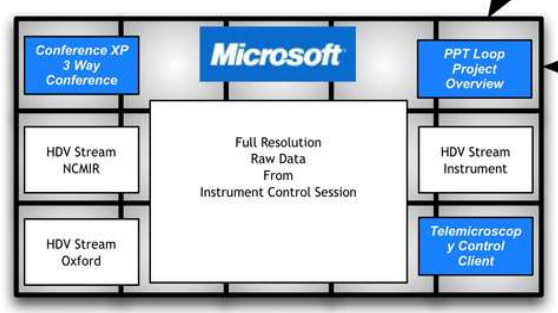
- Remote Control of High End Instrumentation
- Ultra-high Resolution Tiled Displays
- HPC Parallel Computing
- Multi-cast HDTV Streaming

Featuring:
Winccs, .NET, MS-SAGE

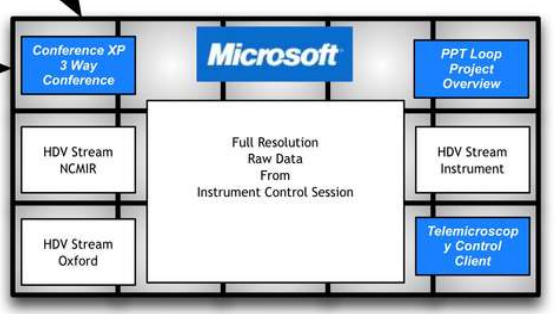


SC2007 - Telemicroscopy Experiment Control Center





NCMIR - Telemicroscopy Experiment Control Center



Oxford - Telemicroscopy Experiment Control Center



UCSD
UCIrvine

NCMIR

oerc
Oxford e-Research Centre

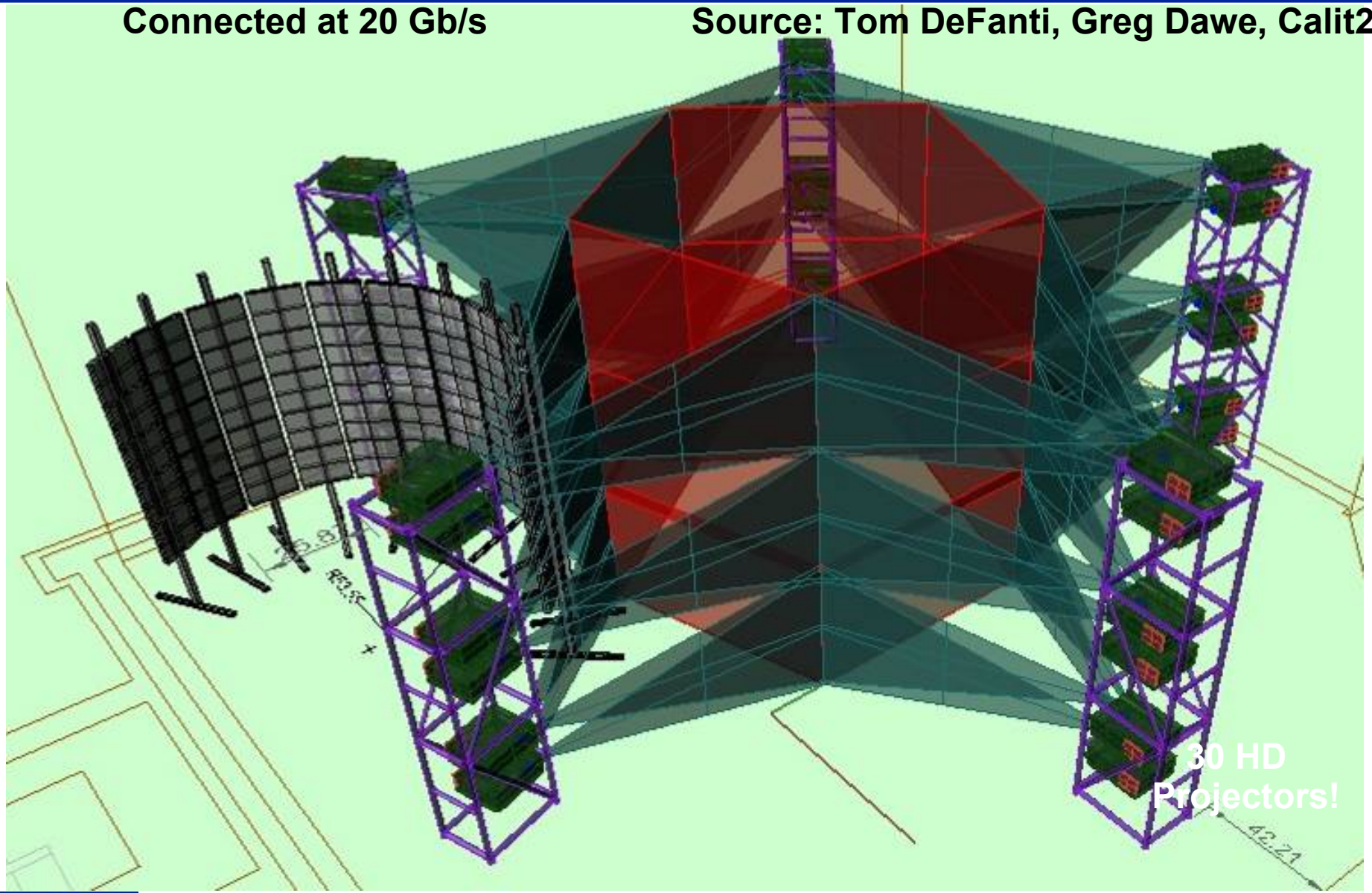
it2

Beyond the OptIPortal LambdaTable, StarCAVE, and Varrier



3D OptIPortals: Calit2 StarCAVE and Varrier Alpha Tests of Telepresence "Holodecks"

