A Cyber-Vision for a 21st Century University of California

Talk to UCOP

Oakland, CA

May 30, 2008

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

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Abstract

During the last few years, a radical restructuring of global optical networks supporting e-Science projects has begun enabling Telepresence, as well as eliminating distance to remote global data repositories, scientific instruments, and computational resources, all from the researcher's campus laboratory. The use of dedicated lightpaths over fiber optic cables enable individual researchers to experience “clear channel” 10,000 megabits/sec, 100-1000 times faster than over today’s shared Internet. I will describe how this user configurable "OptIPuter" global platform opens new frontiers in collaborative work environments, interactive environmental observatories, brain imaging, and marine microbial metagenomics. Because of recent investments by CENIC, the University of California is posed to become the first research university system to bring this ultra-high bandwidth service to the faculty on all ten of its campuses. However, each campus will have to build-out the equivalent of campus “data freeways” in addition to the current shared internet. I will give an update on which campuses are already actively engaged in this activity and the role UCOP can play to accelerate this process…

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Cyberinfrastructure as a "Green Technology": Cisco Telepresence is a Leading Edge Commercial VTC

- 191 Cisco TelePresence in Major Cities Globally
  - US/Canada: 83 CTS 3000, 46 CTS 1000
  - APAC: 17 CTS 3000, 4 CTS 1000
  - Japan: 4 CTS 3000, 2 CTS 1000
  - Europe: 22 CTS 3000, 10 CTS 1000
  - Emerging: 3 CTS 3000
- Overall Average Utilization is 45%

- 85,854 TelePresence Meetings Scheduled to Date
  - Weekly Average is 2,263 Meetings
- 108,736 Hours
  - Average is 1.25 Hours

- 13,450 Meetings Avoided Travel
  Average to Date
  (Based on 8 Participants)

  ~$107.60 M To Date
- Cubic Meters of Emissions Saved 16,039,052 (6,775 Cars off the Road)

Uses QoS Over Shared Internet ~ 15 mbps

Cisco Bought WebEx





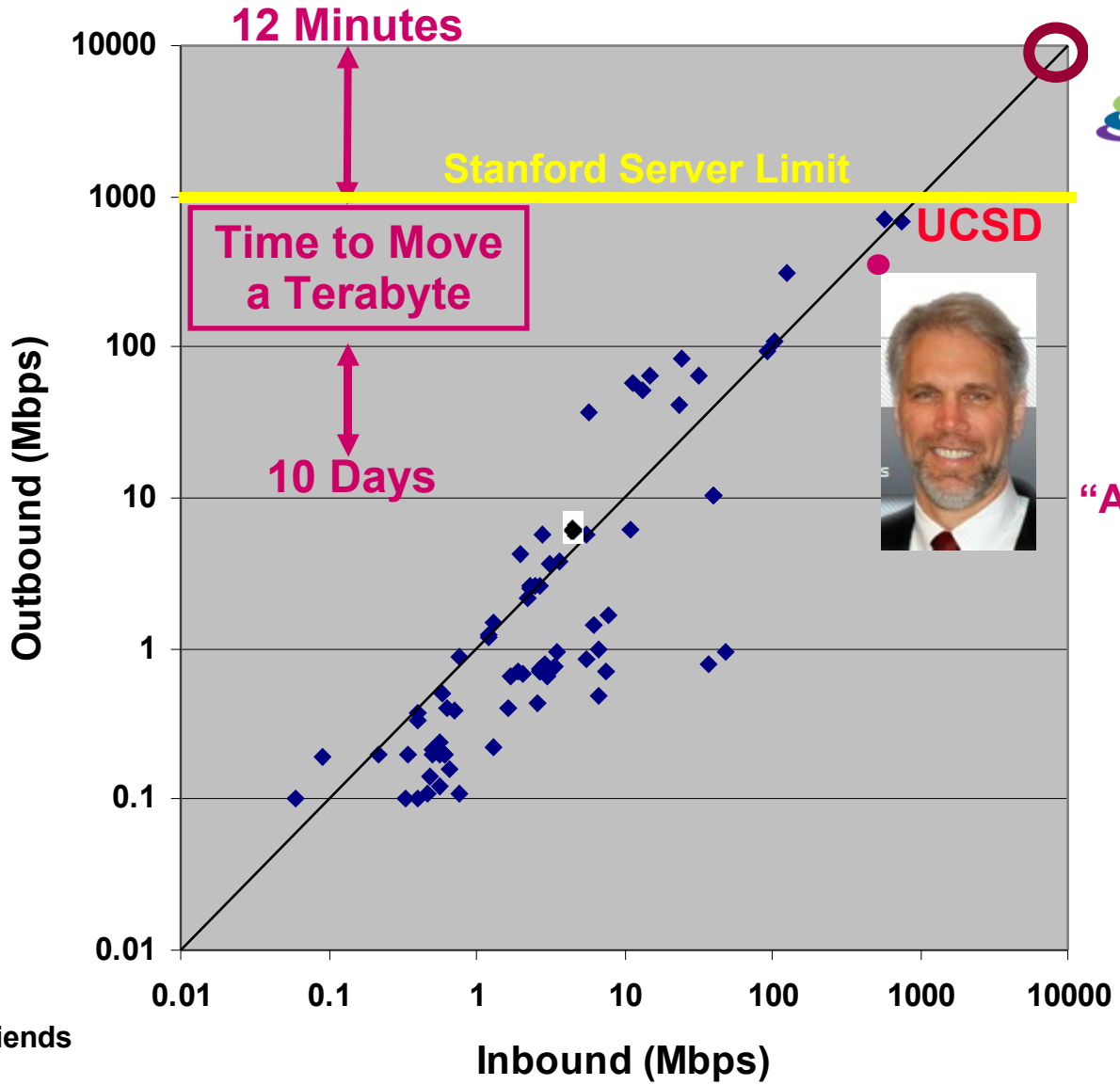
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Source: Cisco 3/22/08

Shared Internet Bandwidth: Unpredictable, Widely Varying, Jitter, Asymmetric

Computers In:

Australia
Canada
Czech Rep.
India
Japan
Korea
Mexico
Moorea
Netherlands
Poland
Taiwan
United States



OptIPuter

1000x Normal Internet!

"Average" Bandwidth

Data Intensive Sciences Require Fast Predictable Bandwidth

Source: Larry Smarr and Friends

Measured Bandwidth from User Computer to Stanford Gigabit Server in Megabits/sec
http://netspeed.stanford.edu/

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The Unrelenting Exponential Growth of Data Requires an Exponential Growth in Bandwidth

- **"The Global Information Grid will need to store and access exabytes of data on a realtime basis by 2010"**
  - **Dr. Henry Dardy (DOD), Optical Fiber Conference, Los Angeles, CA USA, Mar 2006**

- **"Each LHC experiment foresees a recorded raw data rate of 1 to several PetaBytes/year"**
  - **Dr. Harvey Neuman (Cal Tech), Professor of Physics**

- **"US Bancorp backs up 100 TB financial data every night – now."**
  - **David Grabski (VP Information Tech. US Bancorp), Qwest High Performance Networking Summit, Denver, CO. USA, June 2006**

- **"The VLA facility is now able to generate 700 Gbps of astronomical data and the Extended VLA will reach 3.2 Terabits per second by 2009."**
  - **Dr. Steven Durand, National Radio Astronomy Observatory, e-VLBI Workshop, MIT Haystack Observatory, Sep 2006**

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Source: Jerry Sobieski MAX / University of Maryland



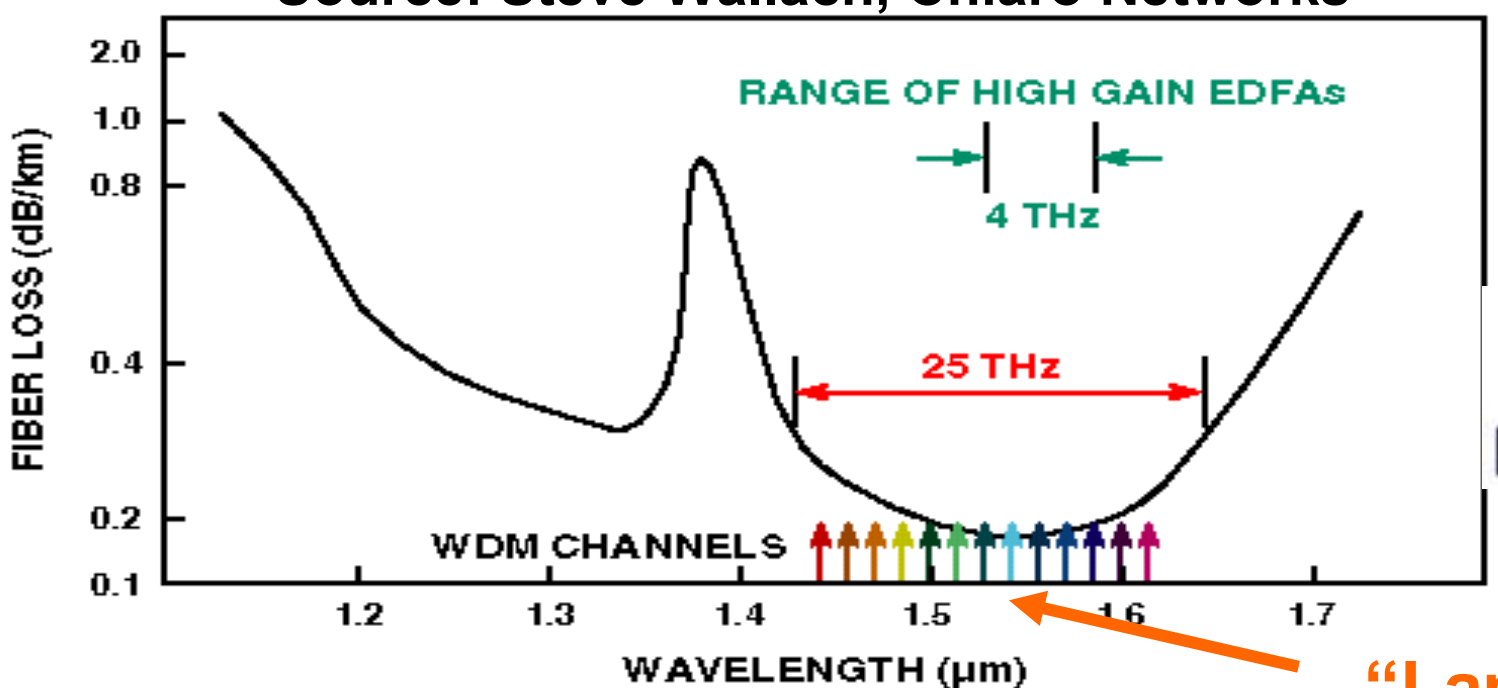
Dedicated Optical Channels Makes High Performance Cyberinfrastructure Possible

WAVELENGTH DIVISION MULTIPLEXING (WDM)

10 Gbps per User ~ 500x Shared Internet Throughput

- EXPLOITS
  - ENORMOUS BANDWIDTH OF SILICA FIBER
  - HIGH-GAIN WIDEBAND OPTICAL AMPLIFIERS

Source: Steve Wallach, Chiaro Networks



CHIARO

"Lambdas"

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Parallel Lambdas are Driving Optical Networking The Way Parallel Processors Drove 1990s Computing

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National Lambda Rail (NLR) Provides Cyberinfrastructure Backbone for U.S. Researchers

