How Personal Lightwaves Enable Telepresence: Collapsing the Flat World to a "Point"

UCLA Marschak Colloquium

Los Angeles, CA

May 9, 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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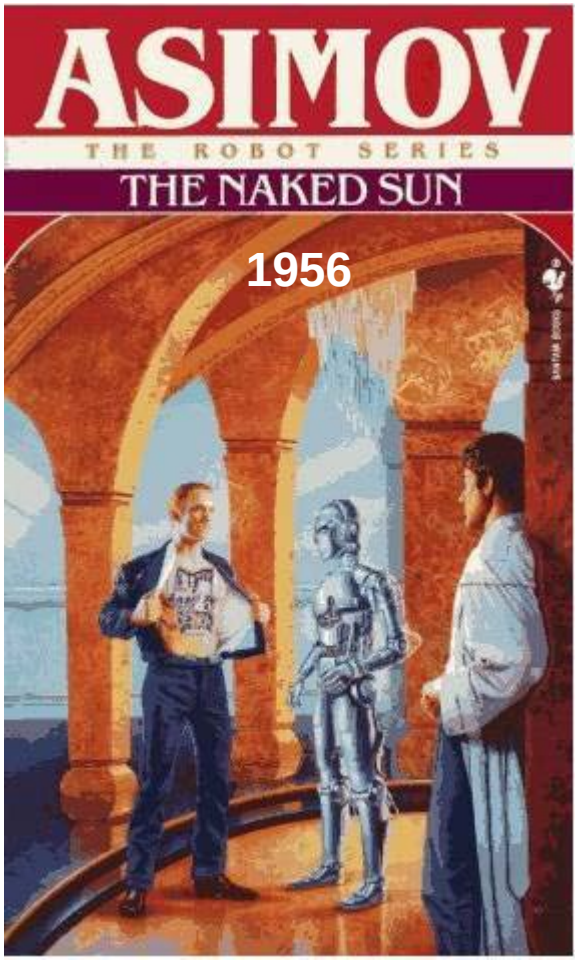
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Abstract

The idea of global Telepresence is over fifty years old, originally being a central feature of science fiction. 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. I will describe how this user configurable "OptIPuter" global platform opens new frontiers in collaborative work environments, digital cinema, interactive environmental observatories, brain imaging, and marine microbial metagenomics. The experiential effect is to collapse the Flat World, created by the shared Internet and Web, to a single point...

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Fifty Years Ago, Asimov Described a World of Telepresence



A policeman from Earth, where the population all lives underground in close quarters, is called in to investigate a murder on a distant world. This world is populated by very few humans, rarely if ever, coming into physical proximity of each other. Instead the people "View" each other with trimensional “holographic” images.

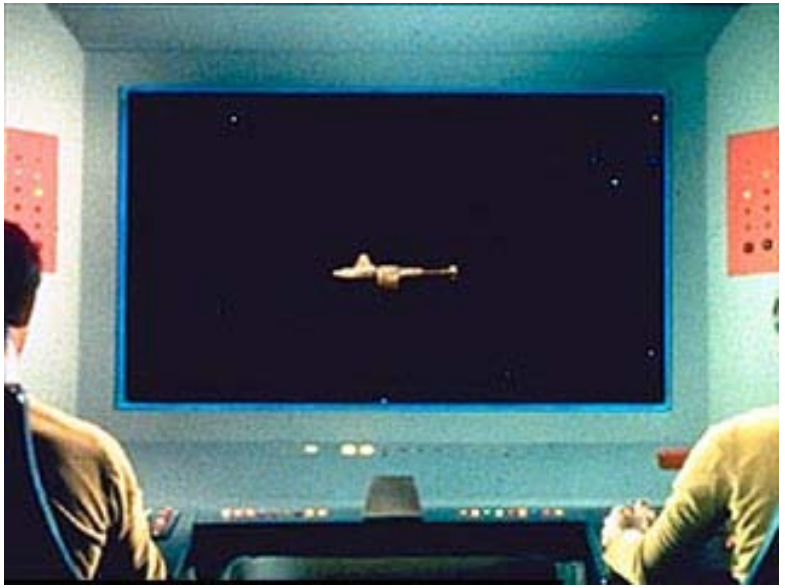
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TV and Movies of 40 Years Ago Envisioned Telepresence Displays









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Source: Star Trek 1966-68; Barbarella 1968

it²

The Bellcore VideoWindow -- A Working Telepresence Experiment



(1989)

“Imagine sitting in your work place lounge having coffee with some colleagues. Now imagine that you and your colleagues are still in the same room, but are separated by a large sheet of glass that does not interfere with your ability to carry on a clear, two-way conversation. Finally, imagine that you have split the room into two parts and moved one part 50 miles down the road, without impairing the quality of your interaction with your friends.”

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Source: Fish, Kraut, and Chalfonte-CSCW 1990 Proceedings

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A Simulation of Telepresence

Using Analog Communications to Prototype the Digital Future

"What we really have to do is eliminate distance between individuals who want to interact with other people and with other computers."
— Larry Smarr, Director, NCSA

- **Televisualization:**
  - **Telepresence**
  - **Remote Interactive Visual Supercomputing**
  - **Multi-disciplinary Scientific Visualization**







"We're using satellite technology…to demo what It might be like to have high-speed fiber-optic links between advanced computers in two different geographic locations."

— Al Gore, Senator
Chair, US Senate Subcommittee on Science, Technology and Space

ATT & Sun

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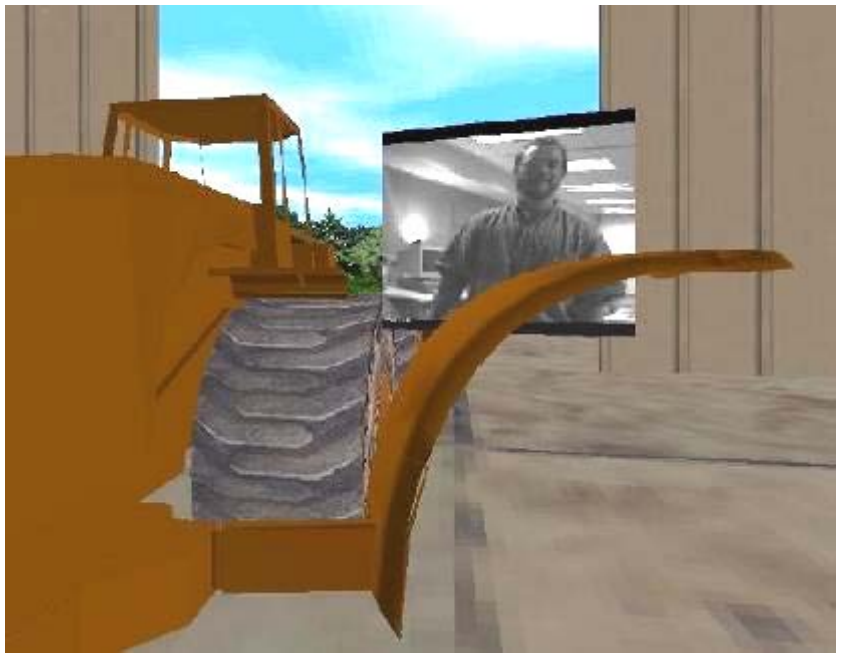
SIGGRAPH 1989

NCSA™

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Caterpillar / NCSA: Distributed Virtual Reality for Global-Scale Collaborative Prototyping





NCSA™

Real Time Linked Virtual Reality and Audio-Video Between NCSA, Peoria, Houston, and Germany