Connected at 20 Gb/s **Source: Tom DeFanti, Greg Dawe, Calit2**

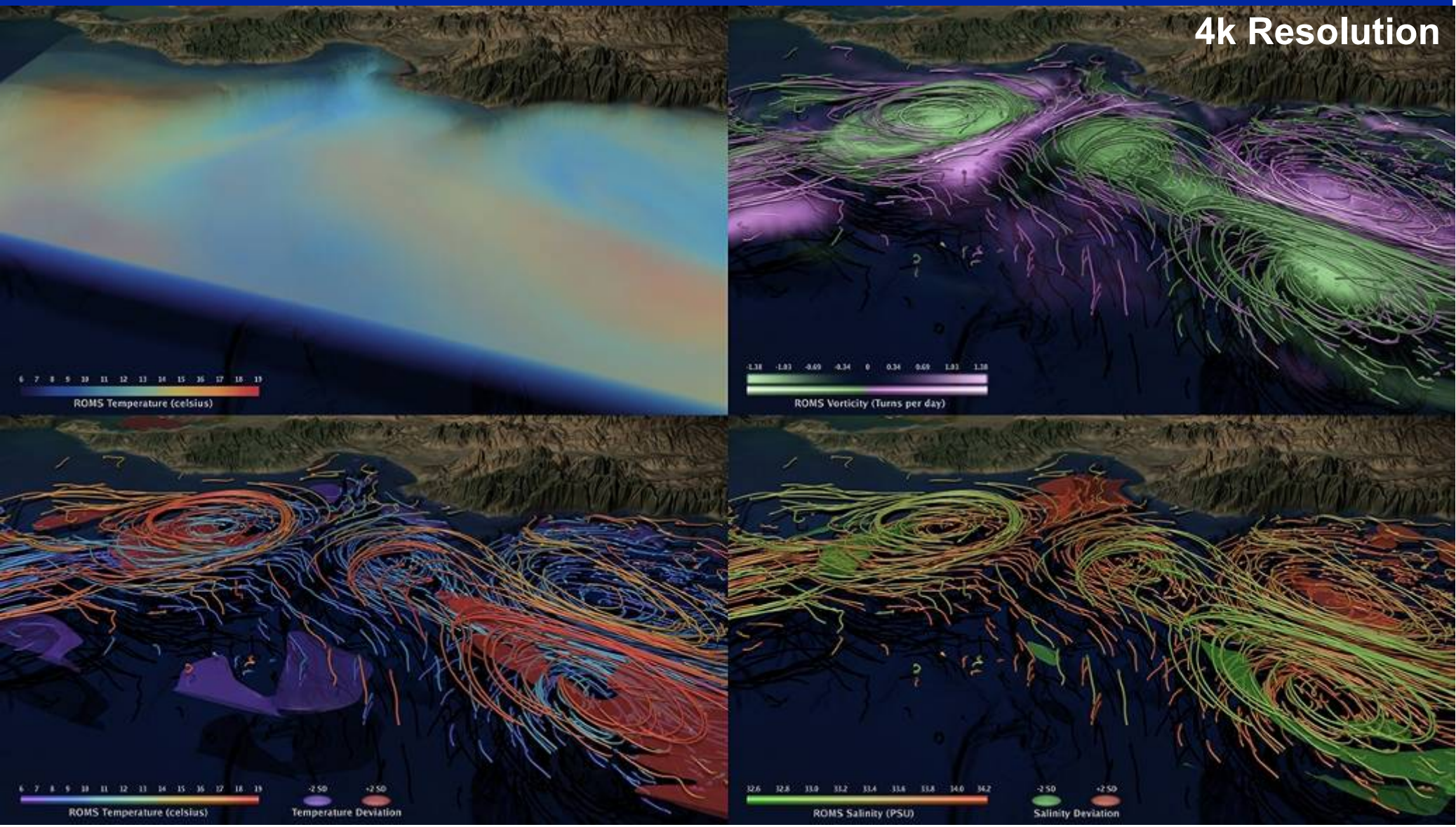


UCSD
UCIrvine

60 GB Texture Memory,
Renders Images 3,200 Times the Speed of Single PC

it²

Beyond HD- 4k For Science
CineGrid Integrates 4k into OptIPortals

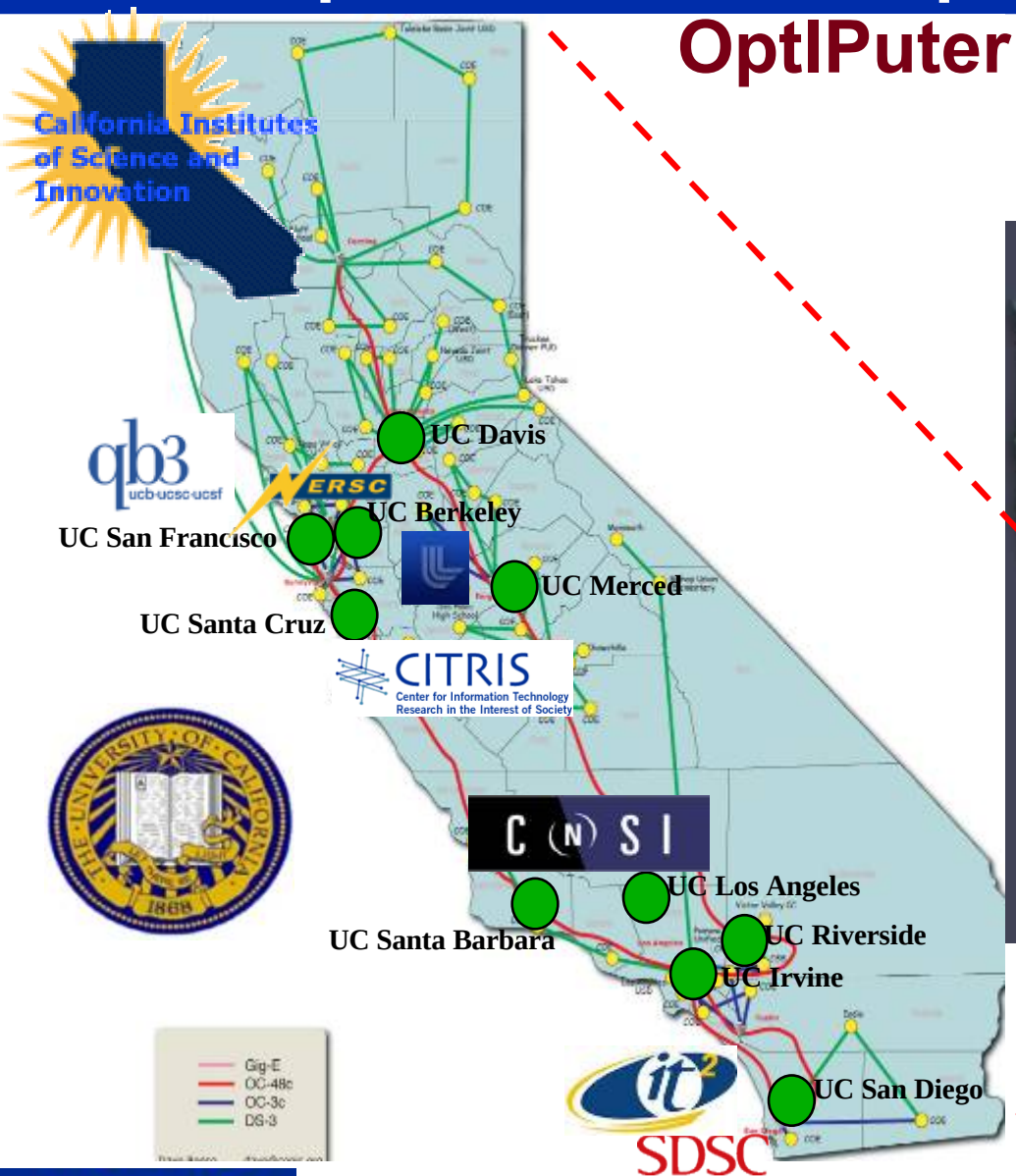


UCSD
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Source: Donna Cox, Robert Patterson, NCSA
Funded by NSF LOOKING Grant

it²

Calit2/SDSC Proposal to Create a UC Cyberinfrastructure of OptIPuter "On-Ramps" to TeraGrid Resources



OptIPuter + CalREN-XD + TeraGrid = "OptiGrid"



Creating a Critical Mass of End Users on a Secure LambdaGrid