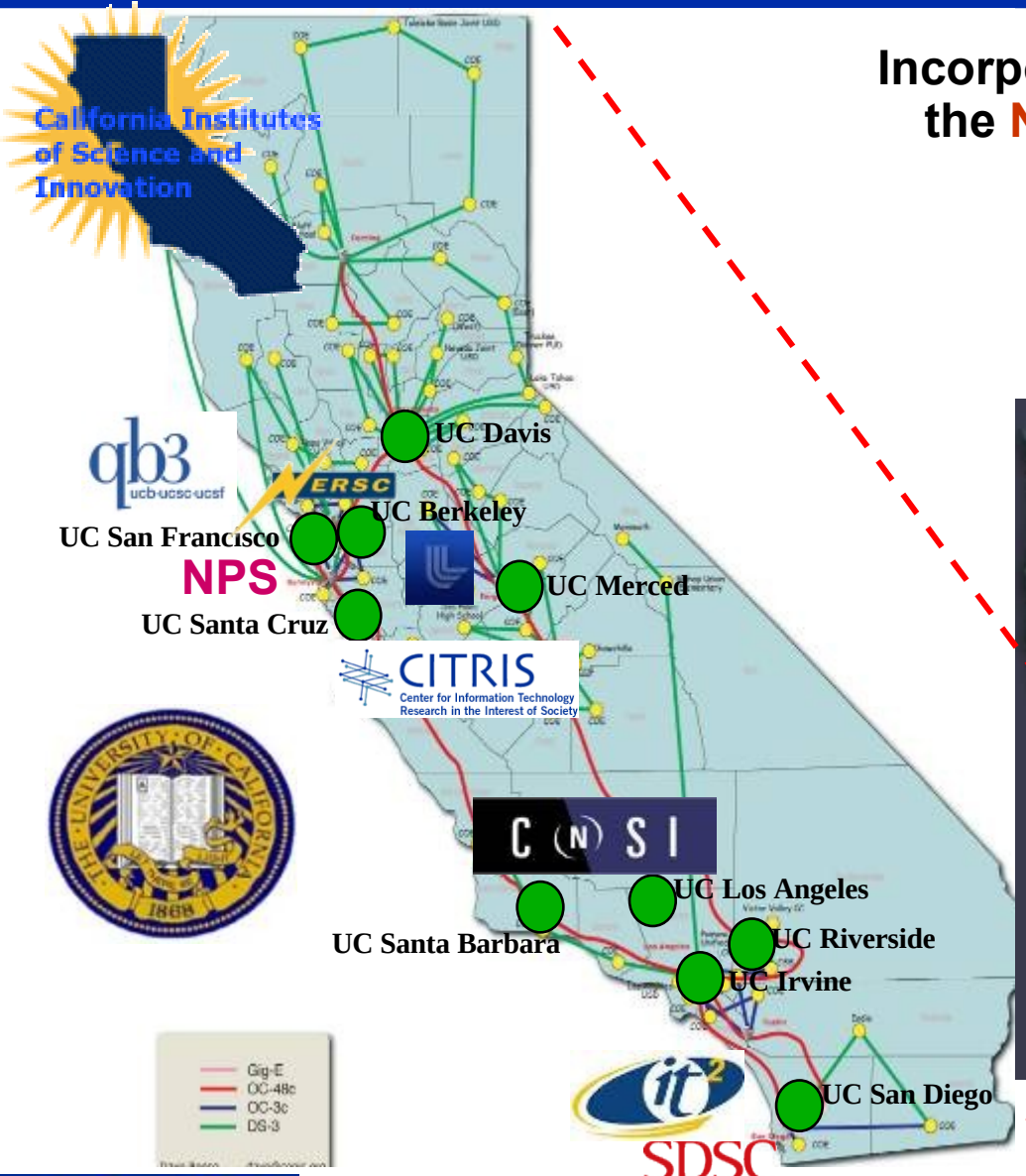


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NLR 4 x 10Gb Lambdas Initially
Capable of 40 x 10Gb wavelengths at Buildout

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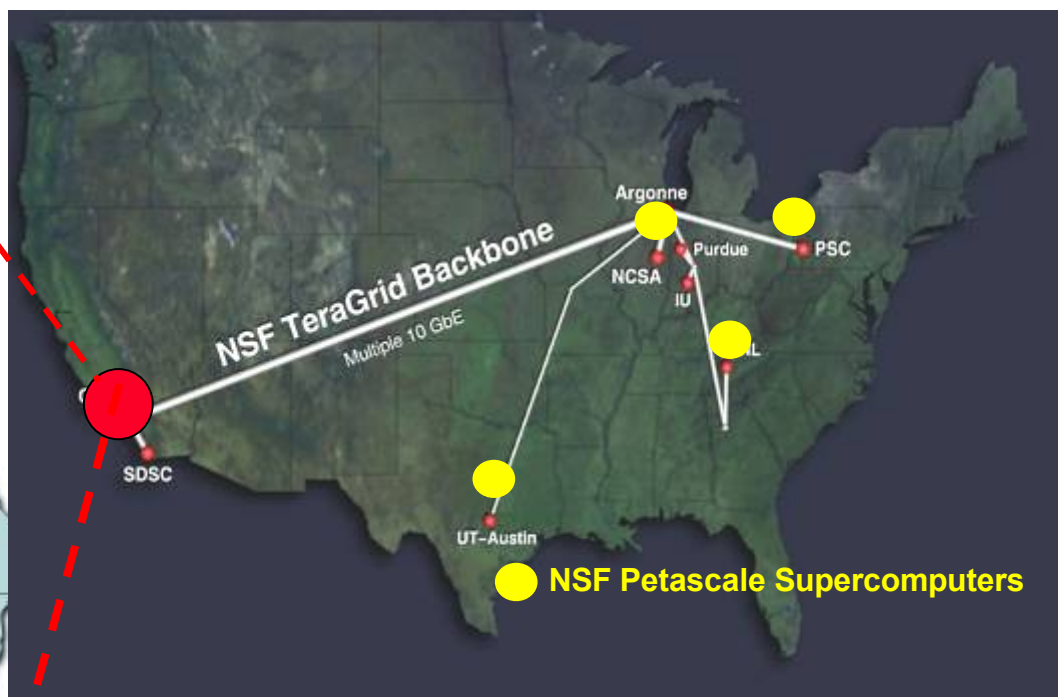
Calit2/SDSC Proposal to Create a UC Cyberinfrastructure of OptIPuter "On-Ramps" to NLR & TeraGrid Resources



CENIC "Hybrid Network"
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

~ $14 M

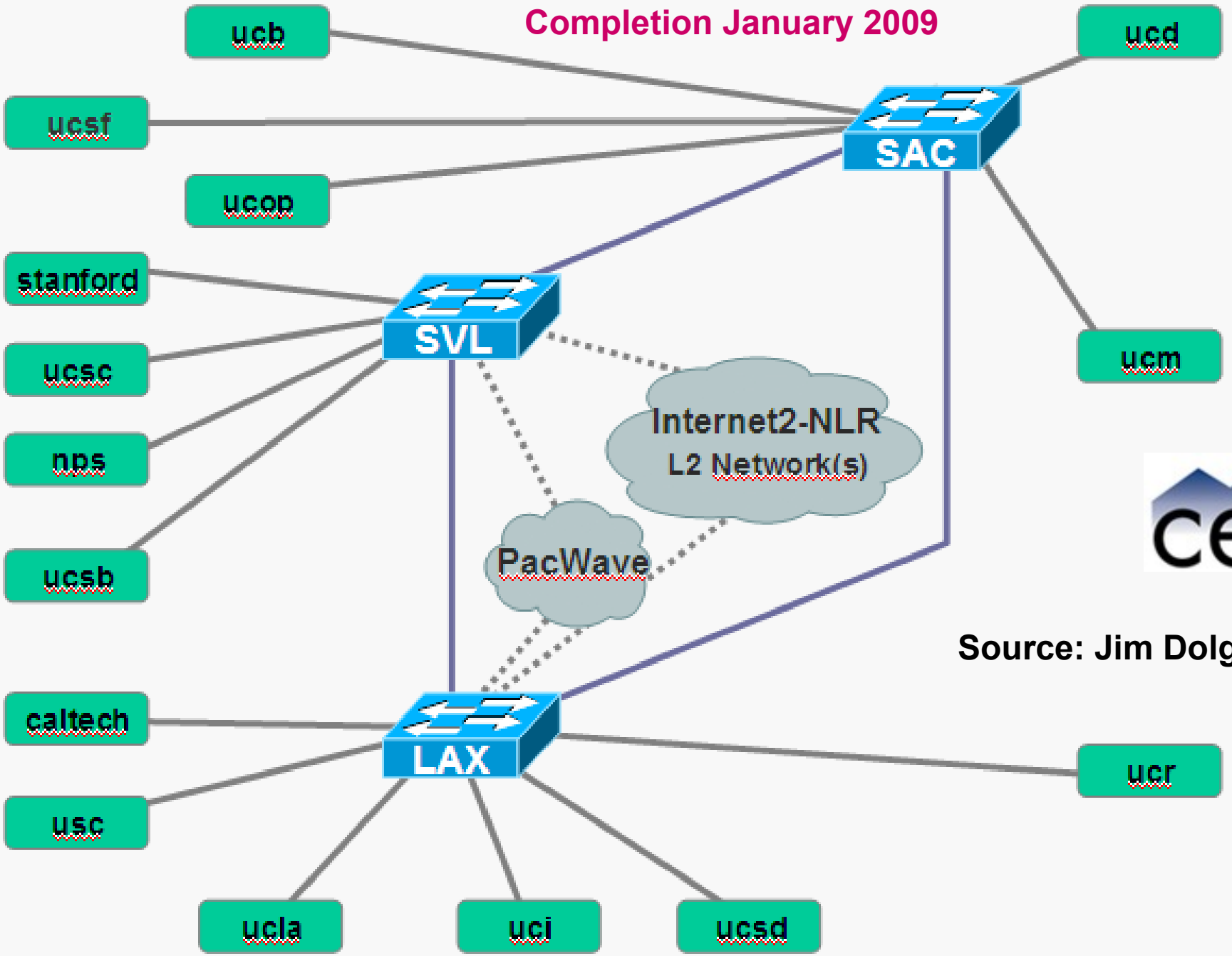


Creating a Critical Mass of End Users on a Secure LambdaGrid

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Source: Fran Berman, SDSC , Larry Smarr, Calit2

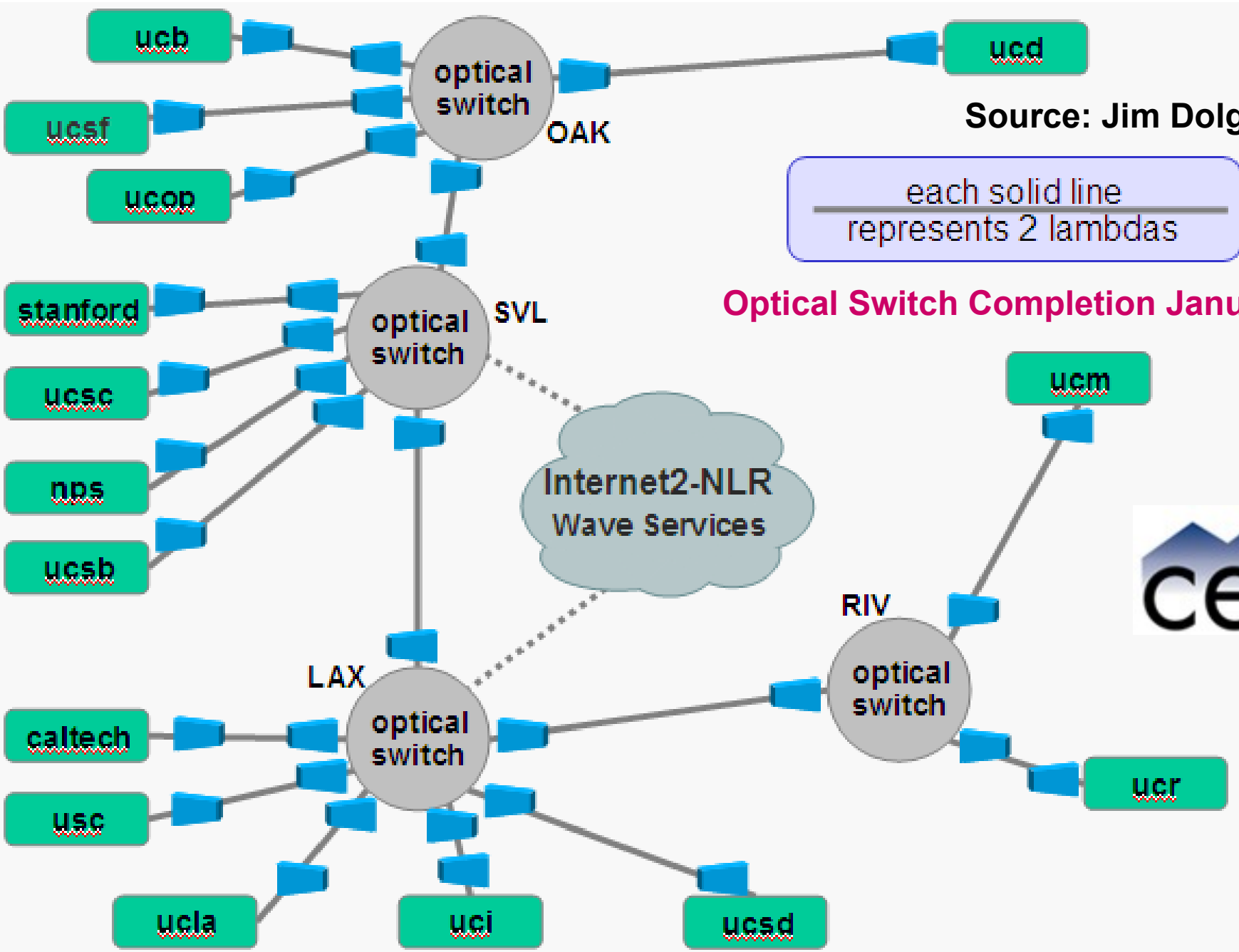
CENIC Switched Ethernet Network
HPRng-L2 Design