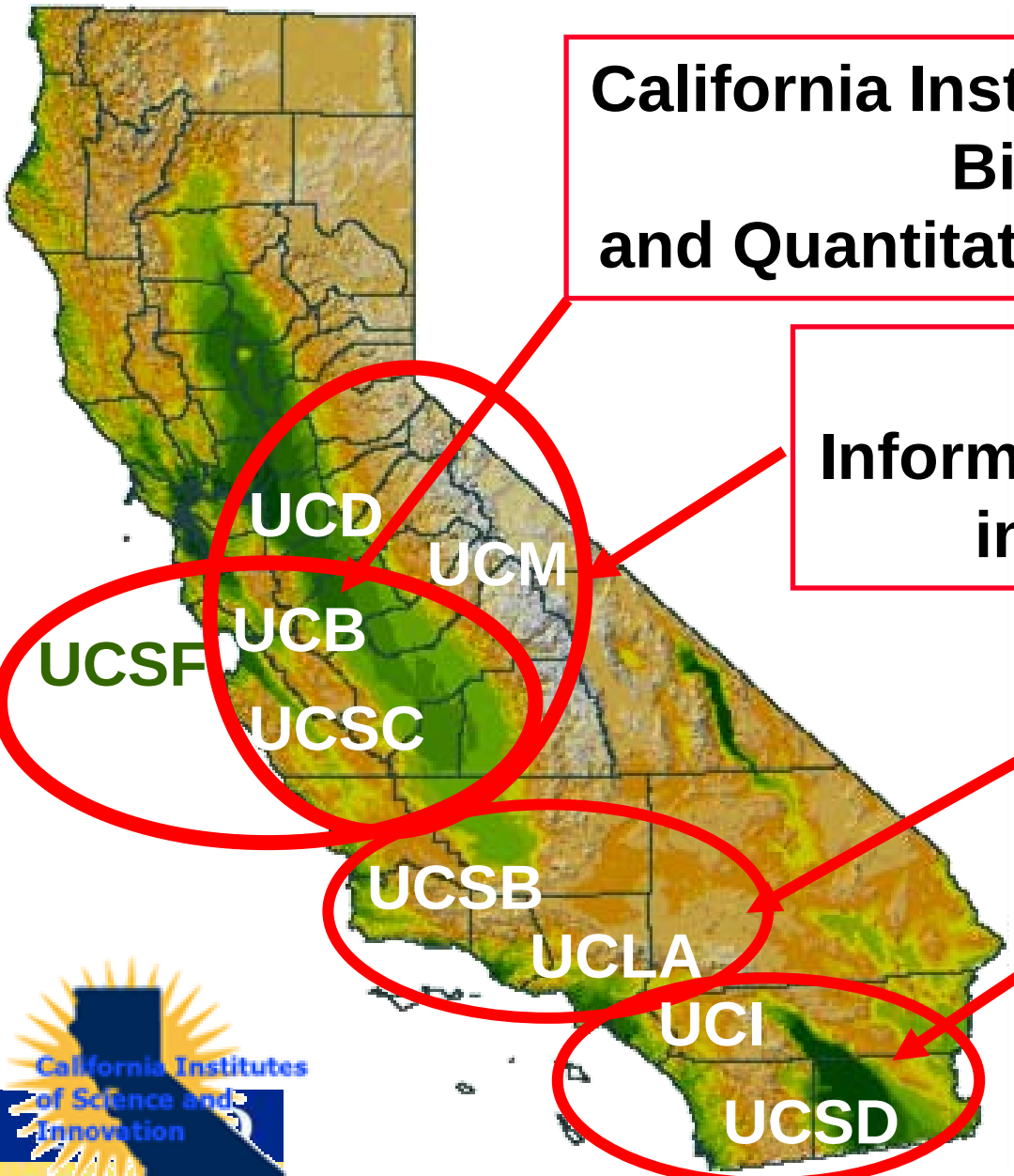
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1996

www.sv.vt.edu/future/vt-cave/apps/CatDistVR/DVR.html

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California's Institutes for Science and Innovation
A Bold Experiment in Collaborative Research



California Institute for Bioengineering, Biotechnology, and Quantitative Biomedical Research

Center for Information Technology Research in the Interest of Society

California NanoSystems Institute

California Institute for Telecommunications and Information Technology

California Institutes of Science and Innovation

UCHVR

www.ucop.edu/california-institutes

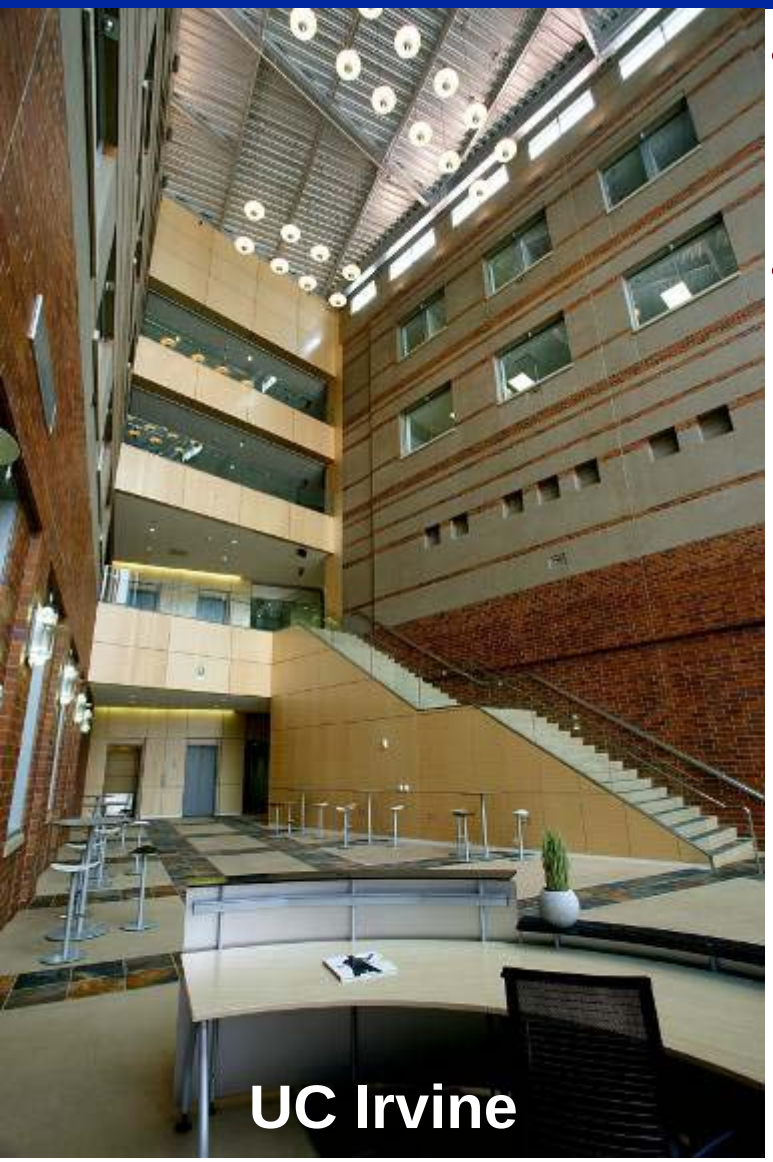
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Calit2 Continues to Pursue Its Initial Mission:

Envisioning How the Extension of Innovative Telecommunications and Information Technologies Throughout the Physical World will Transform Critical Applications Important to the California Economy and its Citizens' Quality Of Life.

Calit2 is a University of California "Institutional Innovation" Experiment on How to Invent a Persistent Collaborative Research and Education Environment that Provides Insight into How the UC, a Major Research University, Might Evolve in the Future.

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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Broadband Depends on Where You Are



- **Mobile Broadband**
  - **0.1-0.5 Mbps**

100,000 Fold Range
All Here Today!



- **Home Broadband**
  - **1-10 Mbps**

"The future is already here,
it's just not evenly distributed"
William Gibson, Author of Neuromancer



- **University Dorm Room Broadband**
  - **10-100 Mbps**



- **Calit2 Global Broadband**
  - **1,000-10,000 Mbps**

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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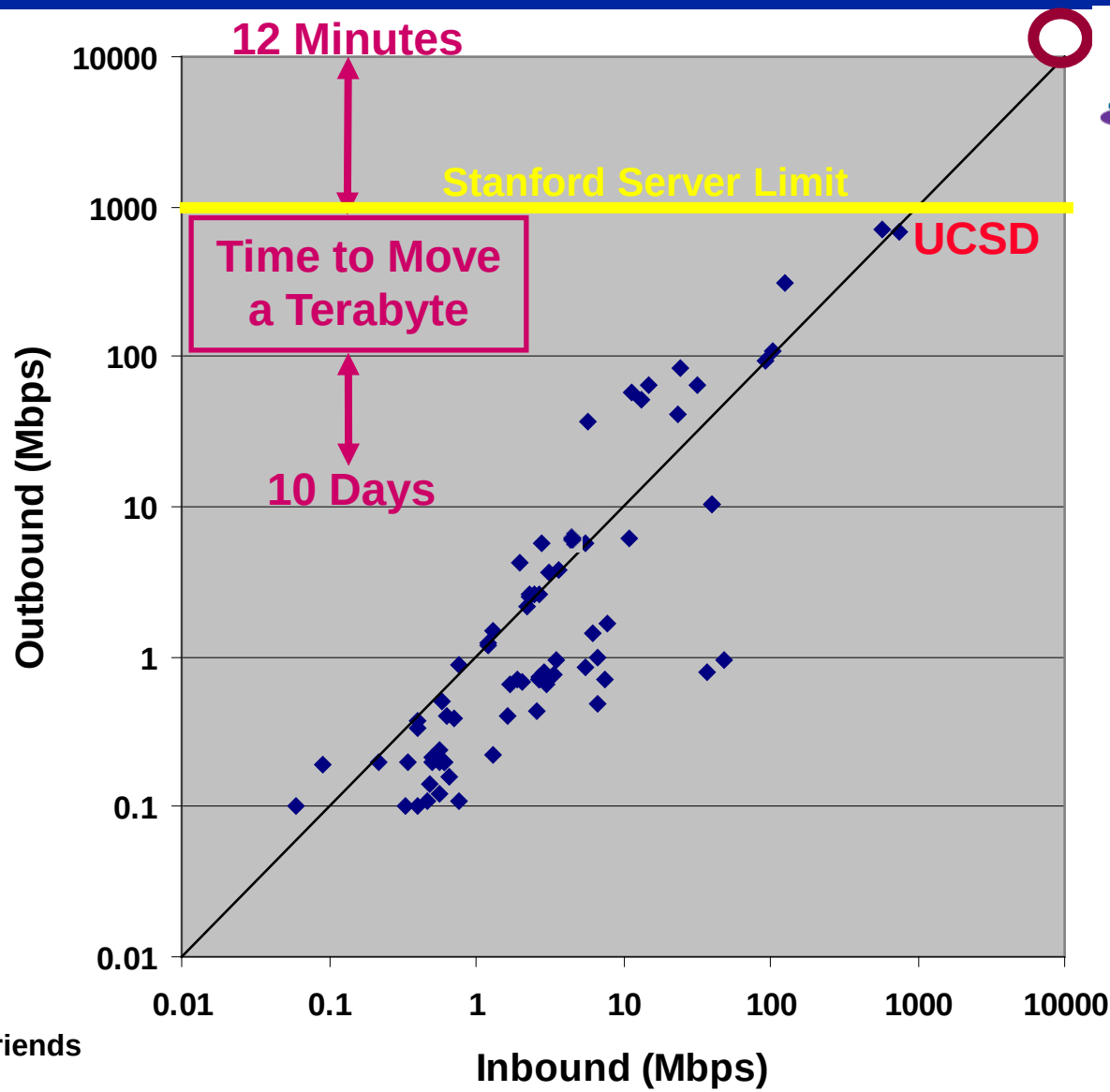
Source: Jerry Sobieski MAX / University of Maryland



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!