UCSD
UCIrvine

Source: Fran Berman, SDSC , Larry Smarr, Calit2

California (CENIC) Network Directions

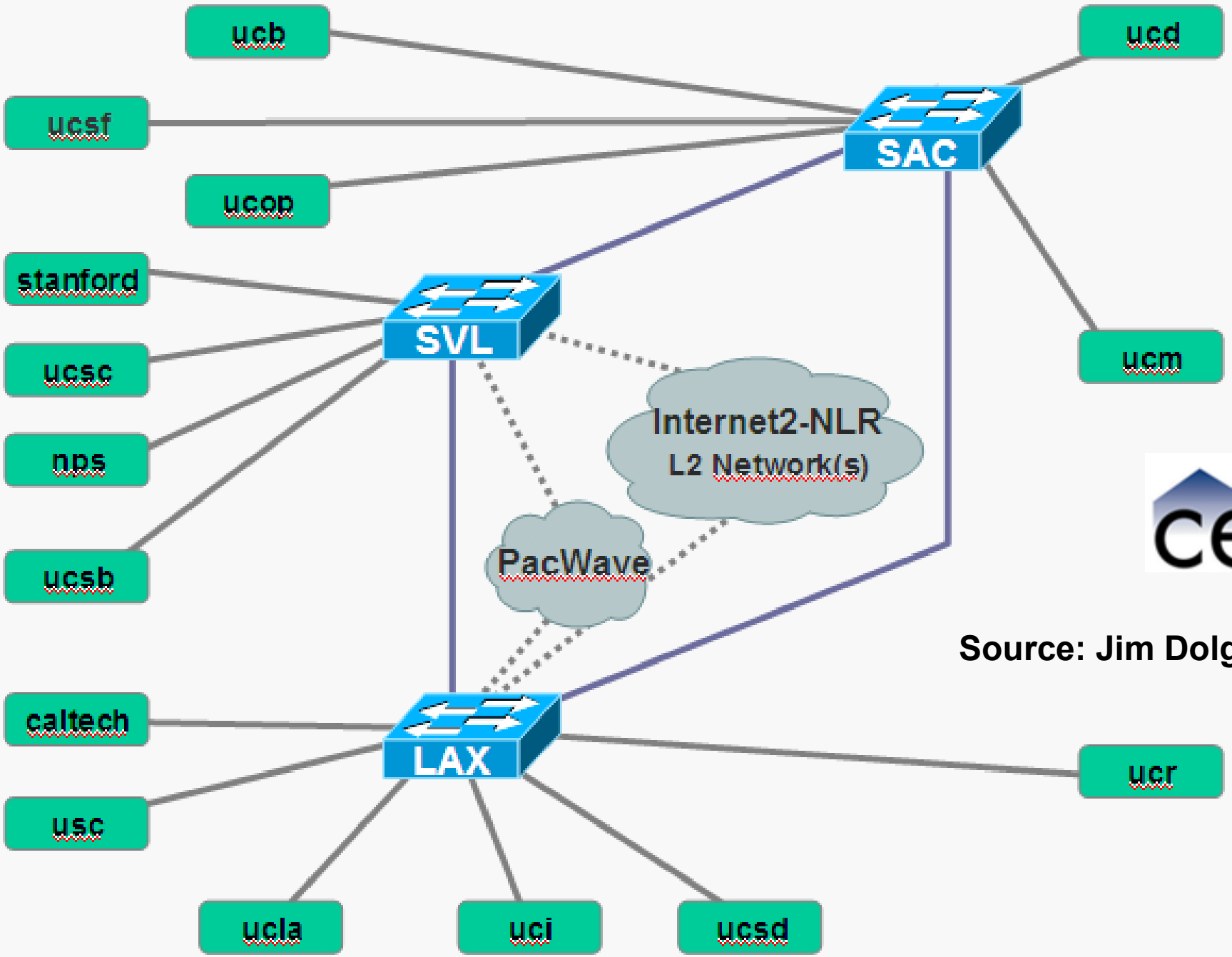
- More Bandwidth to Research University Campuses
  - One or Two 10GE Connections to Every Campus
- More Bandwidth on the Backbone
  - 40Gbps Or 100Gbps
- Support for New Protocols and Features
  - IPv6 Multicast
  - Jumbo Frames: 9000 (or More) Bytes
- "Hybrid Network" Design, Incorporating Traditional Routed IP Service and the New Frame and Optical Circuit Services:
  - "HPRng-L3" = Routed IP Network
  - "HPRng-L2" = Switched Ethernet Network
  - "HPRng-L1" = Switched Optical Network