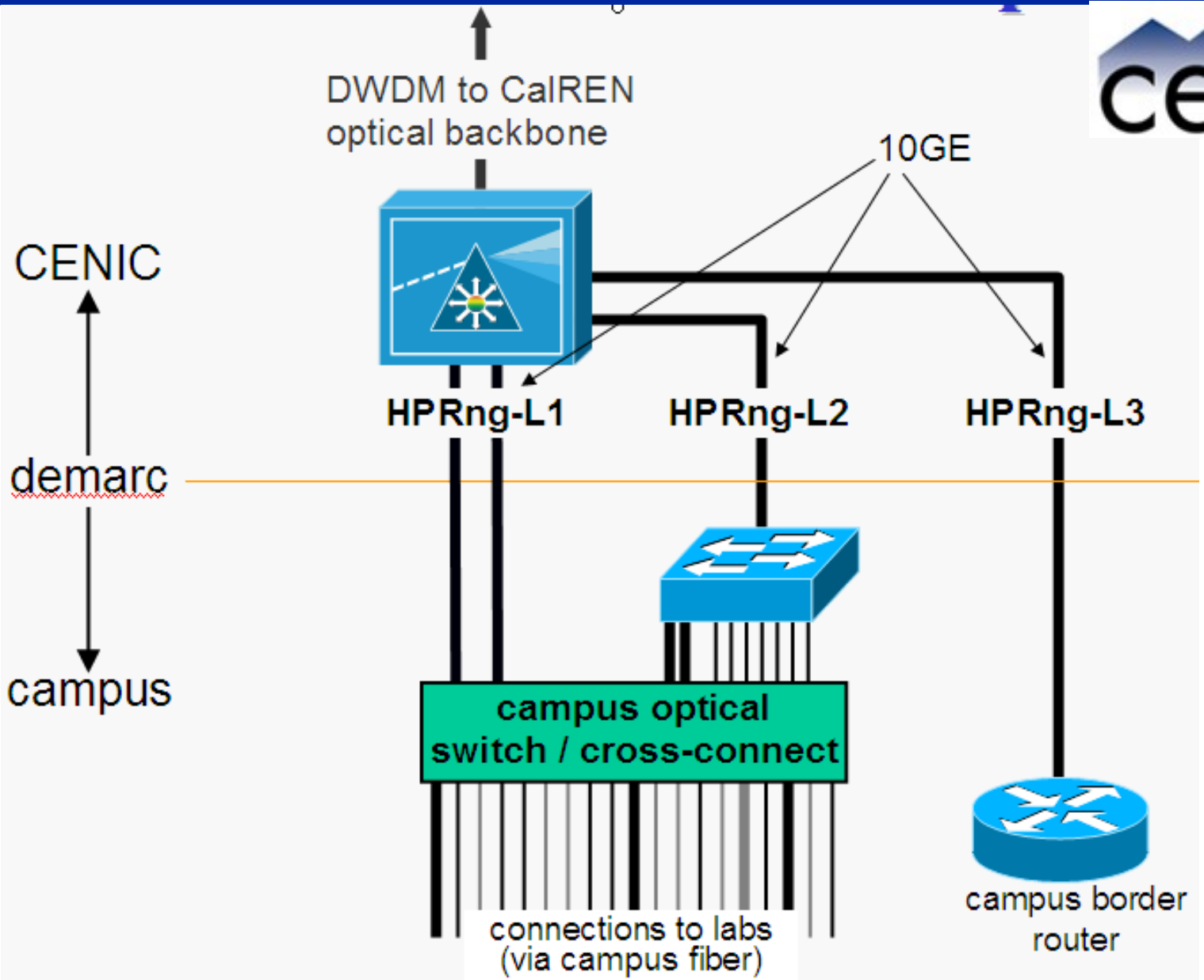
cenic

Source: Jim Dolgonas, CENIC

CENIC Switched Optical Network
HPRng-L1 design

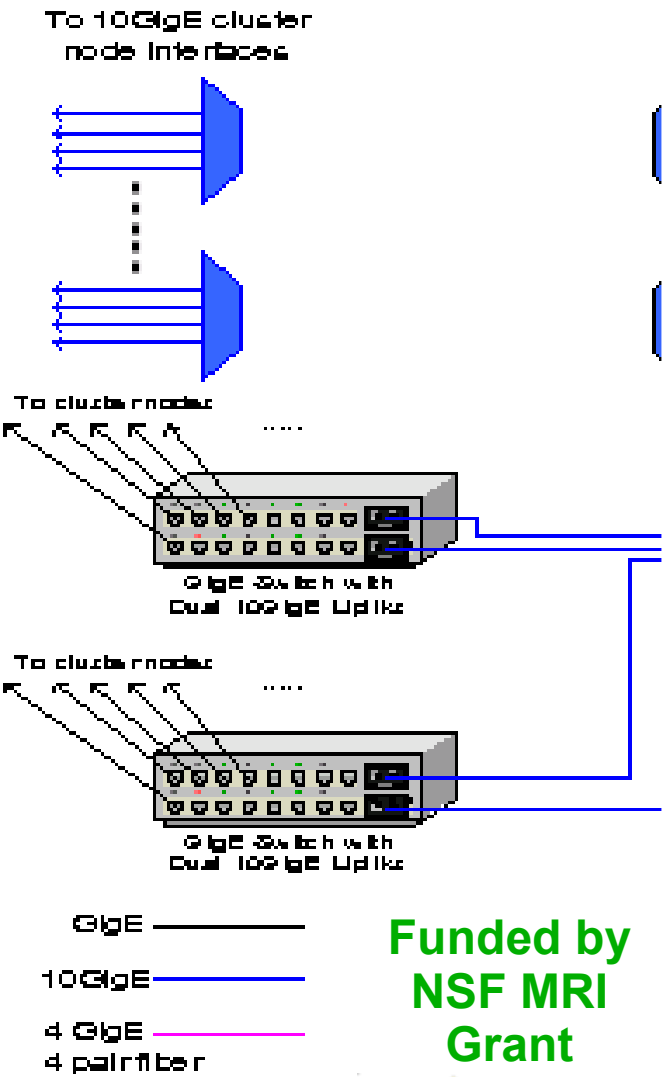


Campus Preparations Needed to Accept CENIC CalREN Handoff to Campus



Source: Jim Dolgonas, CENIC

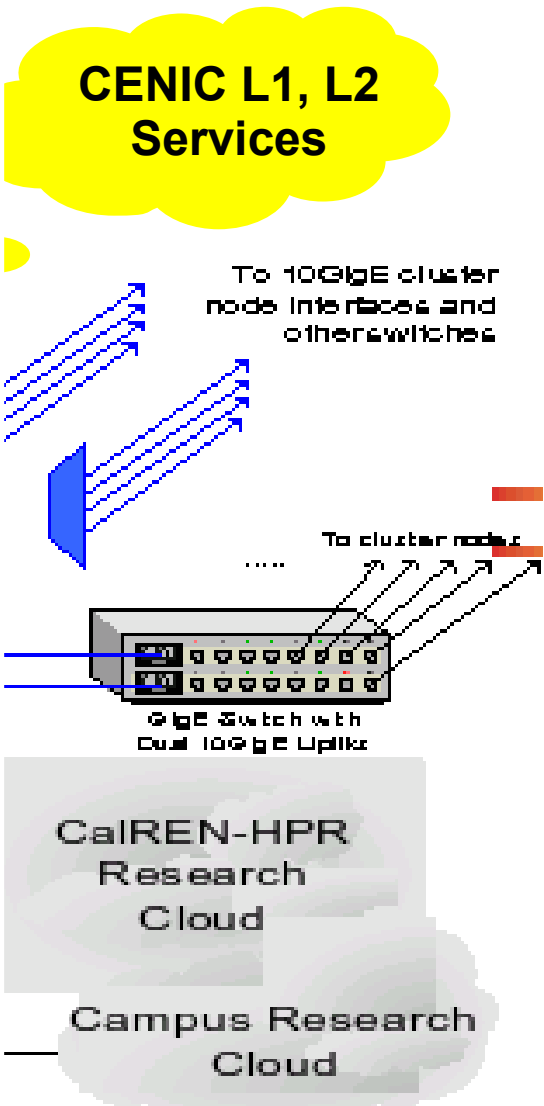
Current UCSD Experimental Optical Core: Ready to Couple to CENIC L1, L2, L3 Services



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

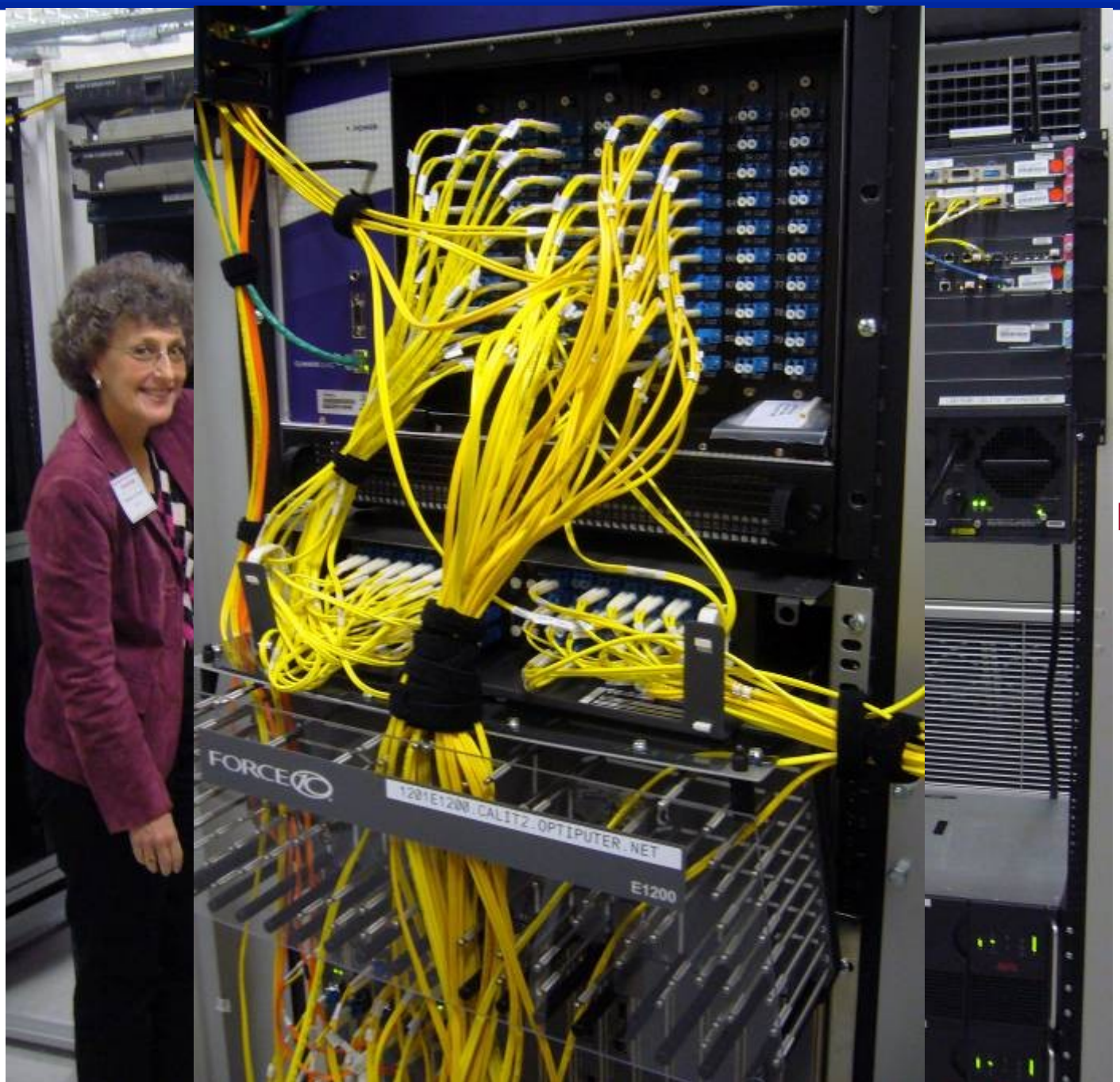


Funded by NSF MRI Grant

OptIPuter Border Router

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

Calit2 Sunlight Optical Exchange Contains Quartzite



10:45 am
Feb. 21, 2008

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Optically Connected "Green" Modular Datacenters: UCSD Installing Two Sun Microsystems Boxes

UCSD Structural Engineering Dept.