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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Cisco Telepresence Provides 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

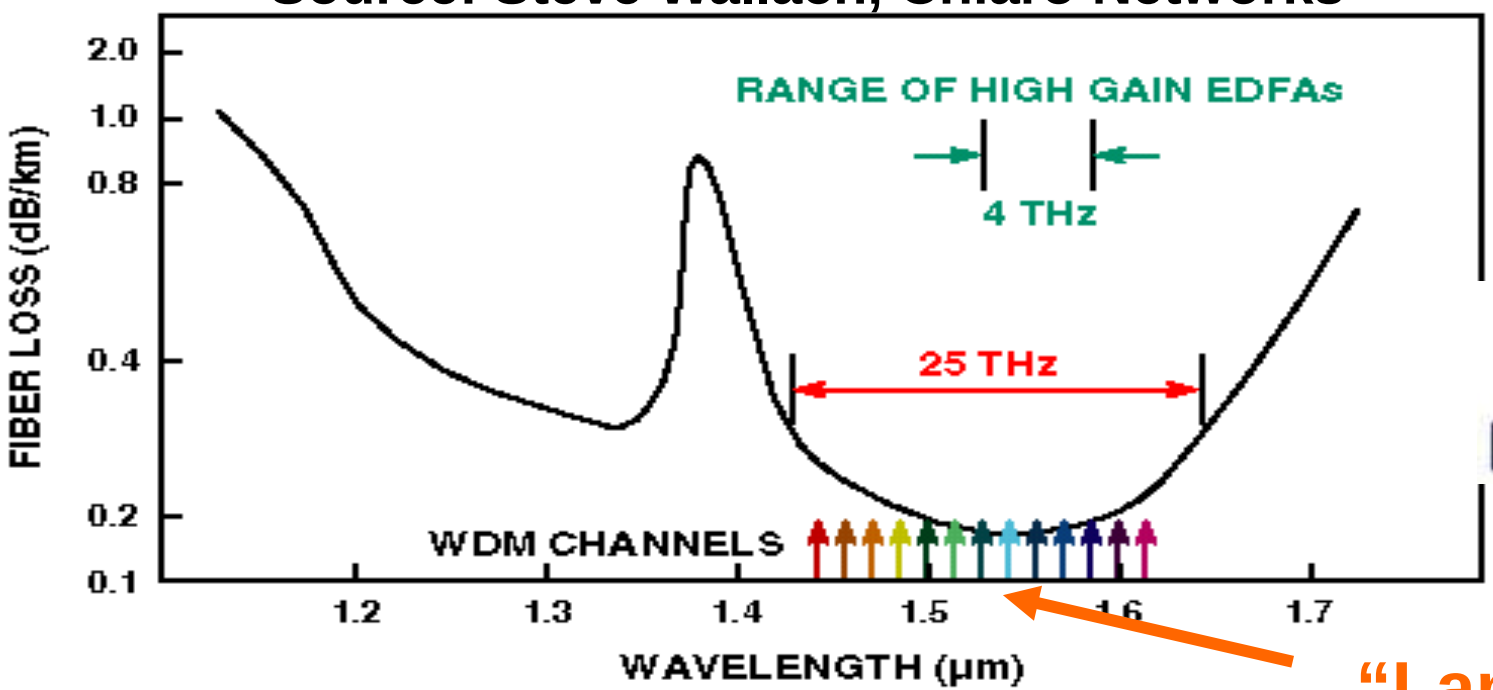
Dedicated Optical Channels Makes High Performance Cyberinfrastructure Possible

WAVELENGTH DIVISION MULTIPLEXING (WDM)

10 Gbps per User ~ 200x Shared Internet Throughput

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

Source: Steve Wallach, Chiaro Networks



CHIARO

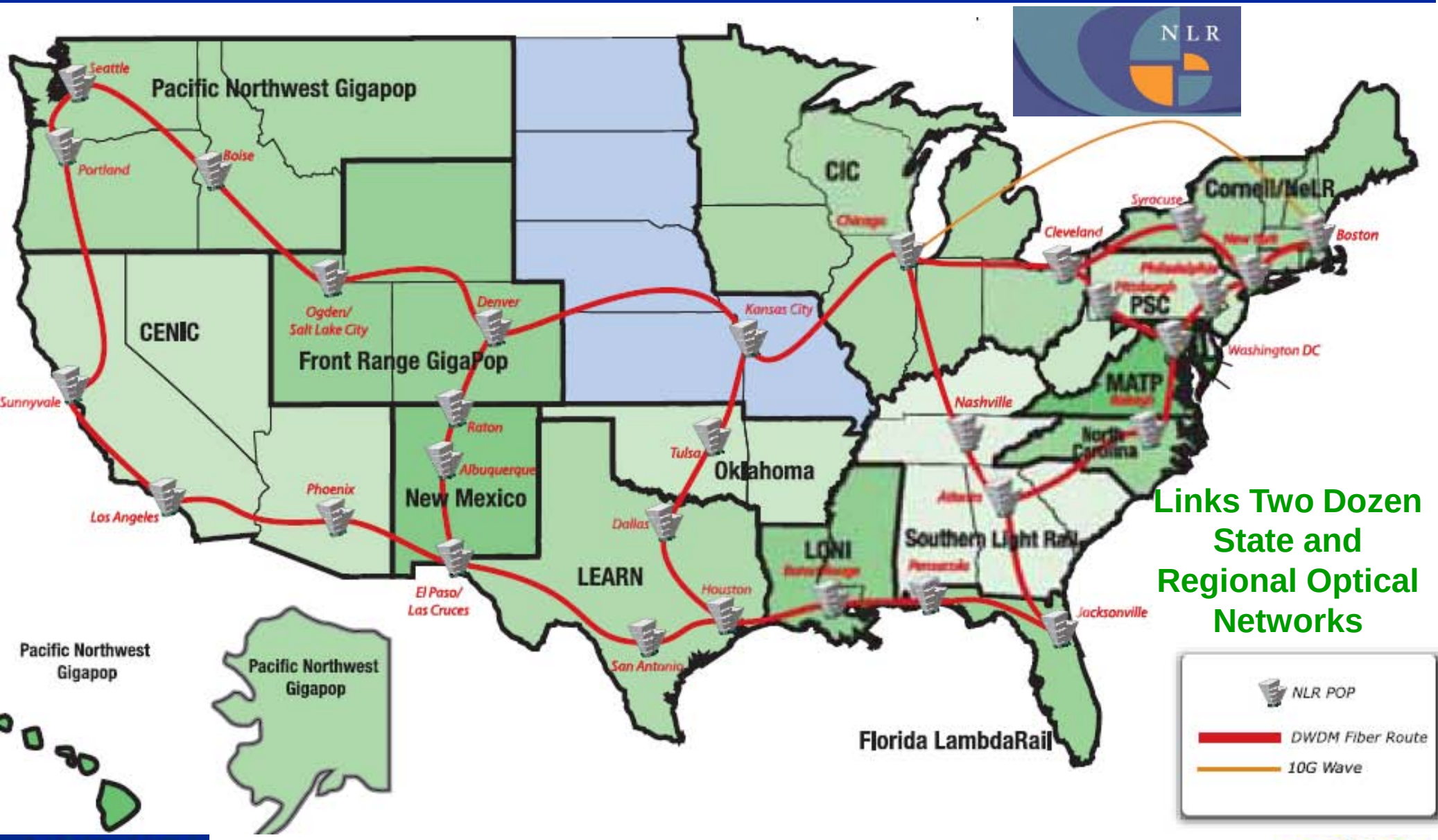
"Lambdas"