} CalREN-XD

UCSD UCIrvine

Source: Jim Dolgonas, CENIC

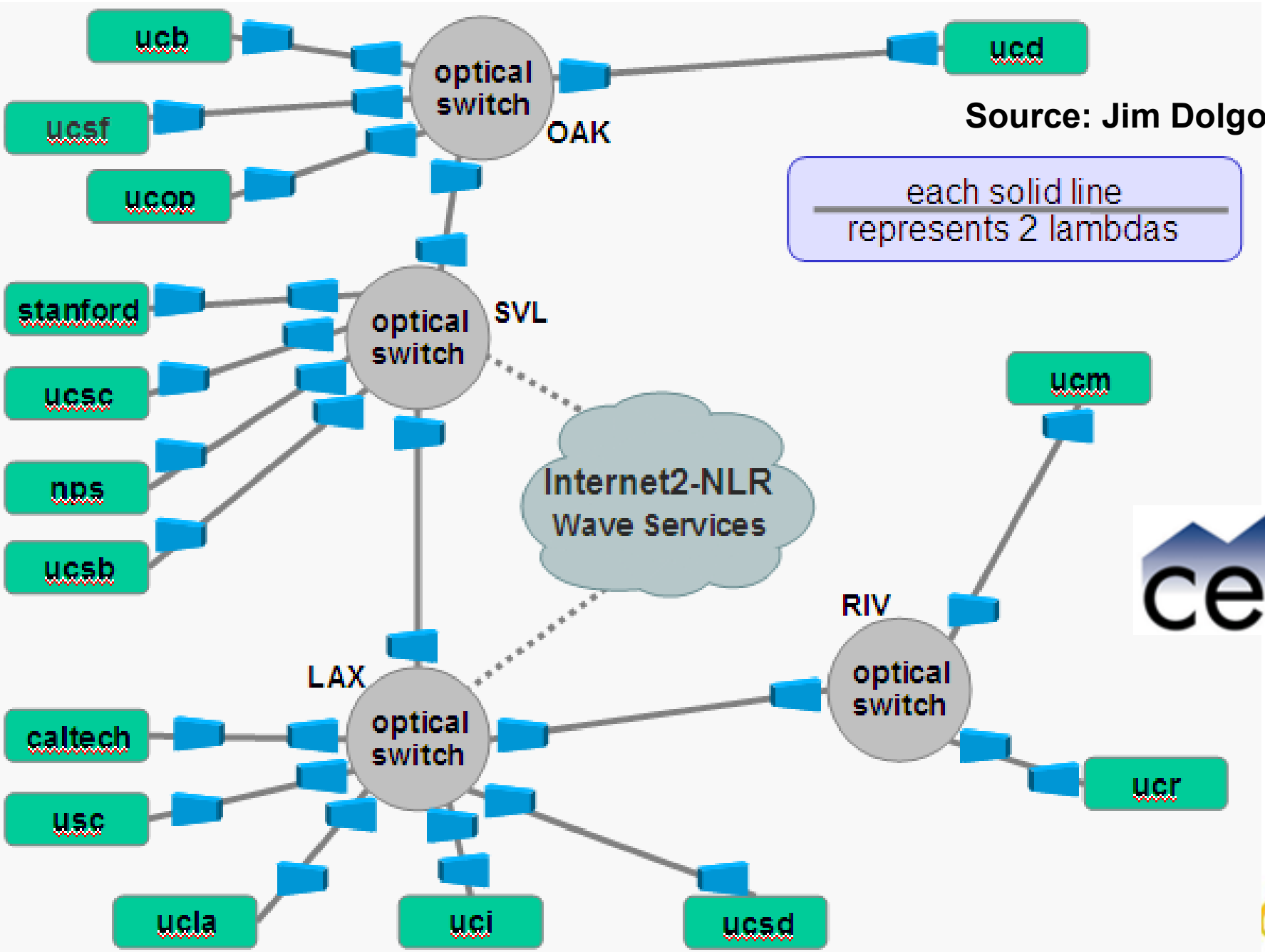
CENIC Switched Ethernet Network
HPRng-L2 Design