Conducted Tests May 2007

UCSD Jacobs School of Engineering



7 Racks plus Network



Takes up 2 Parking Spaces



Data Power Cooling

- **Sun Has Shown up to 40% Reduction in Energy Using Active Management of Disks, CPUs, etc.**
- **Measures Temperature at 40 Points in the Air Stream (5 Spots on 8 Racks), Internal Humidity and Temperature at the Sensor Module, External Temp. and Humidity, Incoming and Exiting Water Temperature and Power Utilization in Each of the 8 Racks**

Sun microsystems

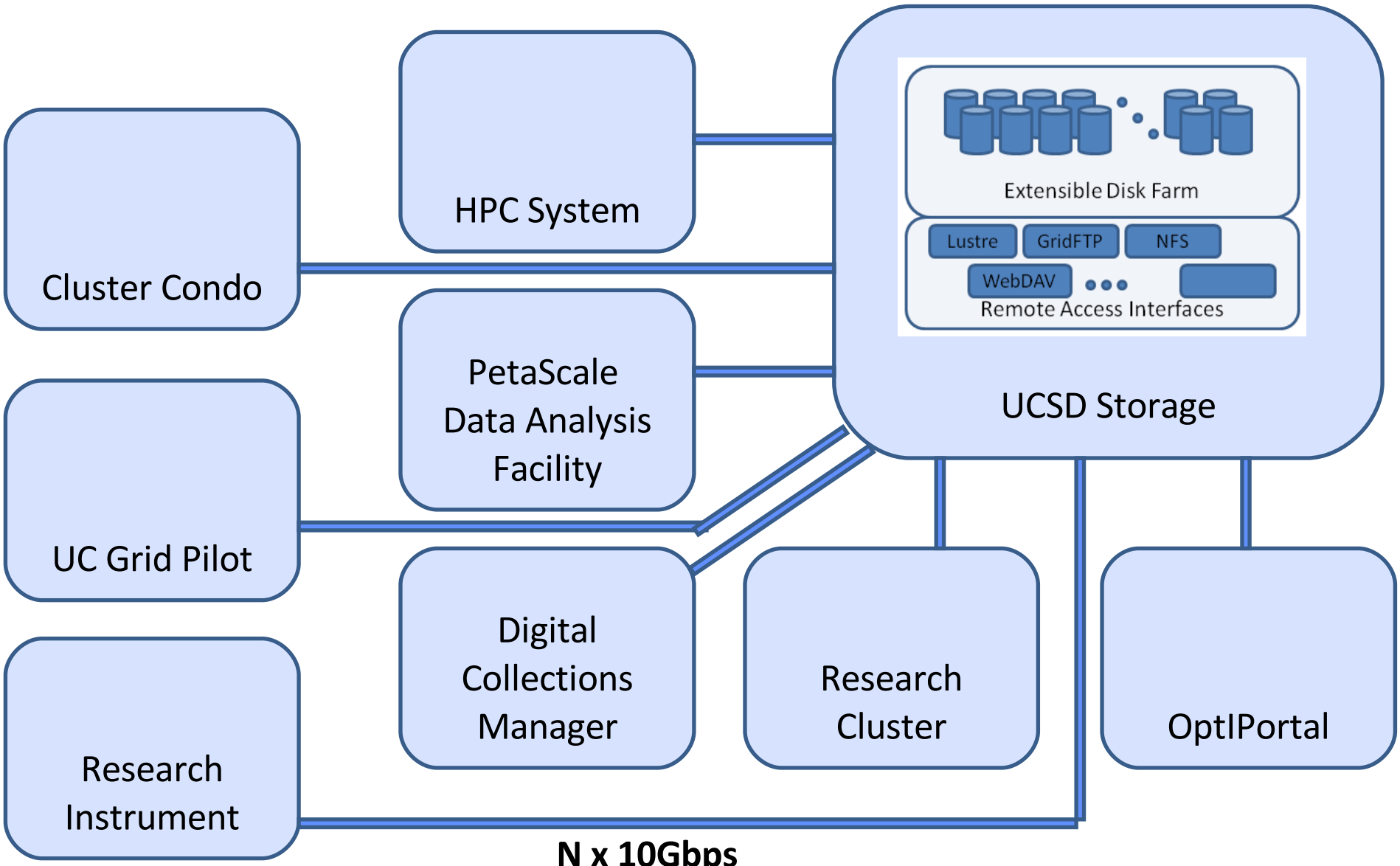
UCSD (Calit2 & SOM) Bought Two Sun Boxes May 2008

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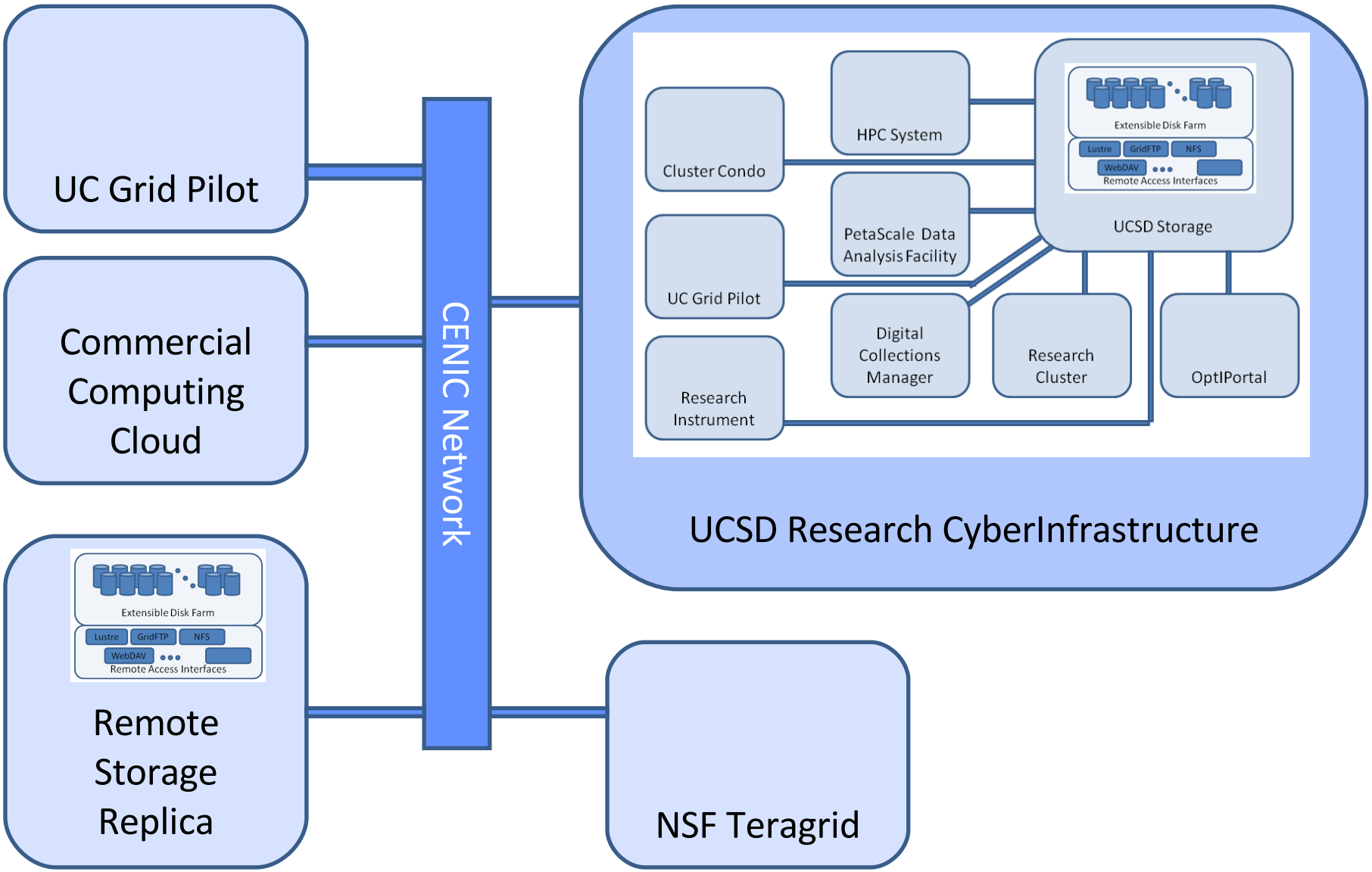
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Use Campus Investment in Fiber and Networks to Physically Connect Campus Resources



Source:Phil Papadopoulos, SDSC/Calit2

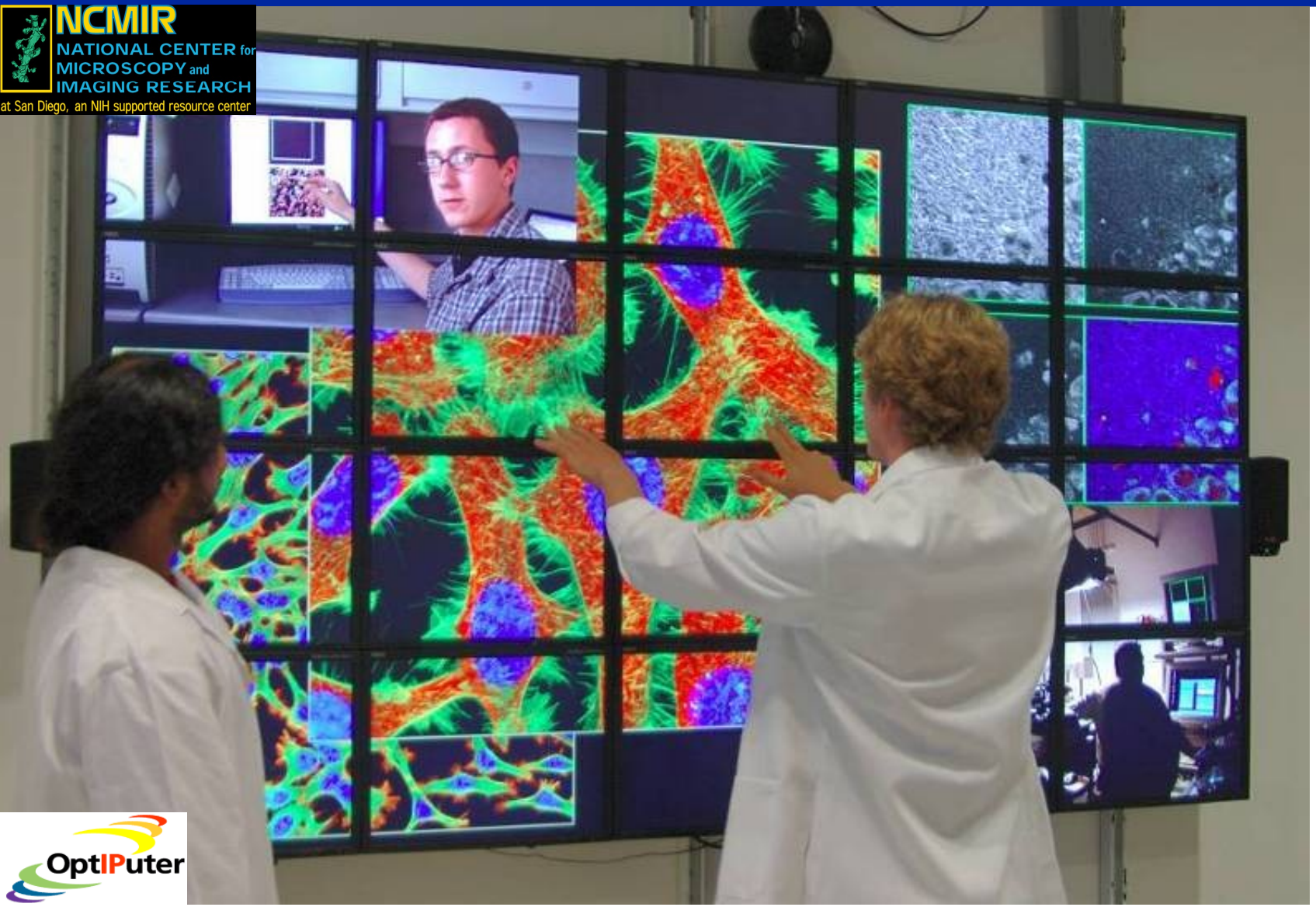
Computing and Storage Available Outside Campus Boundaries