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

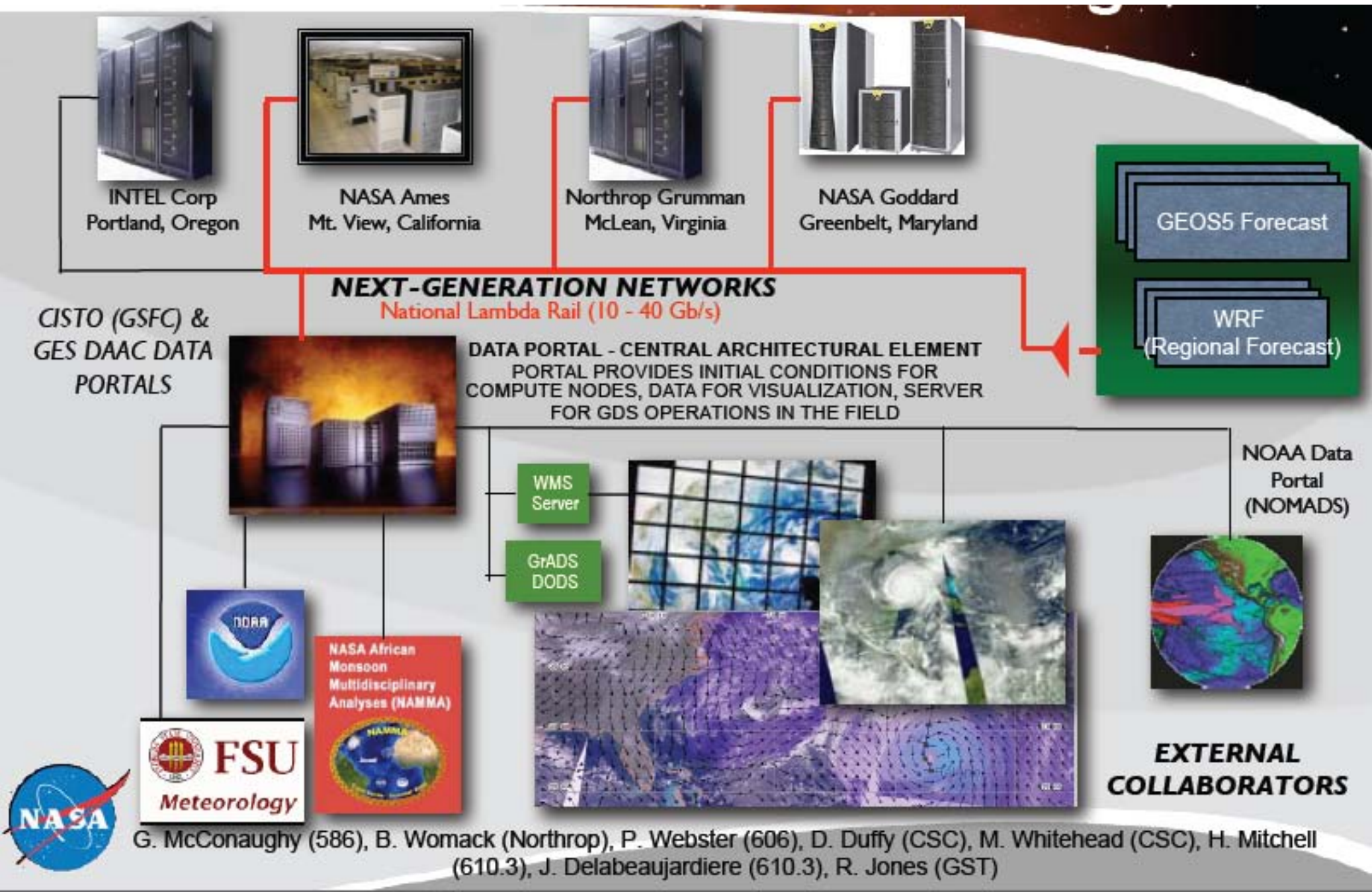


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NLR 4 x 10Gb Lambdas Initially
Capable of 40 x 10Gb wavelengths at Buildout

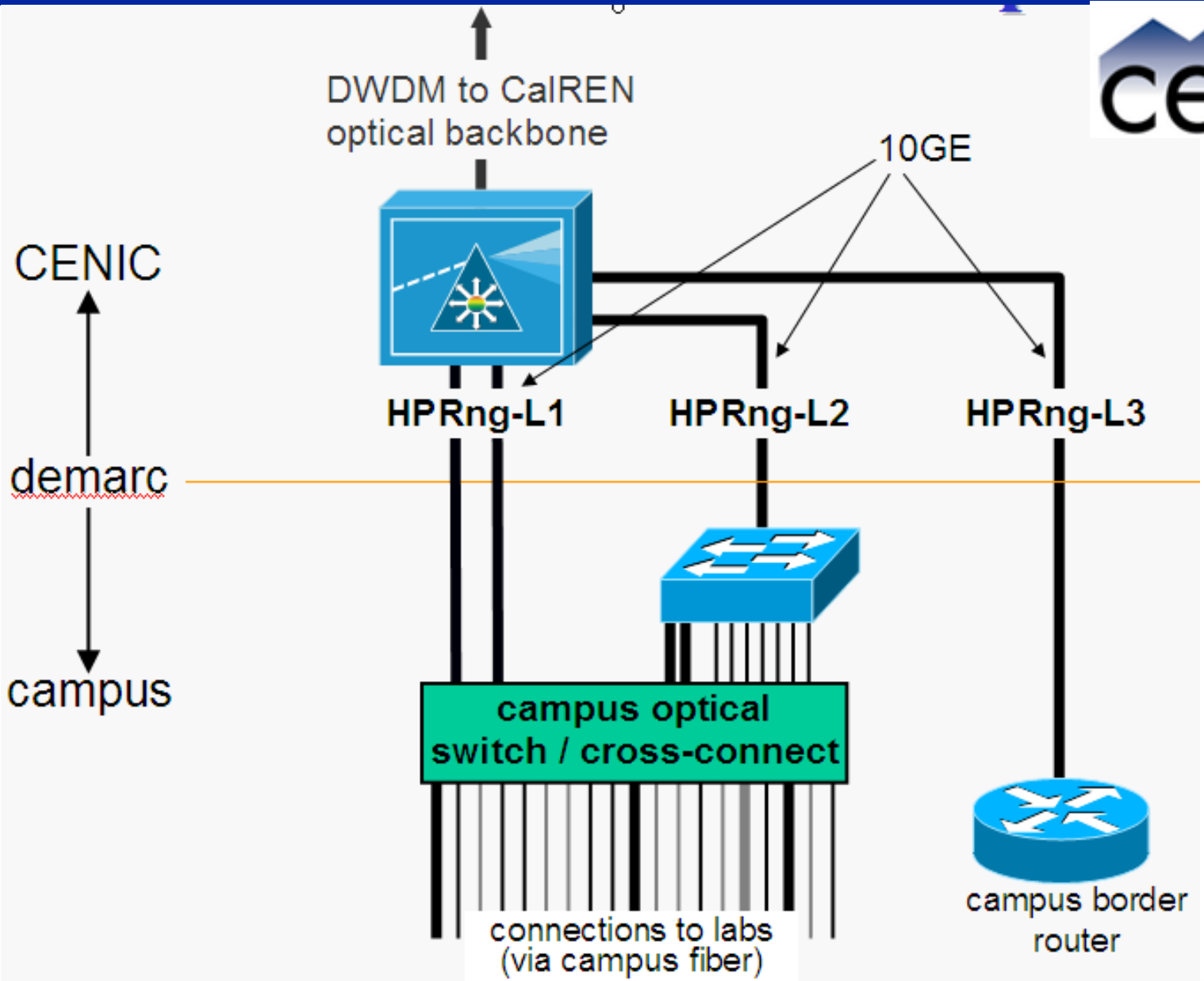
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Distributed Supercomputing: NASA MAP '06 System Configuration Using NLR