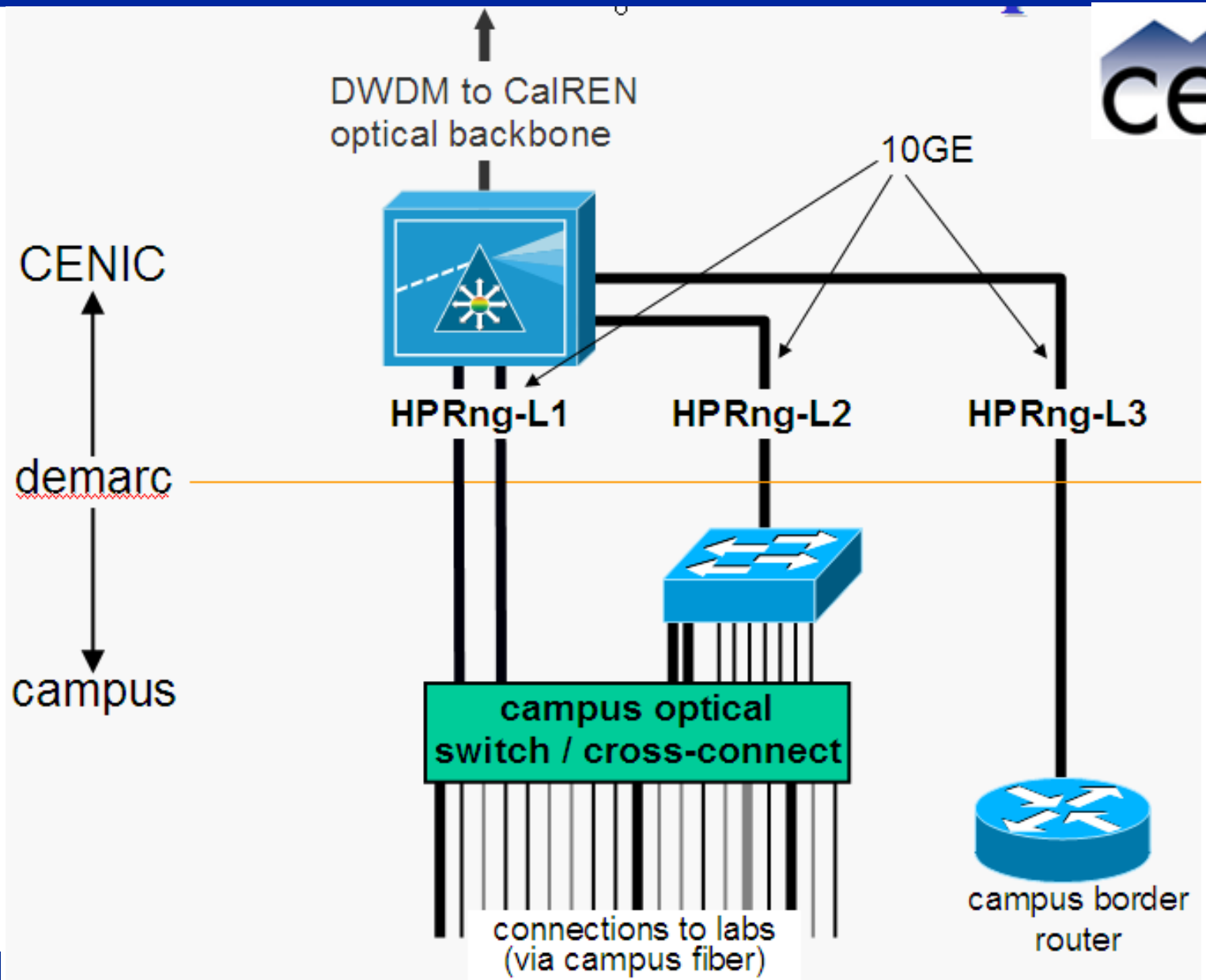
cenic

Source: Jim Dolgonas, CENIC

CENIC Switched Optical Network
HPRng-L1 design

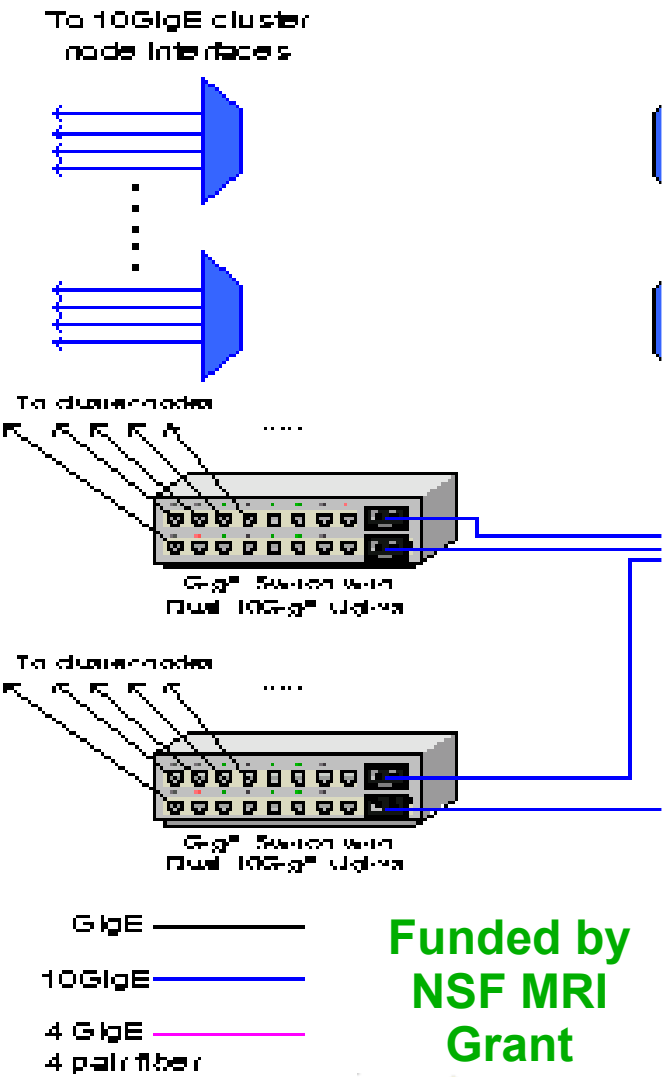


Campus Preparations Needed to Create Lambda "On-Ramps" to Their Campus Researchers