Source:Phil Papadopoulos, SDSC/Calit2

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

NCMIR
NATIONAL CENTER for MICROSCOPY and IMAGING RESEARCH
at San Diego, an NIH supported resource center



Scalable Adaptive Graphics Environment (SAGE)

evl electronic visualization laboratory

NSF

$13.5M Over Five Years

Picture Source: Mark Ellisman, David Lee, Jason Leigh

OptIPuter

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Calit2 (UCSD, UCI) and UIC Lead Campuses—Larry Smarr PI
Univ. Partners: SDSC, USC, SDSU, NW, TA&M, UvA, SARA, KISTI, AIST
Industry: IBM, Sun, Telcordia, Chiaro, Calient, Glimmerglass, Lucent

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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





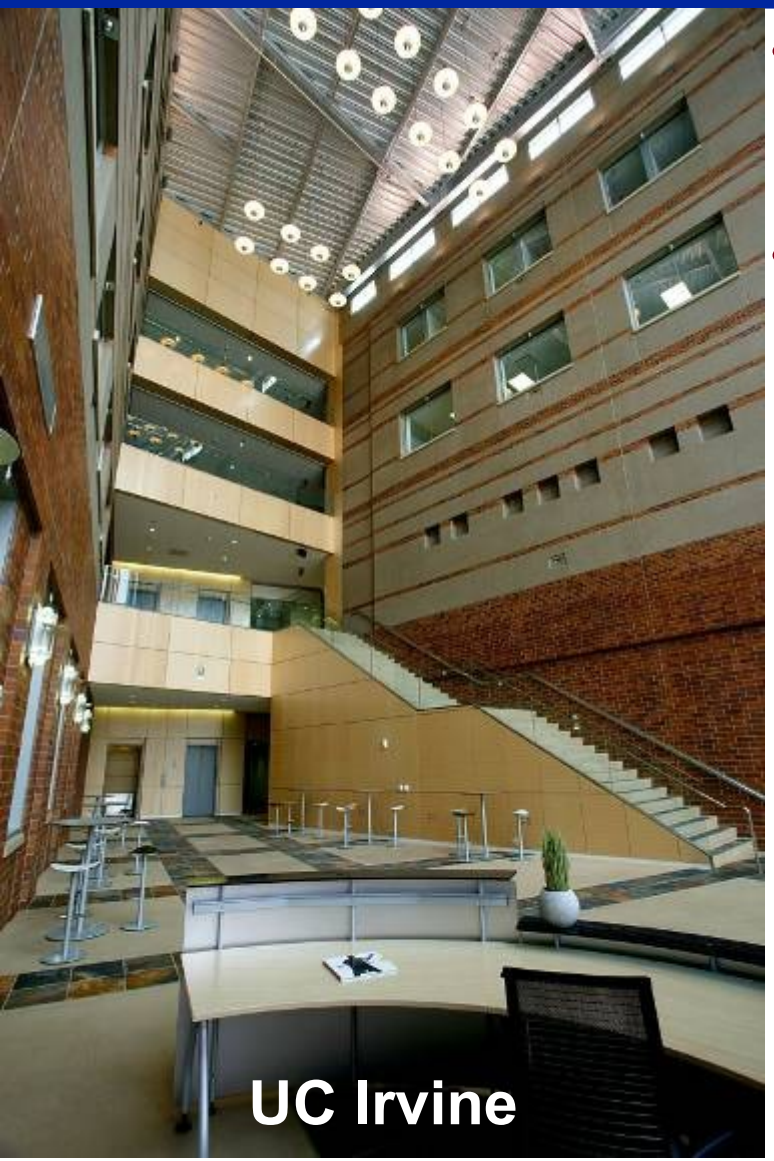
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Powered by Rocks ROCKS

Source: Phil Papadopoulos SDSC, Calit2

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Two New Calit2 Buildings Provide New Laboratories for "Living in the Future"



- "Convergence" Laboratory Facilities
  - Nanotech, BioMEMS, Chips, Radio, Photonics
  - Virtual Reality, Digital Cinema, HDTV, Gaming
- Over 1000 Researchers in Two Buildings
  - Linked via Dedicated Optical Networks

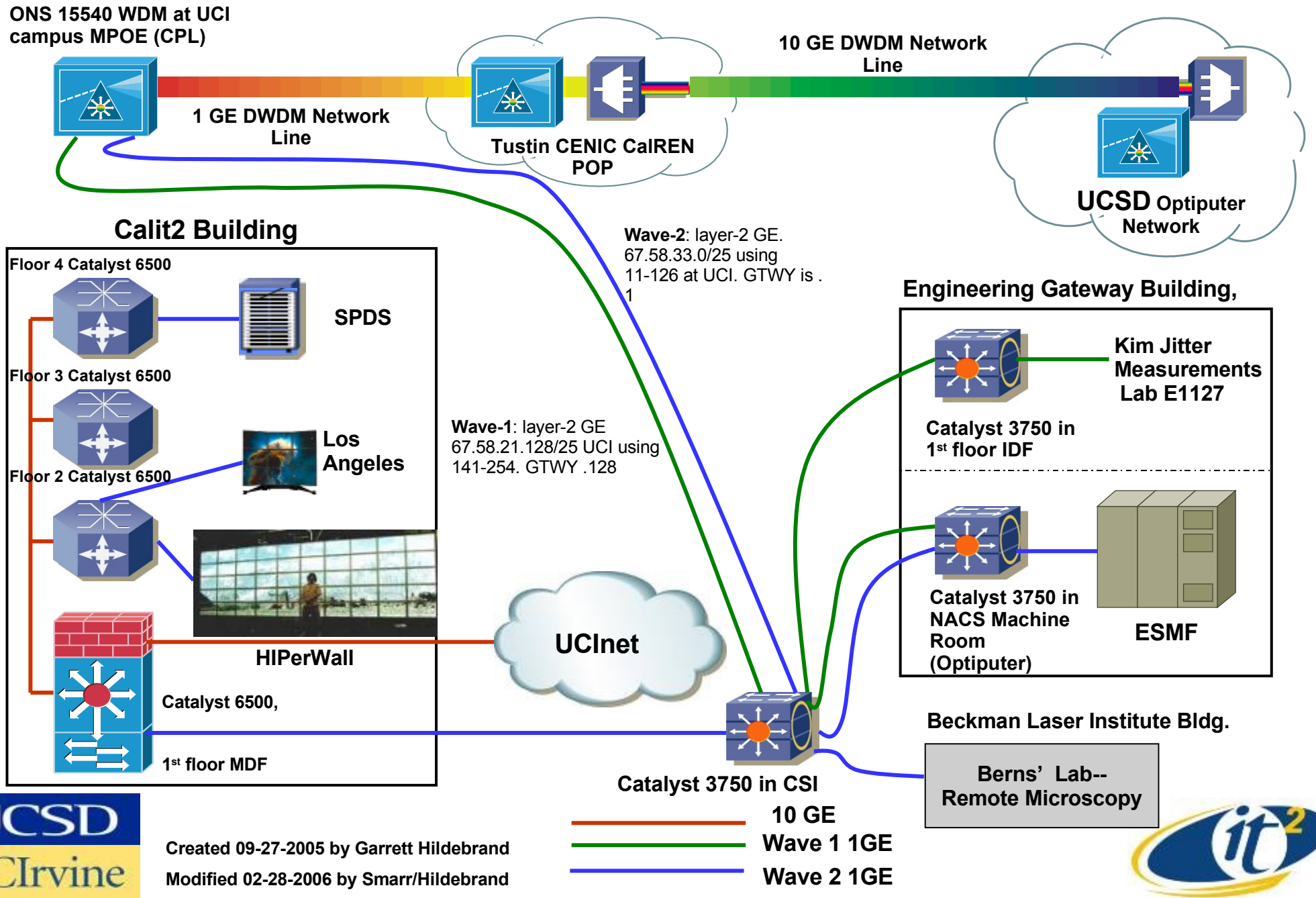


www.calit2.net

Preparing for a World in Which Distance is Eliminated…

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Calit2 at UCI and UCSD Are Prototyping Gigabit Applications—10Gbps Upgrade Planned



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Created 09-27-2005 by Garrett Hildebrand

Modified 02-28-2006 by Smarr/Hildebrand

The Calit2 200 Megapixel HIPerWall OptIPortals at UCSD and UCI are Now a Gbit/s HD Collaboratory

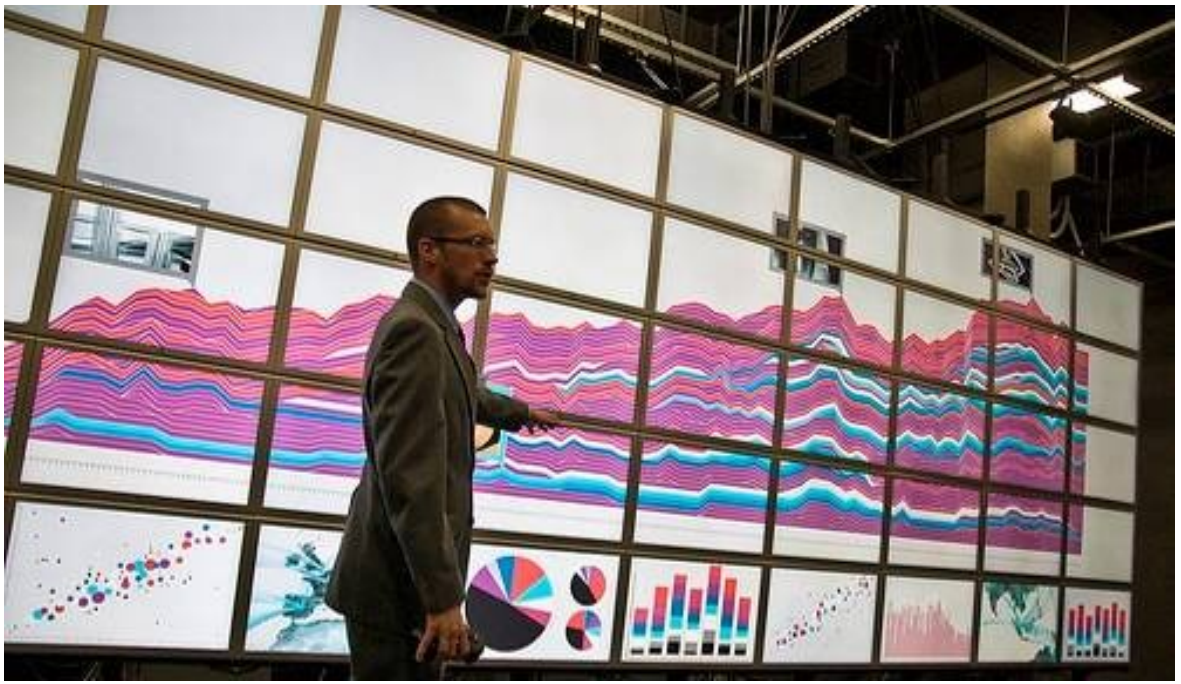


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NASA Ames is Completing a 245 Mpixel Hyperwall as Project Columbia Interface