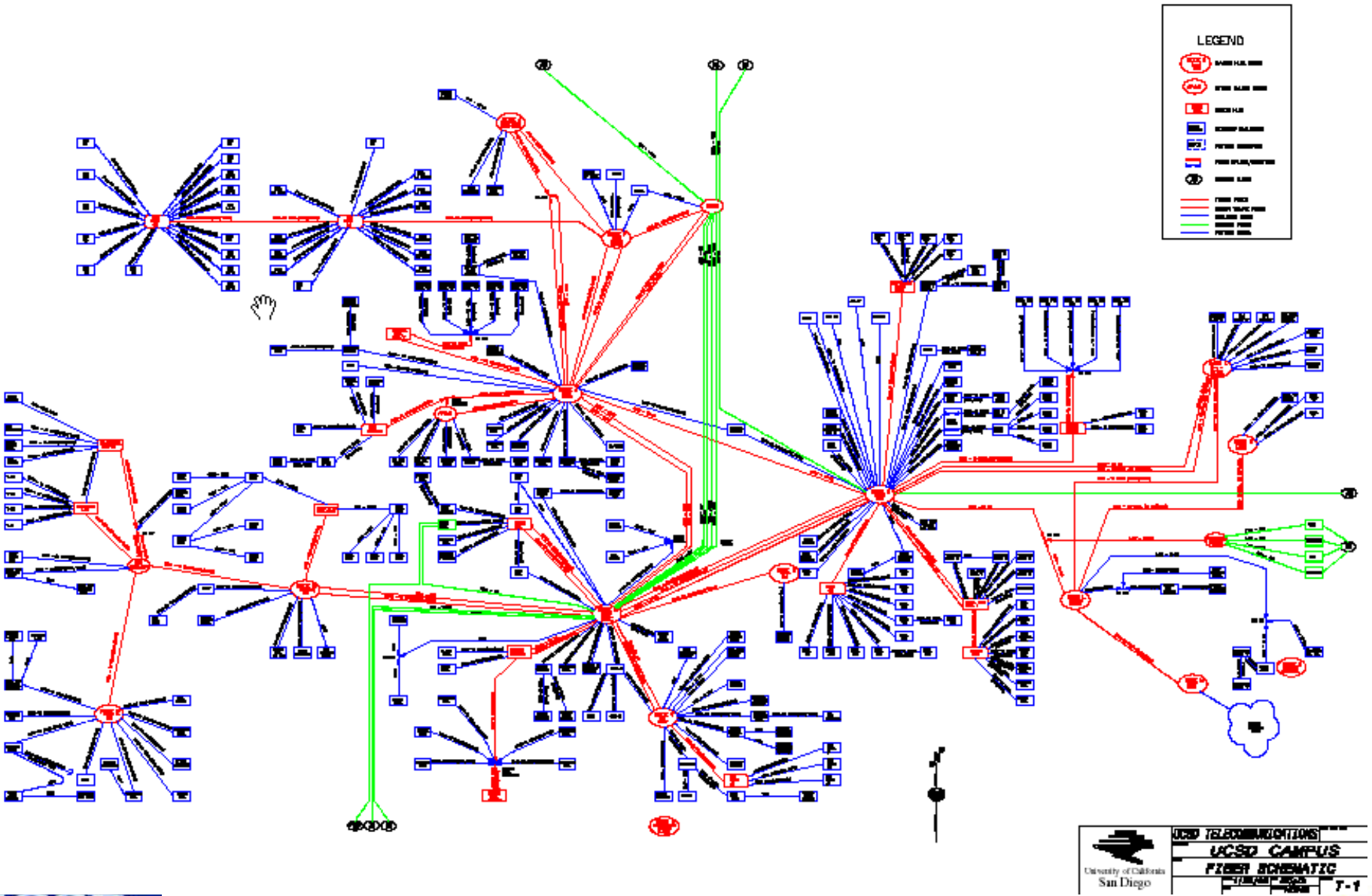
G. McConaughy (586), B. Womack (Northrop), P. Webster (606), D. Duffy (CSC), M. Whitehead (CSC), H. Mitchell (610.3), J. Delabeaujardiere (610.3), R. Jones (GST)

Campus Preparations Needed to Accept CENIC CalREN Handoff to Campus



Source: Jim Dolgonas, CENIC

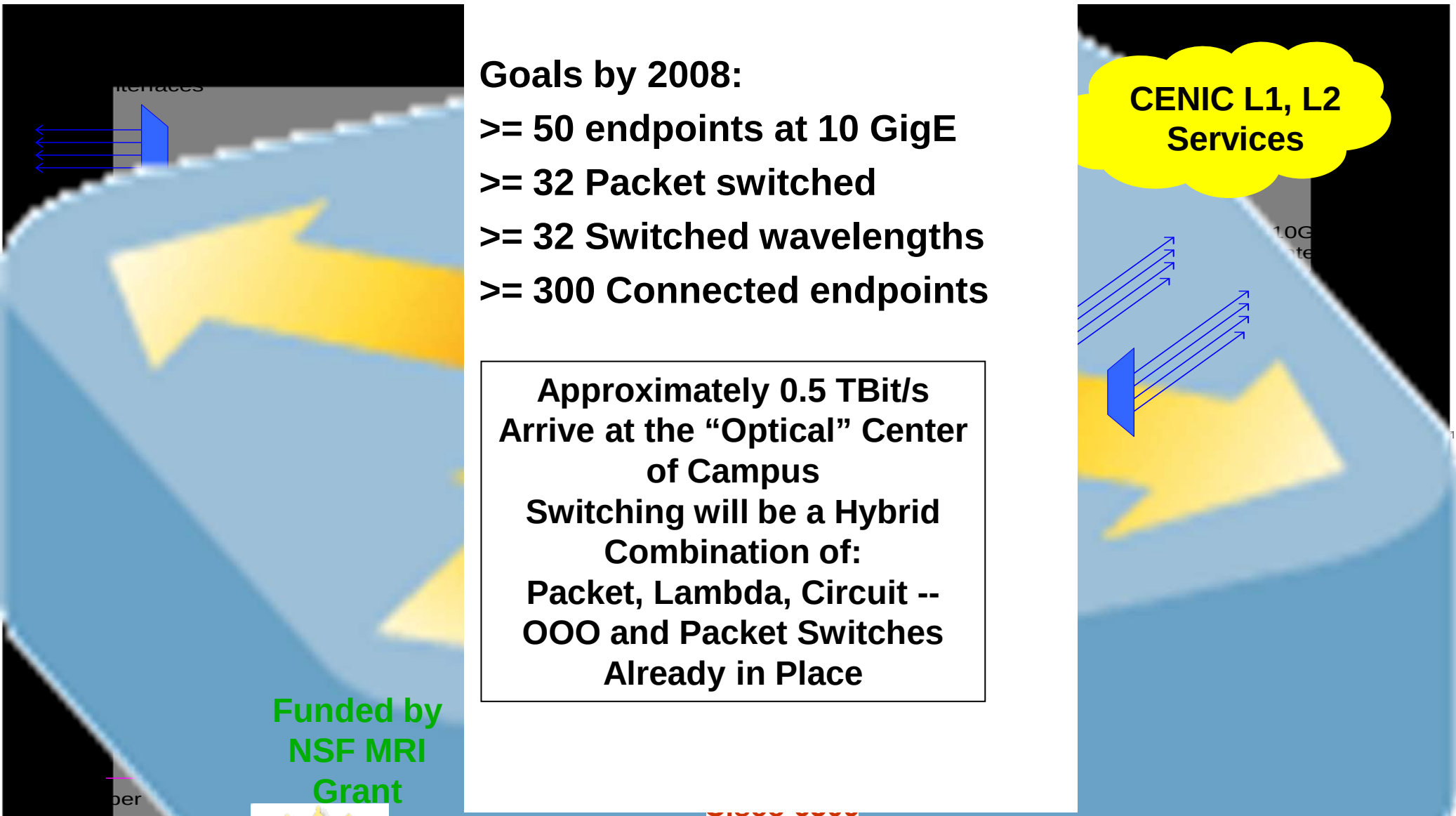
To Build a Campus Dark Fiber Network—
First, Find Out Where All the Campus Conduit Is!



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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)

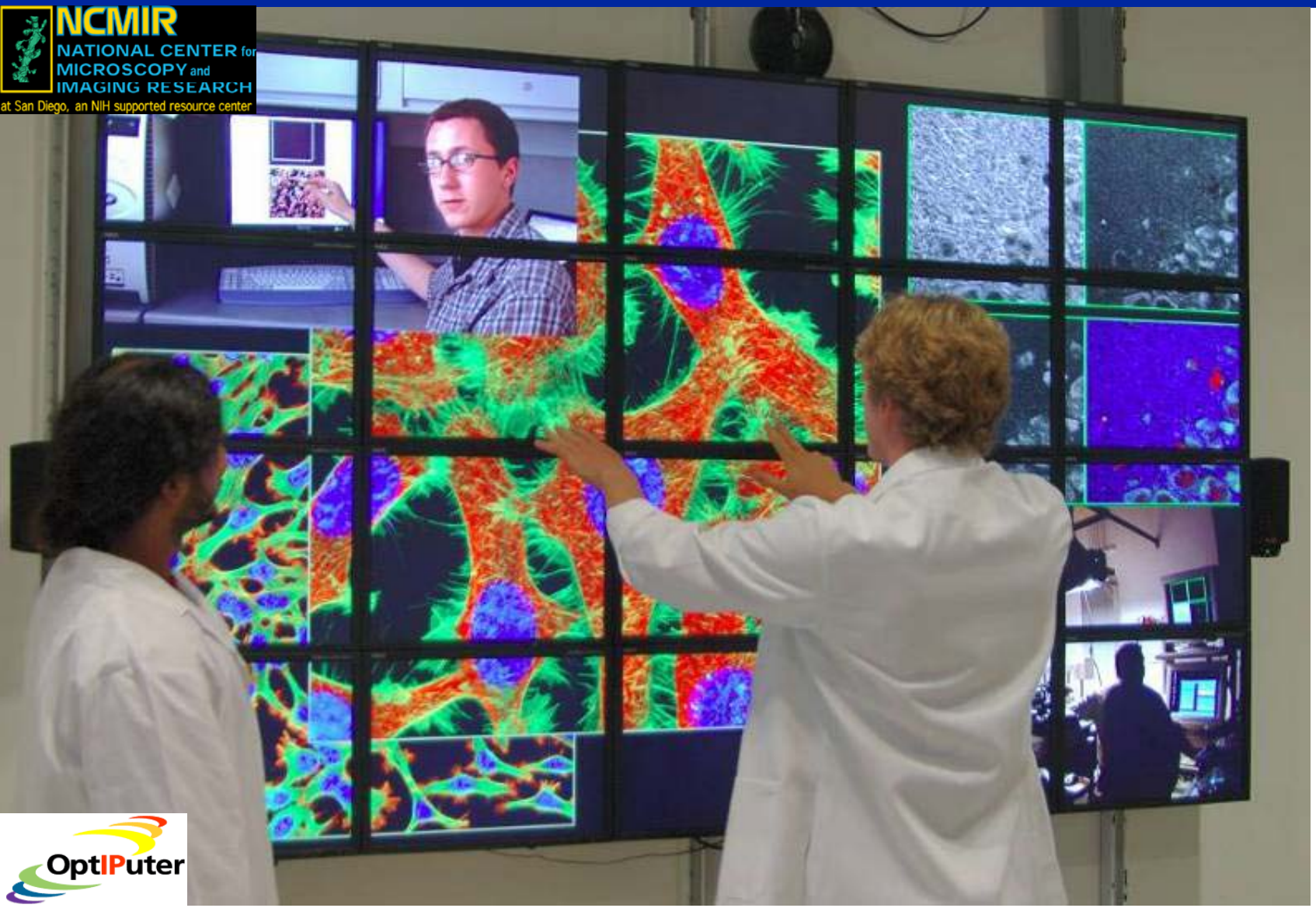
Calit2 Sunlight
Optical Exchange Contains Quartzite