Source: Jim Dolgonas, CENIC

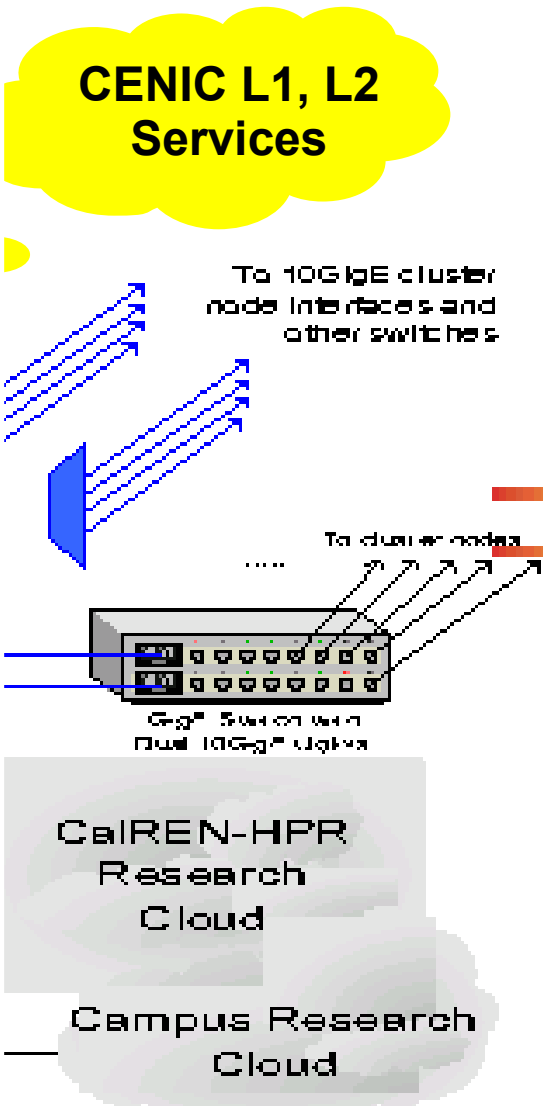
Current UCSD Experimental Optical Core: Ready to Couple to CENIC L1, L2, L3 Services



Goals by 2008:

- >= 50 endpoints at 10 GigE
- >= 32 Packet switched
- >= 32 Switched wavelengths
- >= 300 Connected endpoints

Approximately 0.5 TBit/s Arrive at the "Optical" Center of Campus
Switching will be a Hybrid Combination of:
Packet, Lambda, Circuit -- OOO and Packet Switches Already in Place



Funded by NSF MRI Grant

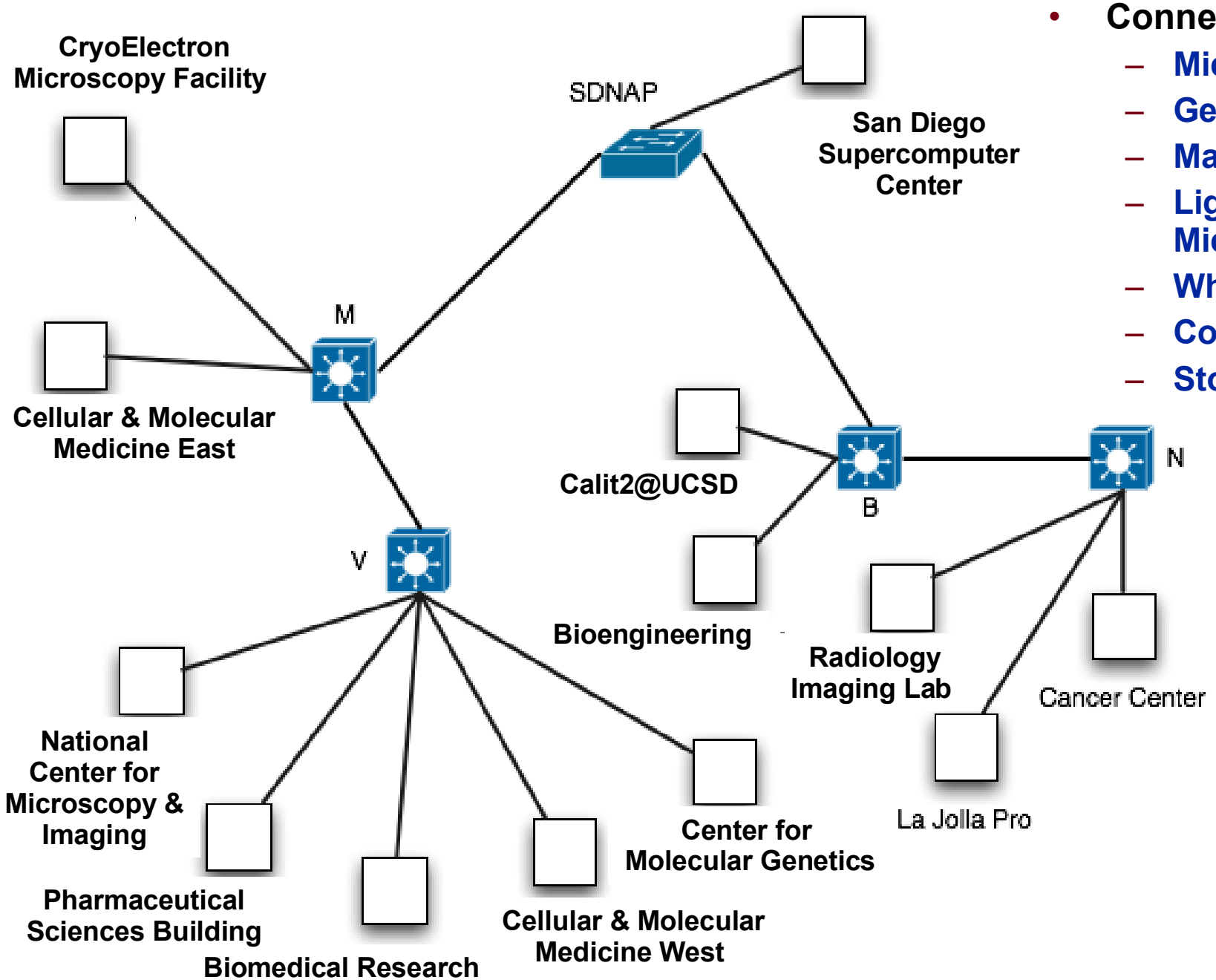
OptIPuter Border Router

Source: Phil Papadopoulos, SDSC/Calit2 (Quartzite PI, OptIPuter co-PI)