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Using HIPerWall OptIPortals for Humanities and Social Sciences



Calit2@UCI
200 Mpixel
HIPerWall



Software Studies Initiative, Calti2@UCSD

Interface Designs for Cultural Analytics Research Environment

Jeremy Douglass (top) & Lev Manovich (bottom)

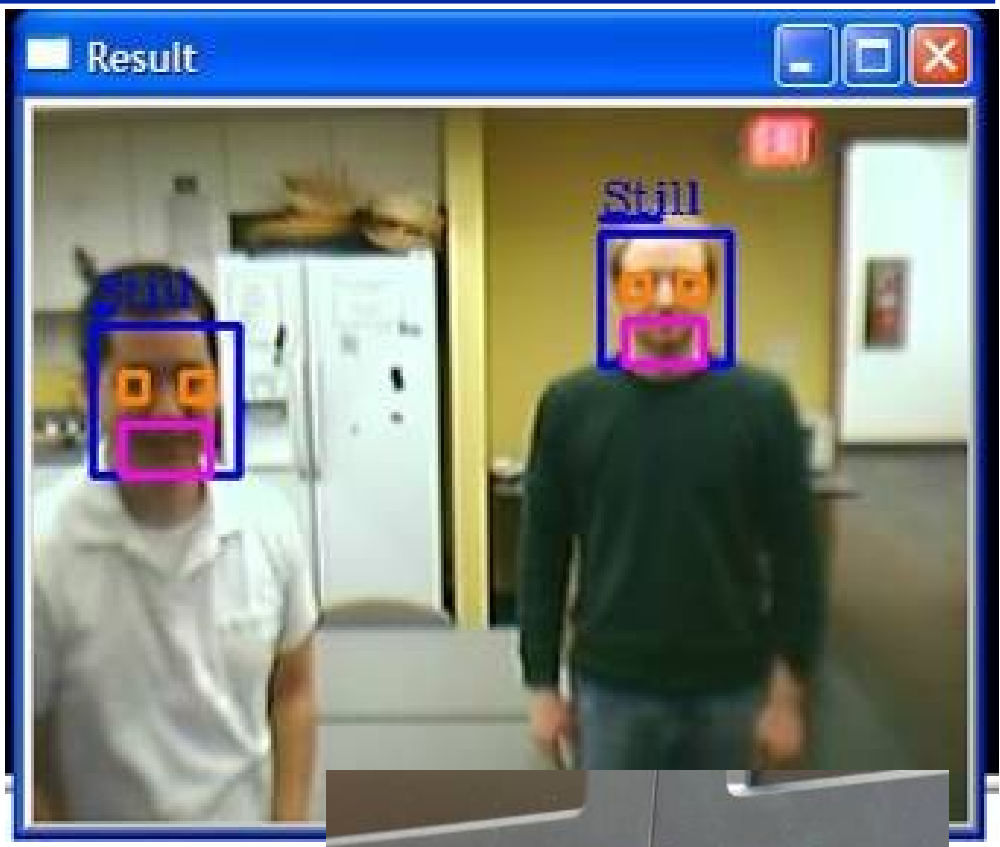
Second Annual Meeting of the Humanities, Arts, Science, and Technology Advanced Collaboratory (HASTAC II)
UC Irvine May 23, 2008

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U Michigan Virtual Space Interaction Testbed (VISIT) Instrumenting OptIPortals for Social Science Research

- Using Cameras Embedded in the Seams of Tiled Displays and Computer Vision Techniques, we can Understand how People Interact with OptIPortals
  - Classify Attention, Expression, Gaze
  - Initial Implementation Based on Attention Interaction Design Toolkit (J. Lee, MIT)
- Close to Producing Usable Eye/Nose Tracking Data using OpenCV





Leading U.S. Researchers on the Social Aspects of Collaboration

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Source: Erik Hofer, UMich, School of Information

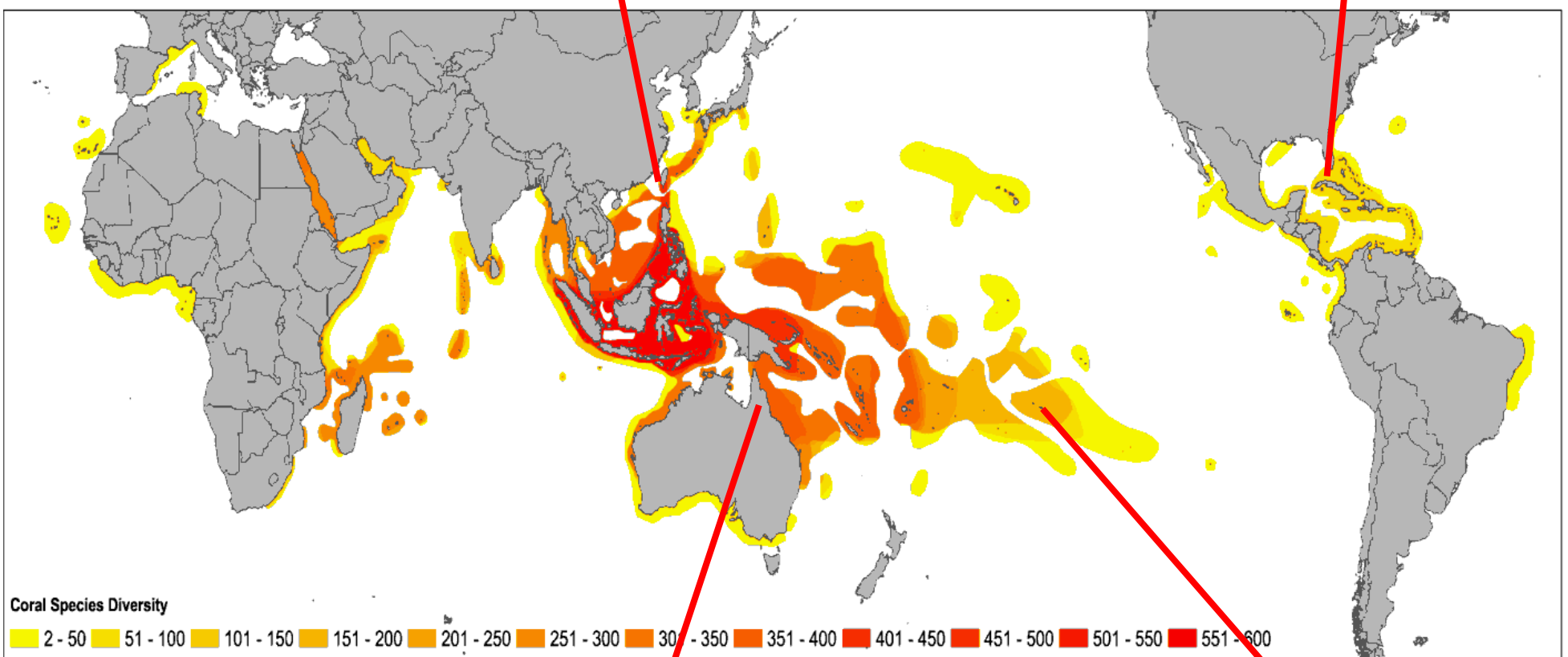
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Coral Reef Environmental Observatory Network (CREON)

www.coralreefeon.org/

Taiwan

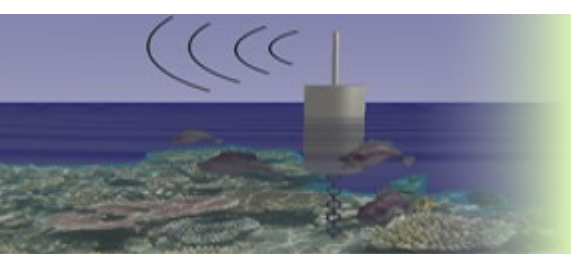
NOAA



NSF Collaboration:
UCSB and AS/NMMBA

GBR

UCSB



Source: Stuart Kininmonth, AIMS

Source : Fang-Pang Lin, NCHC

New Year's Challenge: Streaming Underwater Video From Taiwan's Kenting Reef to Calit2's OptIPortal



Empowering the Scientific Community with Streaming Data Middleware

UCSD: Rajvikram Singh, Sameer Tilak, Jurgen Schulze, Tony Fountain, Peter Arzberger
NCHC : Ebbe Strandell, Sun-In Lin, Yao-Tsung Wang, Fang-Pang Lin

Moorea Coral Reef LTER Site
Current Bandwidth ~ 100kbps, But Fiber Optic Cable by 2010

- **LTER Established Sept. 2004**
  - **PIs: Russ Schmitt, Sally Holbrook, Pete Edmunds, Bob Carpenter**
  - **Deputy Director: Andy Brooks**
- **20 Investigators**
  - **UC Santa Barbara**
  - **CSU Northridge**
  - **UC San Diego / Scripps**
  - **UC Santa Cruz**
  - **UC Davis / Bodega Marine Lab**
  - **University of Hawaii**
- **Field Operations Based from UC Berkeley Gump Research Station**