10:45 am
Feb. 21, 2008

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



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

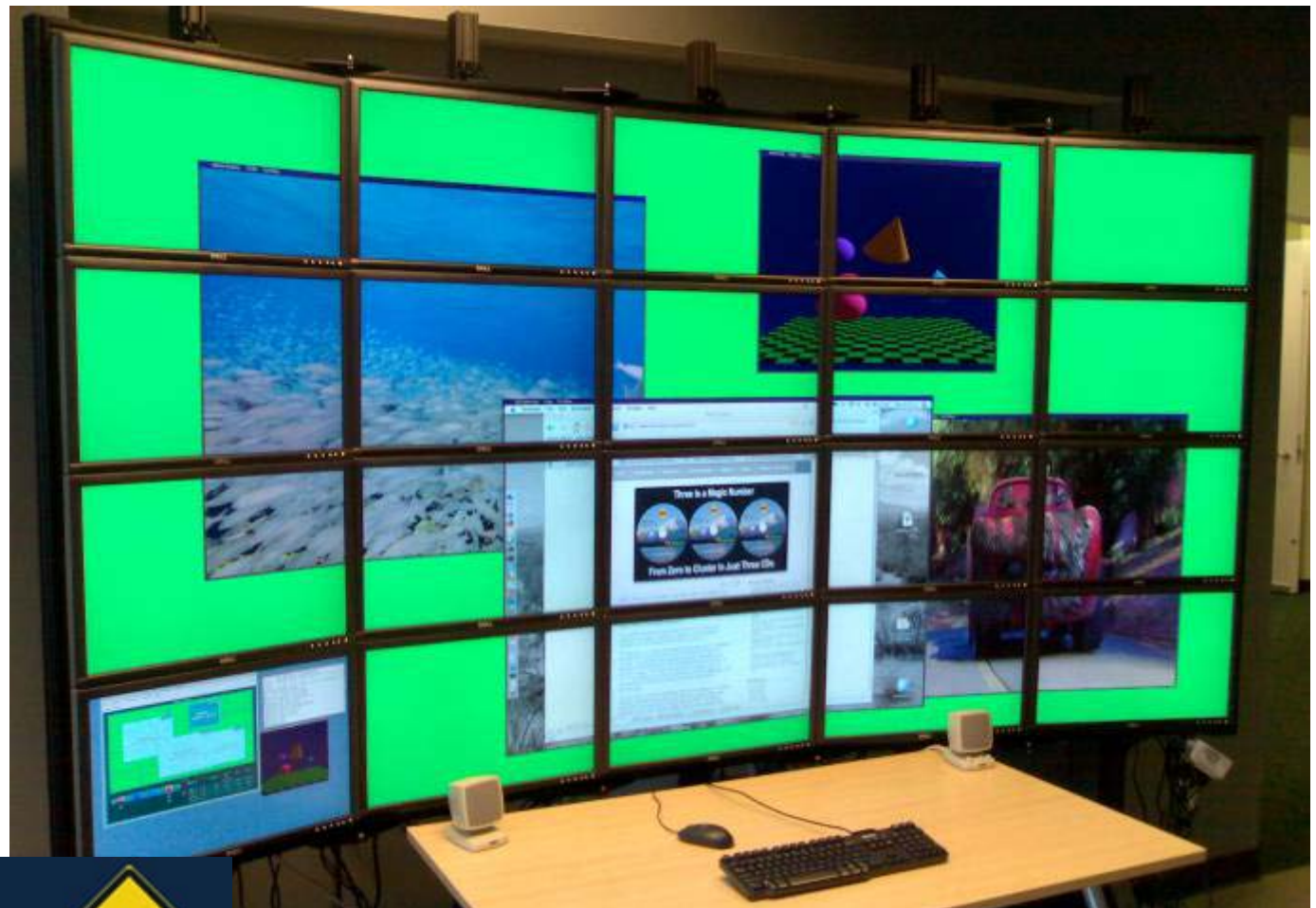
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My OptIPortal™ – Affordable Termination Device for the OptIPuter Global Backplane

- 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





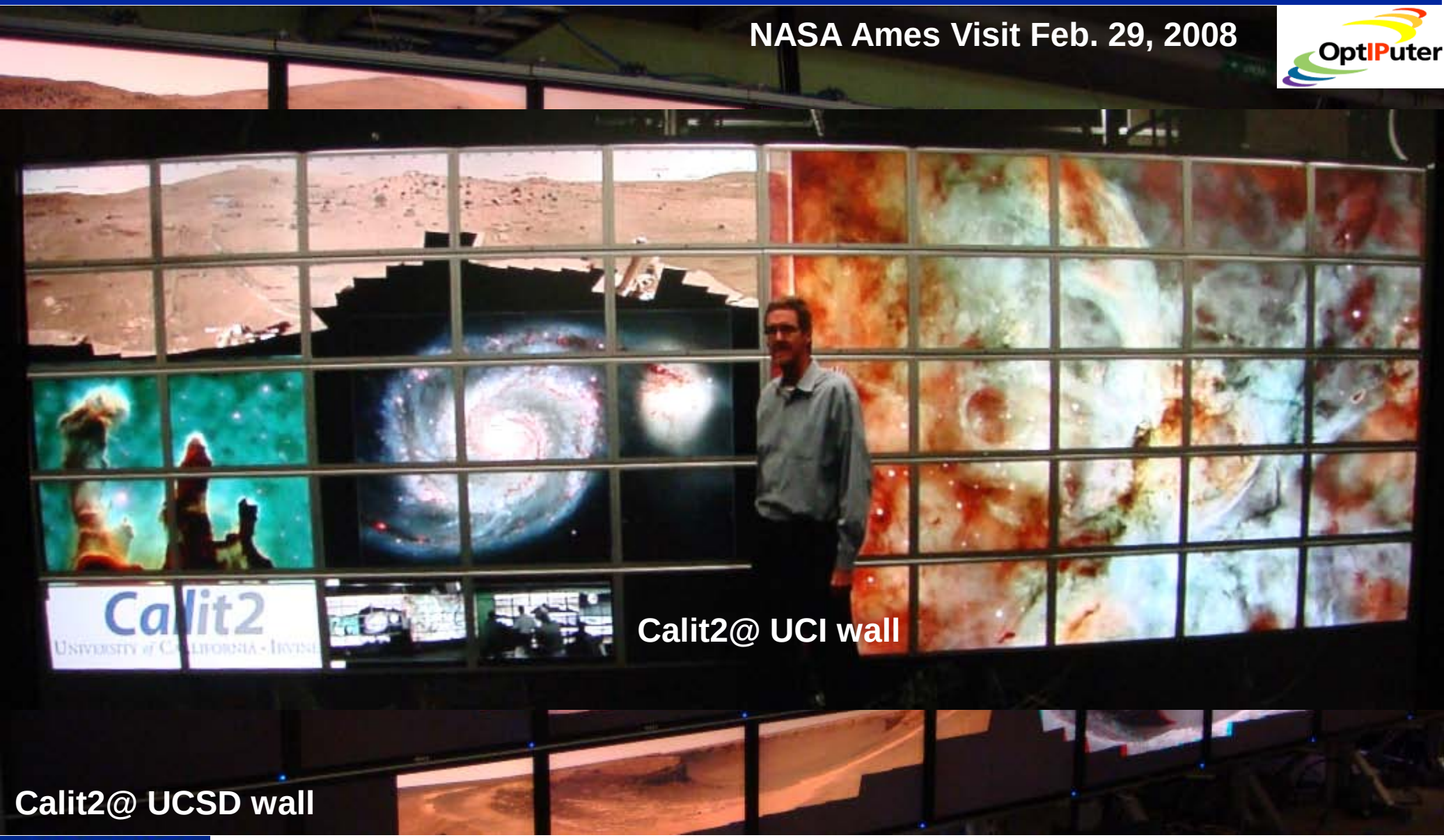
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Source: Phil Papadopoulos SDSC, Calit2

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The Calit2 200 Megapixel 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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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**