UCSD UCIrvine

it2

UCSD Planned Optical Networked Biomedical Researchers and Instruments

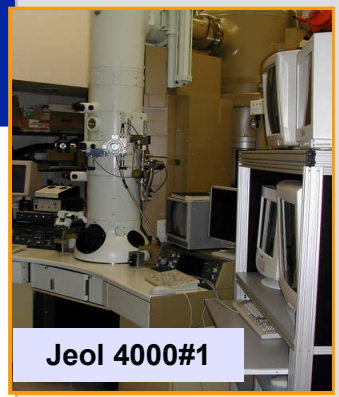


- **Connects at 10 Gbps :**
  - **Microarrays**
  - **Genome Sequencers**
  - **Mass Spectrometry**
  - **Light and Electron Microscopes**
  - **Whole Body Imagers**
  - **Computing**
  - **Storage**

NCMIR FACILITIES

Internal Imaging Instruments

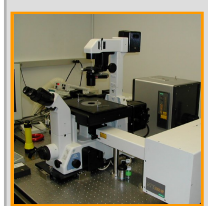
Electron Microscopes


Jeol 4000#1


Jeol 4000 #2

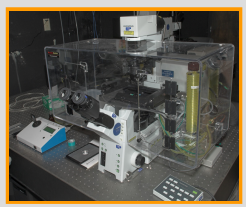
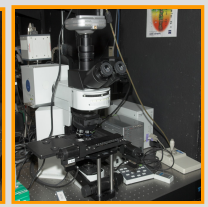

Jeol 3200

Light Microscopes



Nikon Custom High Speed 2 photon Systems


BioRad/Zeiss Radiance

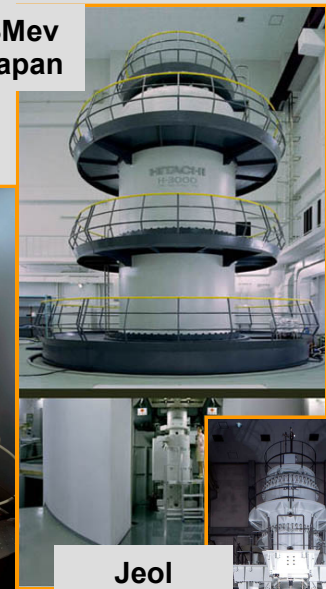


Olympus Co-development Systems

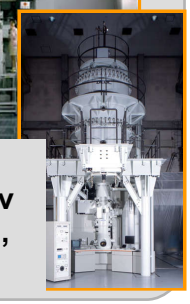
External Imaging Instruments


Jeol 200 KV Fully Corrected Oxford, U.K.

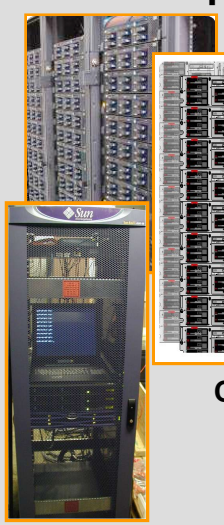

4Pi Microscope Bar Harbor, Jackson Labs

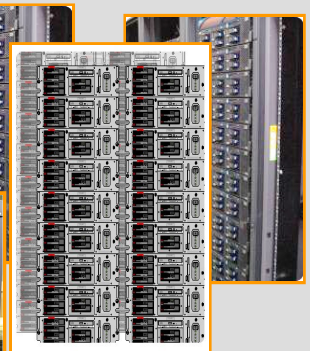
Hitachi 3Mev Osaka, Japan



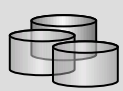

Jeol 1.25Mev Daejon, Korea

Computation and Storage Resources


BIRN Rack


Clusters


Storage






Optical Networking

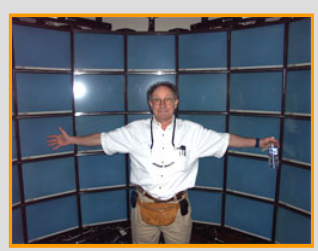

CCDB

OptIPuter

Vizualization/Collaboration & Data Exploration


Calit2


NCMIR



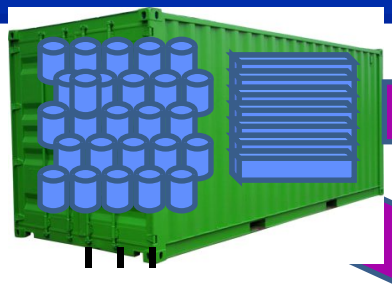
EVL

UCSD UCIrvine

TransPAC evl electronic visualization laboratory INTERNET2 BIRN BIOMEDICAL INFORMATICS RESEARCH NETWORK NCMIR

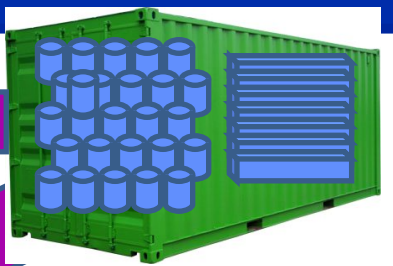
it2

Planned UCSD Production Campus Cyberinfrastructure Supporting Data Intensive Biomedical Research