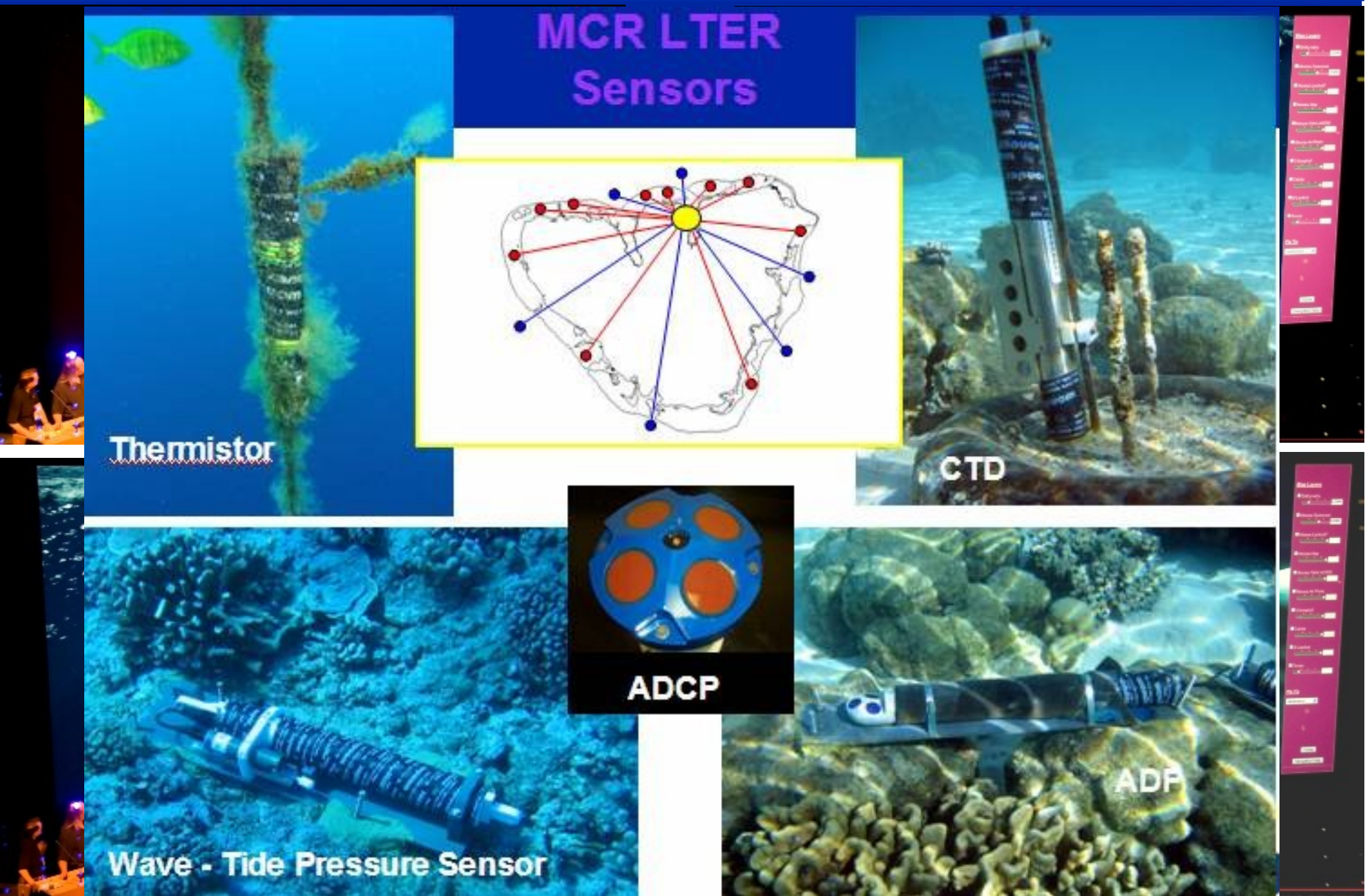






NSF LTER UCSD UCIrvine CREON it2

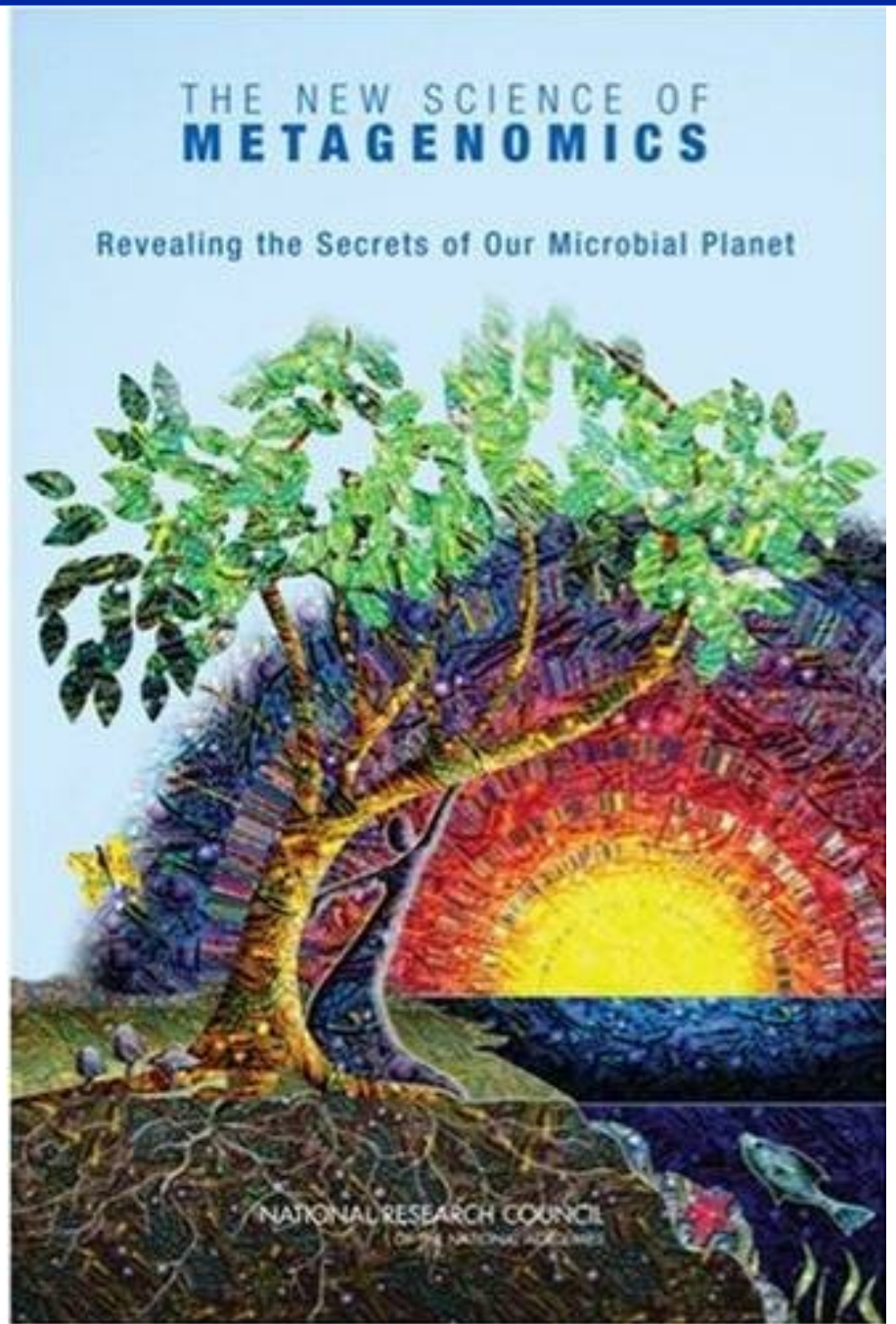
Creating a Digital Moorea
Calit2 Collaboration at UC Gump Station (UCB, UCSB)



The New Science of Metagenomics

NRC Report:

Metagenomic data should be made publicly available in international archives as rapidly as possible.



"The emerging field of metagenomics, where the DNA of entire communities of microbes is studied simultaneously, presents the greatest opportunity -- perhaps since the invention of the microscope – to revolutionize understanding of the microbial world." –

National Research Council
March 27, 2007

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The Genetic Diversity of Ocean Microbes Provides Novel Genetic Components for Bioengineering Clean Energy

Plus 155 Marine Microbial Genomes



Each Sample ~2000 Microbial Species

Specify Ocean Data

Sorcerer II Data Will Double Number of Proteins in GenBank!

camera
Marine Microbial Ecology

MARINE MICROBIOLOGY INITIATIVE

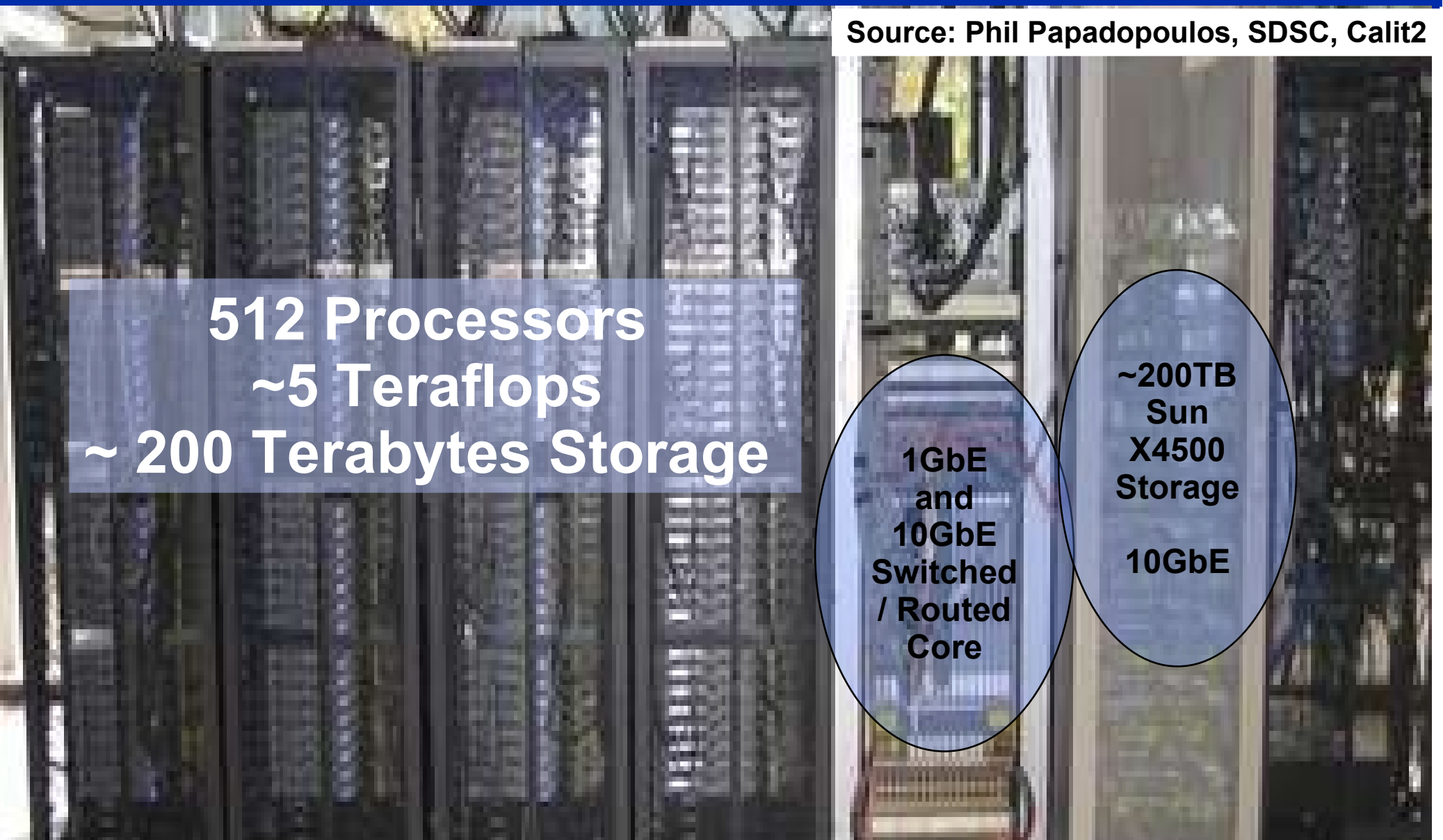
Gordon and Betty MOORE FOUNDATION

J. Craig Venter INSTITUTE

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Calit2 Microbial Metagenomics Cluster- Next Generation Optically Linked Science Data Server

Source: Phil Papadopoulos, SDSC, Calit2



UCSD UCIrvine SDSC ROCKS camera Marine Microbial Ecology J. Craig Venter INSTITUTE it2

CAMERA's
Global Microbial Metagenomics CyberCommunity

Over 2010 Registered Users From Over 50 Countries



camera
Marine Microbial Ecology

J. Craig Venter
INSTITUTE

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OptIPlanet Collaboratory Persistent Infrastructure Between Calit2 and U Washington