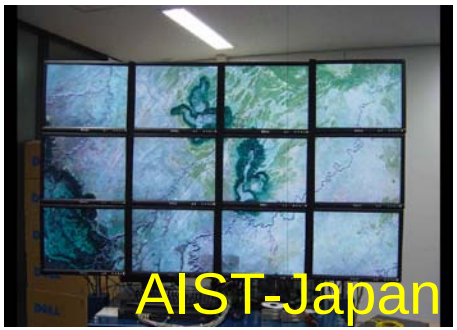
Leading U.S. Researchers on the Social Aspects of Collaboration

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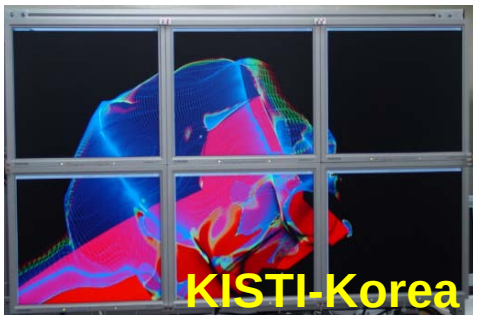
Source: Erik Hofer, UMich, School of Information

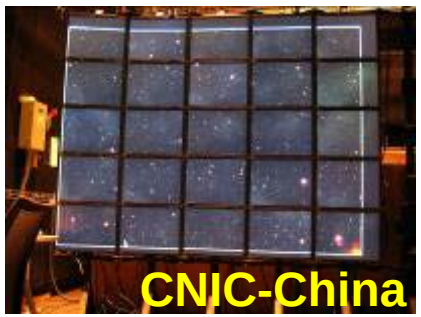
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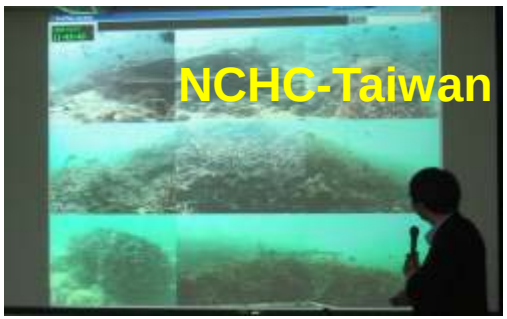
OptIPortals
Are Being Adopted Globally























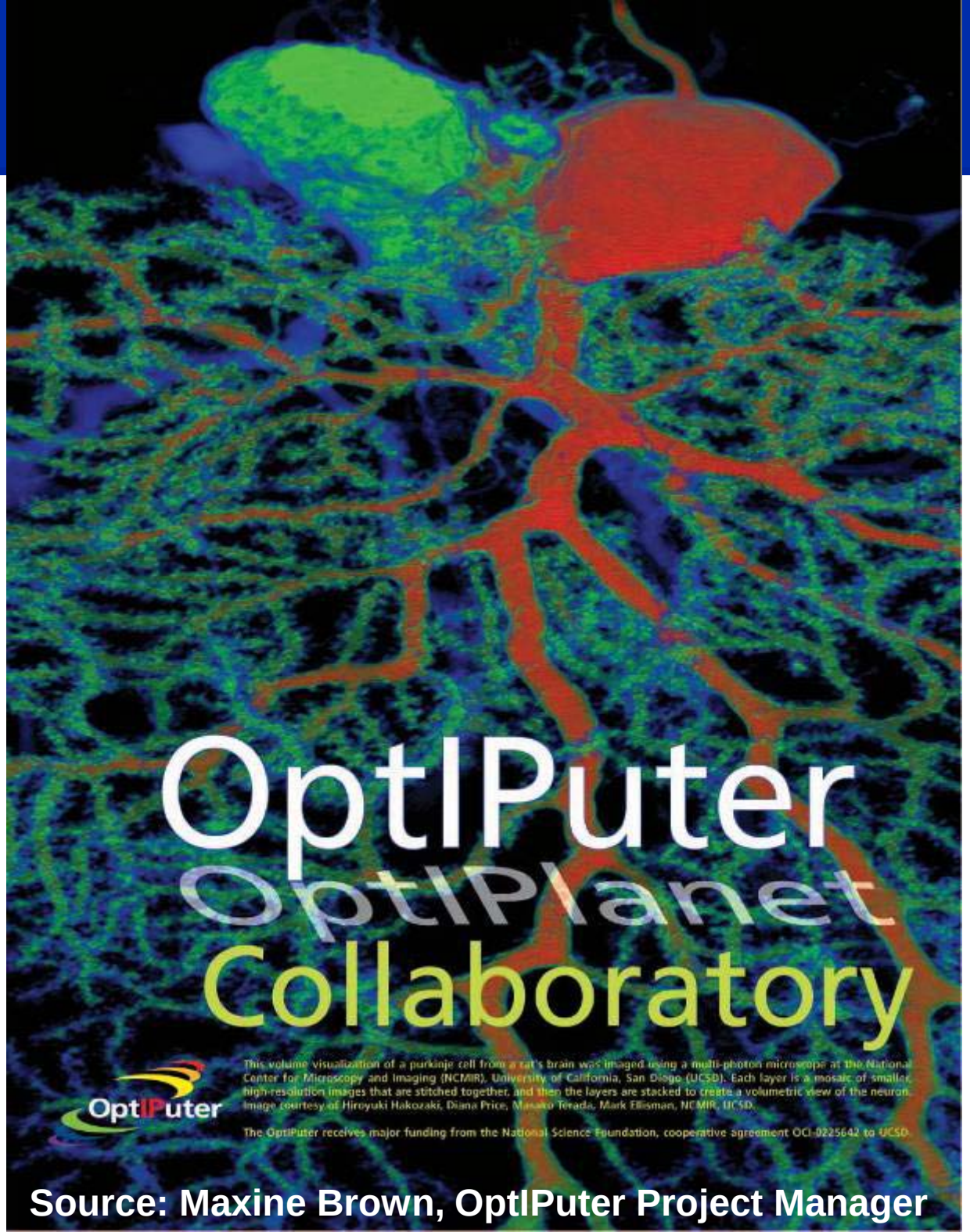


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evl electronic visualization laboratory

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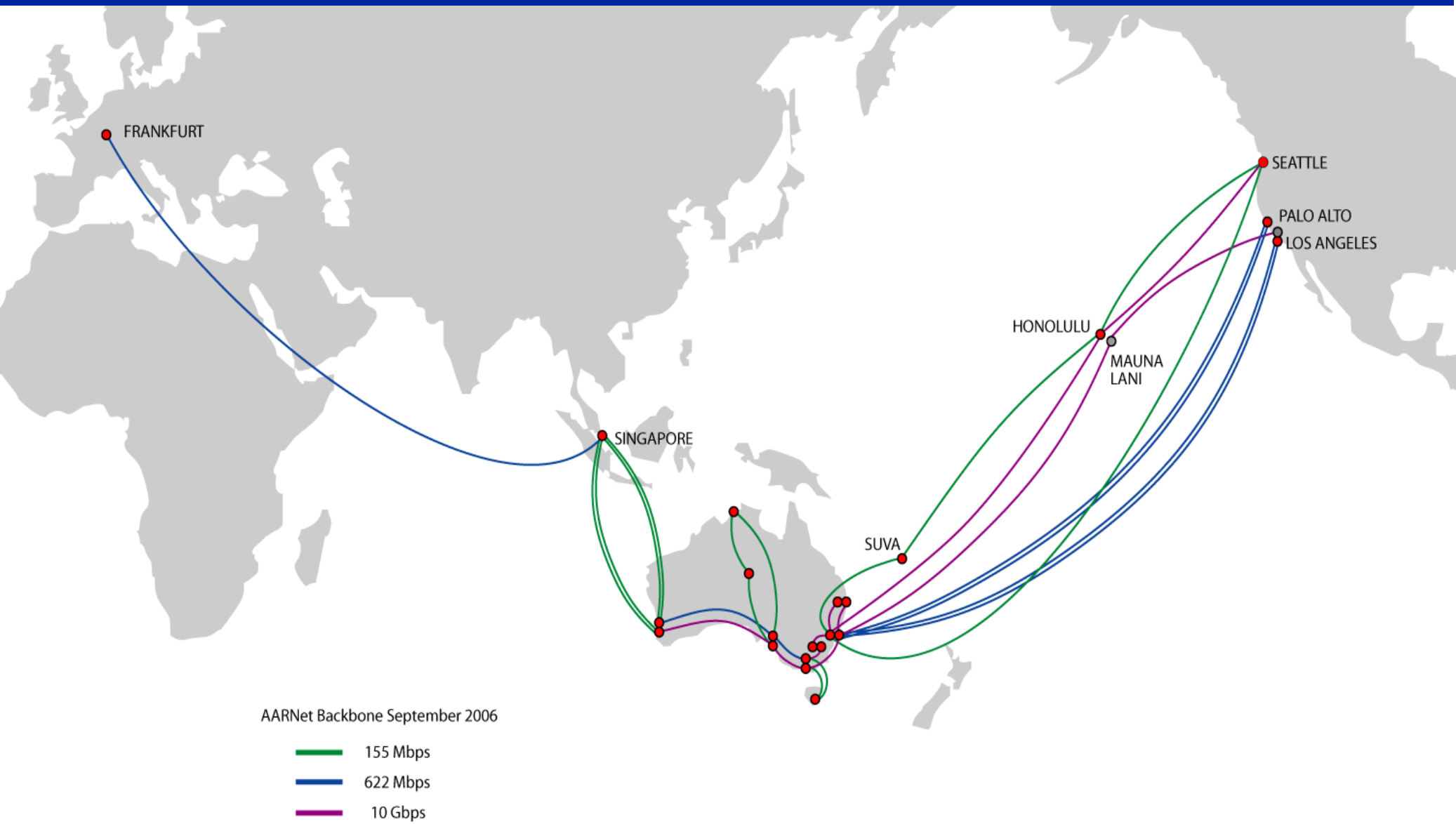
Source: Maxine Brown, OptIPuter Project Manager

Green Initiative:

Can Optical Fiber Replace Airline Travel for Continuing Collaborations ?