Active Data Replication

N x 10 Gbit



Eco-Friendly Storage and Compute

N x 10 Gbit

N x 10 Gbit



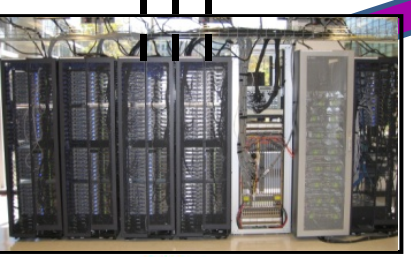
10 Gigabit L2/L3 Switch

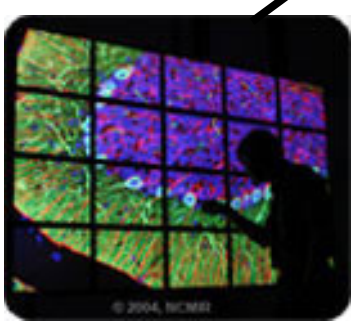
"Network in a box"
- > 200 Connections
- DWDM or Gray Optics

On-Demand Physical Connections

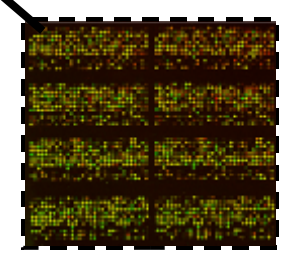
Wide-Area 10G
- CENIC/HPRng
- NLR Cavewave
- I2 NewNet
- Cinegrid
- …

Single 10 Gbit









Microarray

Your Lab Here

camera Marine Microbial Ecology

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NBCR

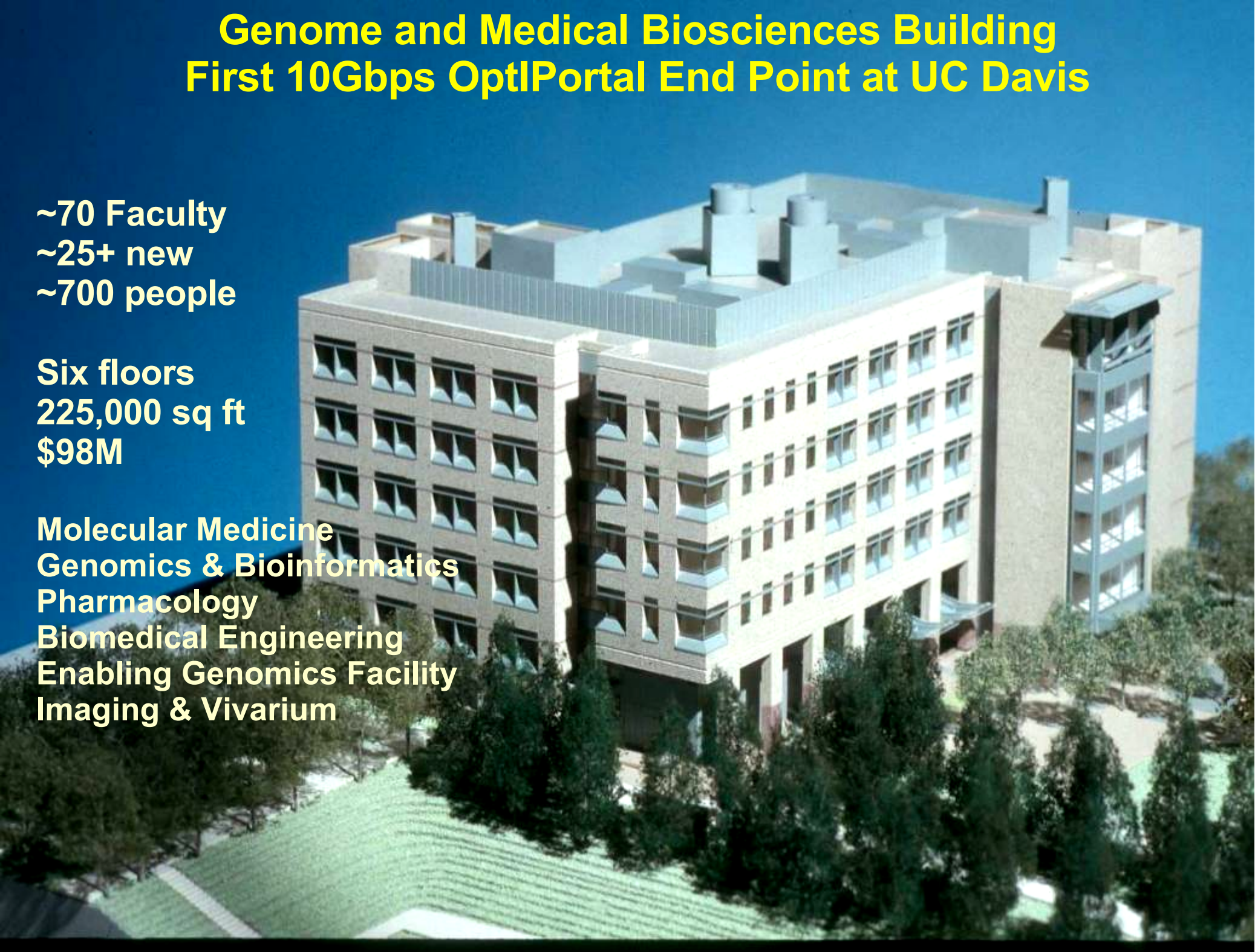
UCSD

UCIrvine

Source: Phil Papadopoulos, SDSC/Calit2; Elazar Harel, UCSD

it2

Genome and Medical Biosciences Building
First 10Gbps OptIPortal End Point at UC Davis



~70 Faculty
~25+ new
~700 people

Six floors
225,000 sq ft
$98M

Molecular Medicine
Genomics & Bioinformatics
Pharmacology
Biomedical Engineering
Enabling Genomics Facility
Imaging & Vivarium