OptIPuter

Ginger Armbrust's Diatoms: Micrographs, Chromosomes, Genetic Assembly

ROCKS



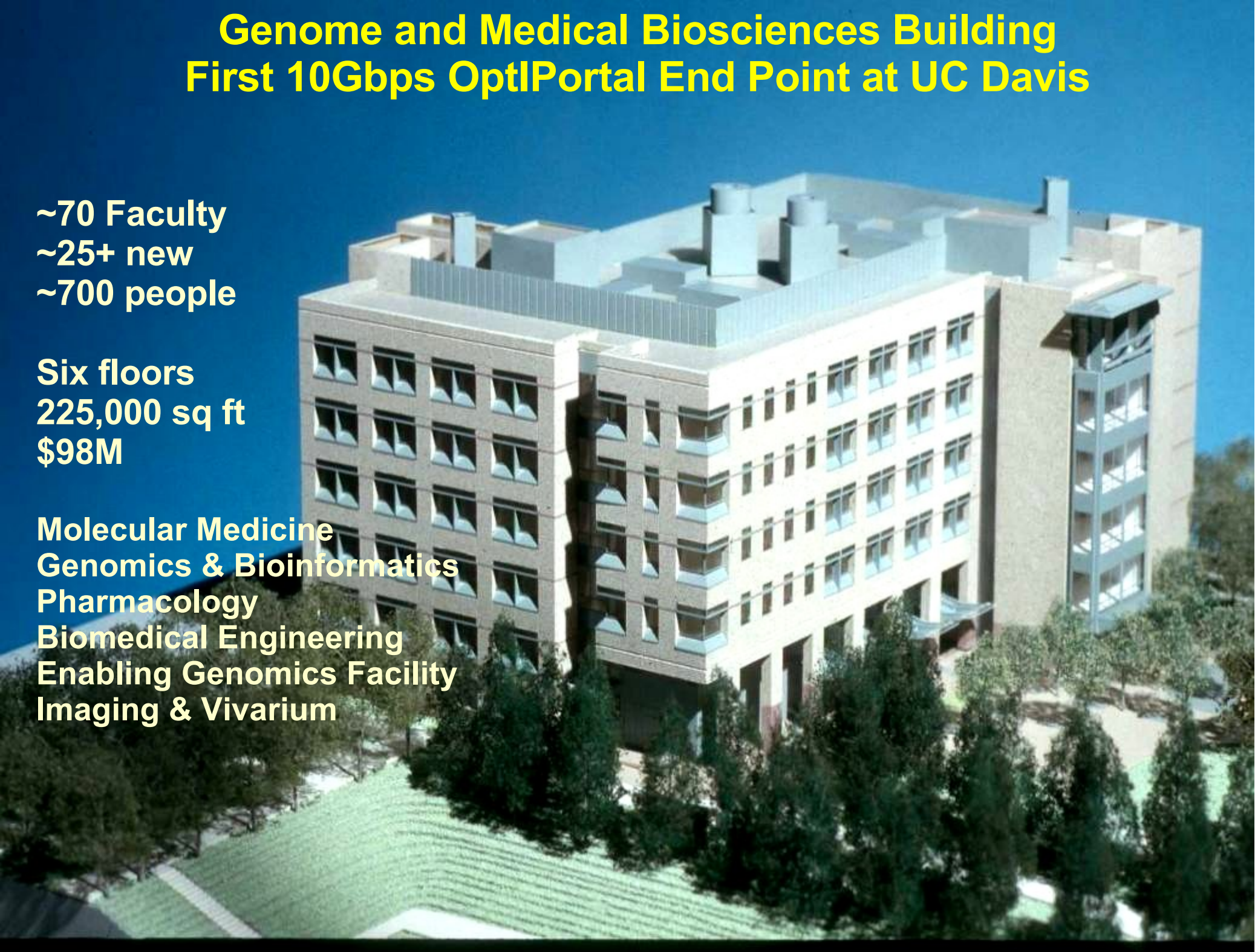




UW's Research Channel
Michael Wellings

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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

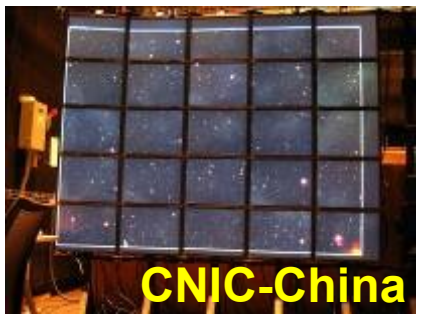
Molecular Medicine
Genomics & Bioinformatics
Pharmacology
Biomedical Engineering
Enabling Genomics Facility
Imaging & Vivarium

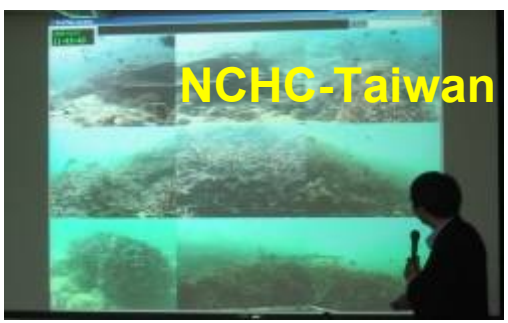
OptIPortals
Are Being Adopted Globally


AIST-Japan


Osaka U-Japan


KISTI-Korea


CNIC-China


NCHC-Taiwan


UZurich


SARA- Netherlands



Brno-Czech Republic


EVL@UIC


Calit2@UCSD


Calit2@UCI



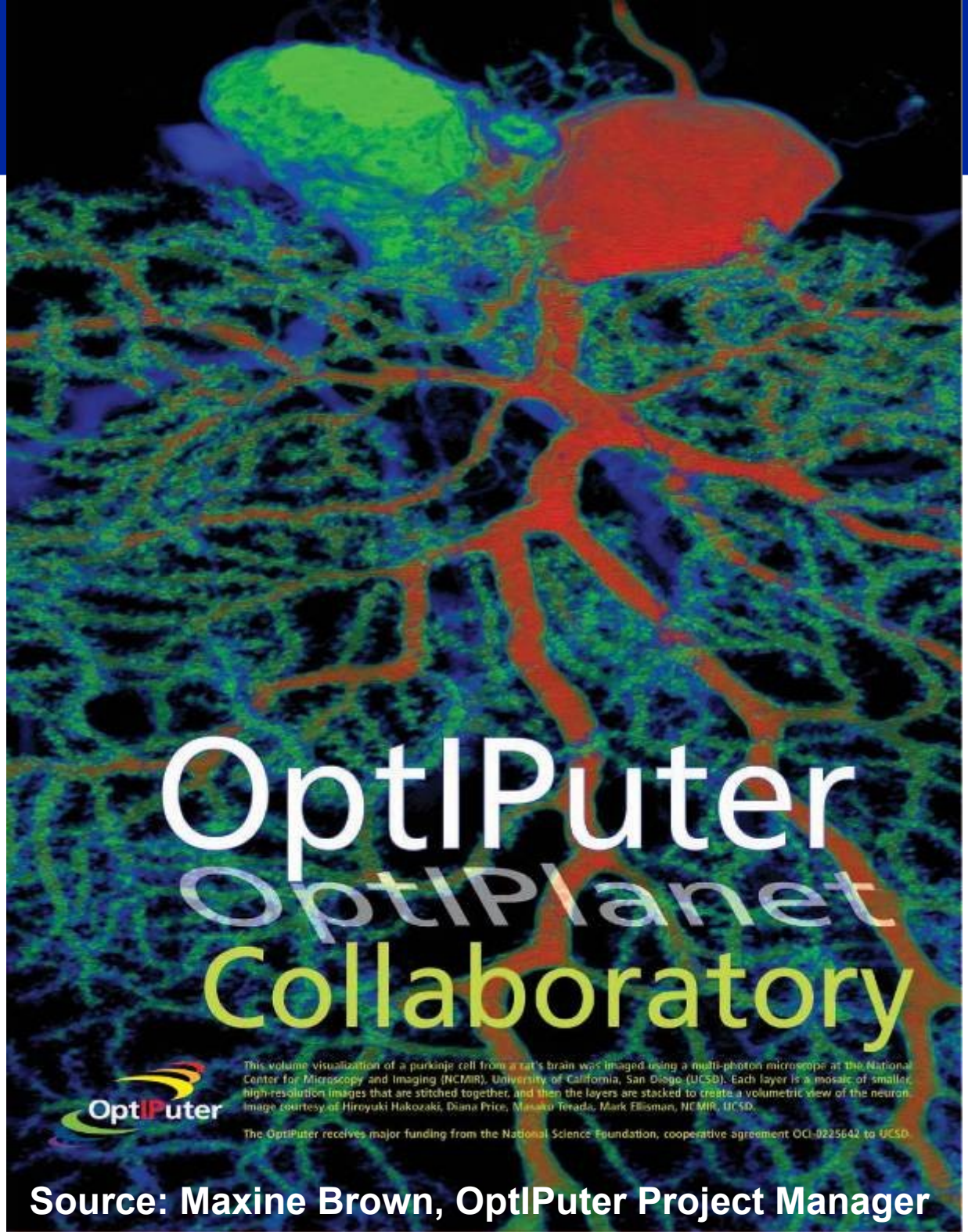
U. Melbourne, Australia

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Powered by Rocks ROCKS

evl electronic visualization laboratory

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Source: Maxine Brown, OptIPuter Project Manager

Green Initiative:

Can Optical Fiber Replace Airline Travel for Continuing Collaborations ?

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Launch of the 100 Megapixel OzIPortal Over Qvidium Compressed HD on 1 Gbps CENIC/PW/AARNet Fiber



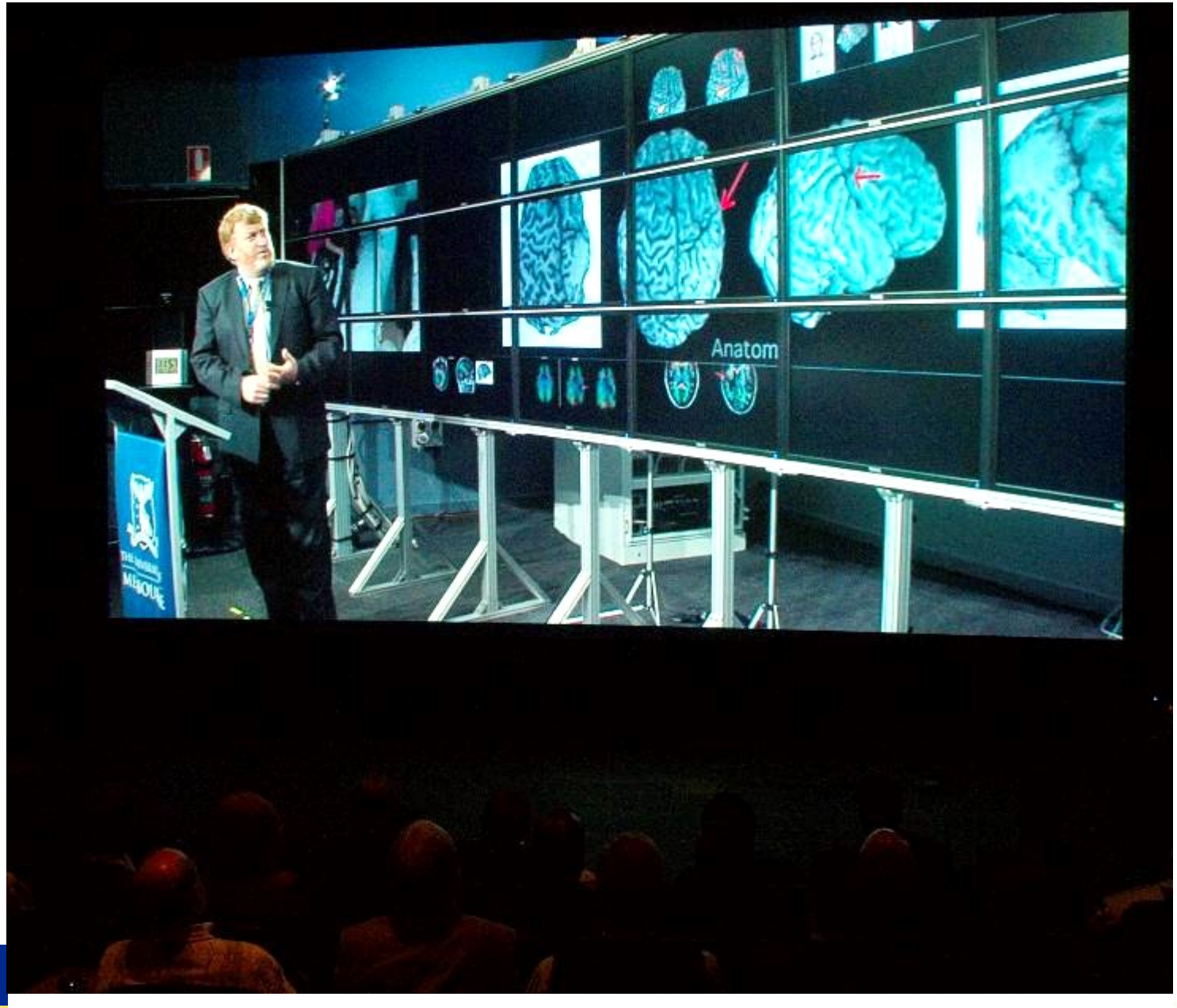
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No Calit2 Person Physically Flew to Australia to Bring This Up!

www.calit2.net/newsroom/release.php?id=1219

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UM Professor Graeme Jackson Planning Brain Surgery for Severe Epilepsy



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www.calit2.net/newsroom/release.php?id=1219

Victoria Premier and Australian Deputy Prime Minister Asking Questions



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www.calit2.net/newsroom/release.php?id=1219

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University of Melbourne Vice Chancellor Glyn Davis in Calit2 Replies to Question from Australia



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OptIPuterizing Australian Universities in 2008: CENIC Coupling to AARNet



UMelbourne/Calit2 Telepresence Session May 21, 2008

Augmented by Many Physical Visits This Year
Culminating in Two Week Lecture Tour
of Australian Research Universities
by Larry Smarr October 2008

Phil Scanlan
Founder-
Australian American Leadership Dialogue
www.aald.org



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