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AARNet International Network



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

“Using the Link to Build the Link”
Calit2 and Univ. Melbourne Technology Teams

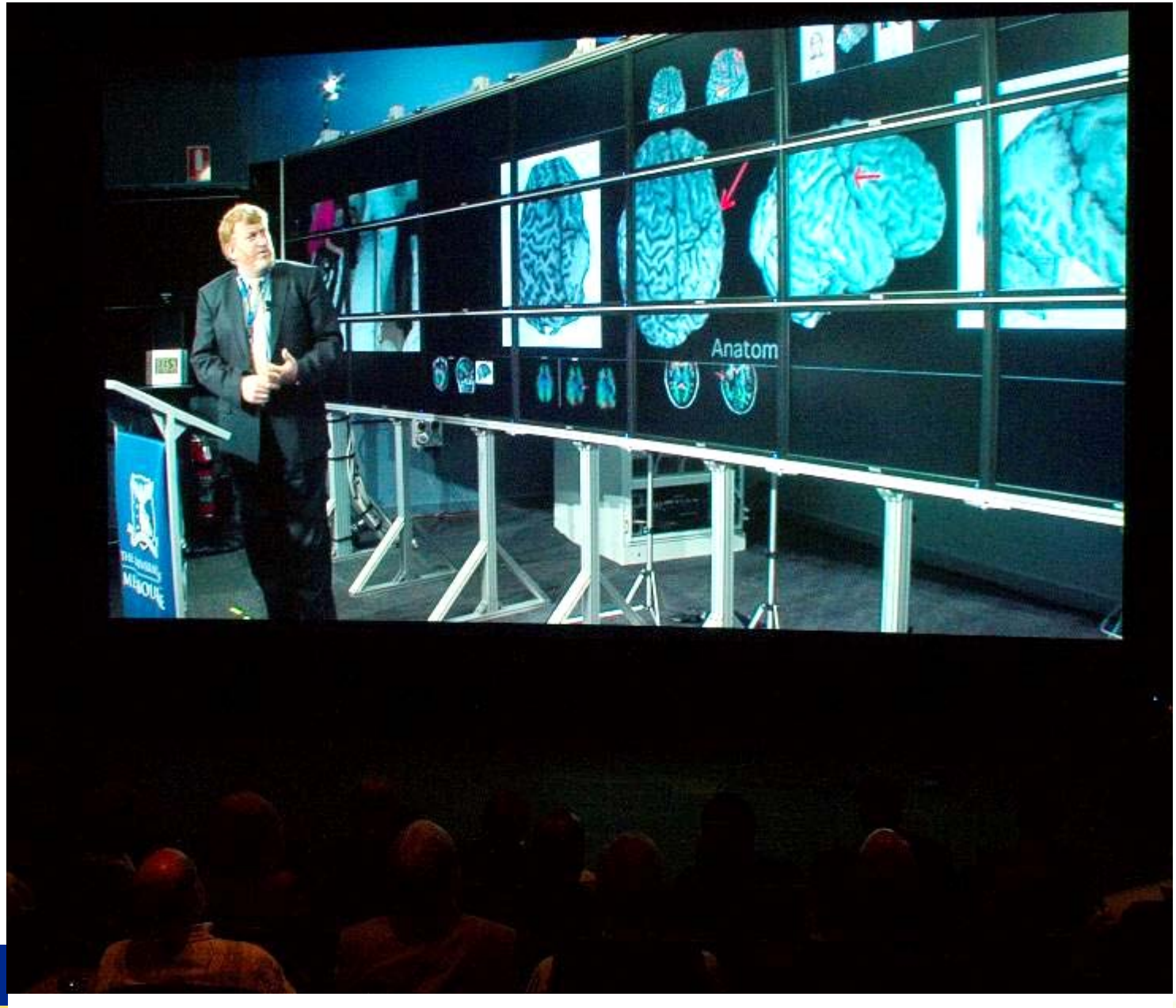


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No Calit2 Person Physically Flew to Australia to Bring This Up!

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

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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SAGE Global Visualcasting to Europe September 2007



Calit2, SDSC, and SIO are Creating Environmental Observatory Rooms



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Remote Interactive High Definition Video of Deep Sea Hydrothermal Vents



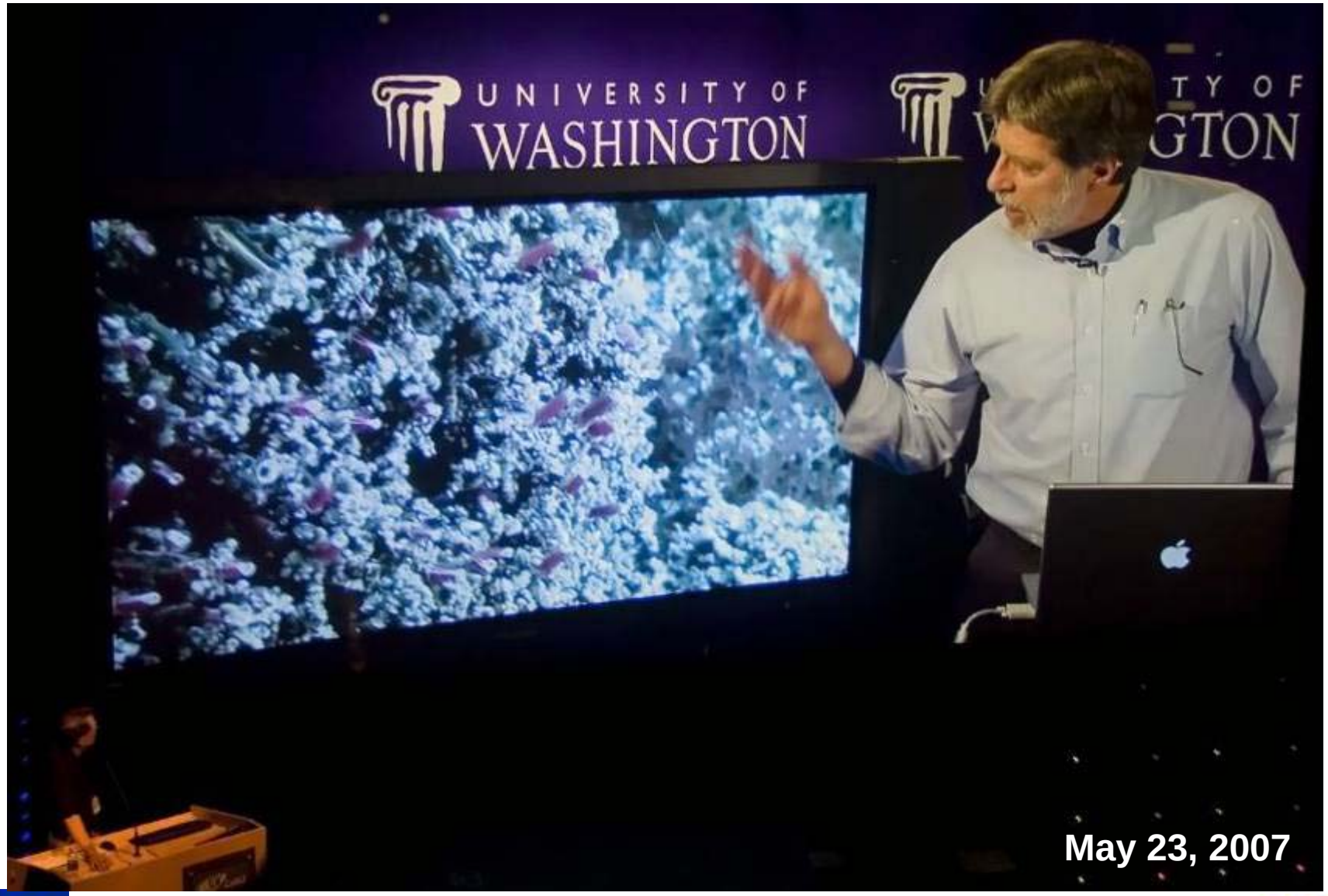
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Source John Delaney & Deborah Kelley, UWash

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e-Science Collaboratory Without Walls Enabled by iHDTV Uncompressed HD Telepresence

1500 Mbits/sec Calit2 to UW Research Channel Over NLR



John Delaney, PI LOOKING, Neptune

Photo: Harry Ammons, SDSC

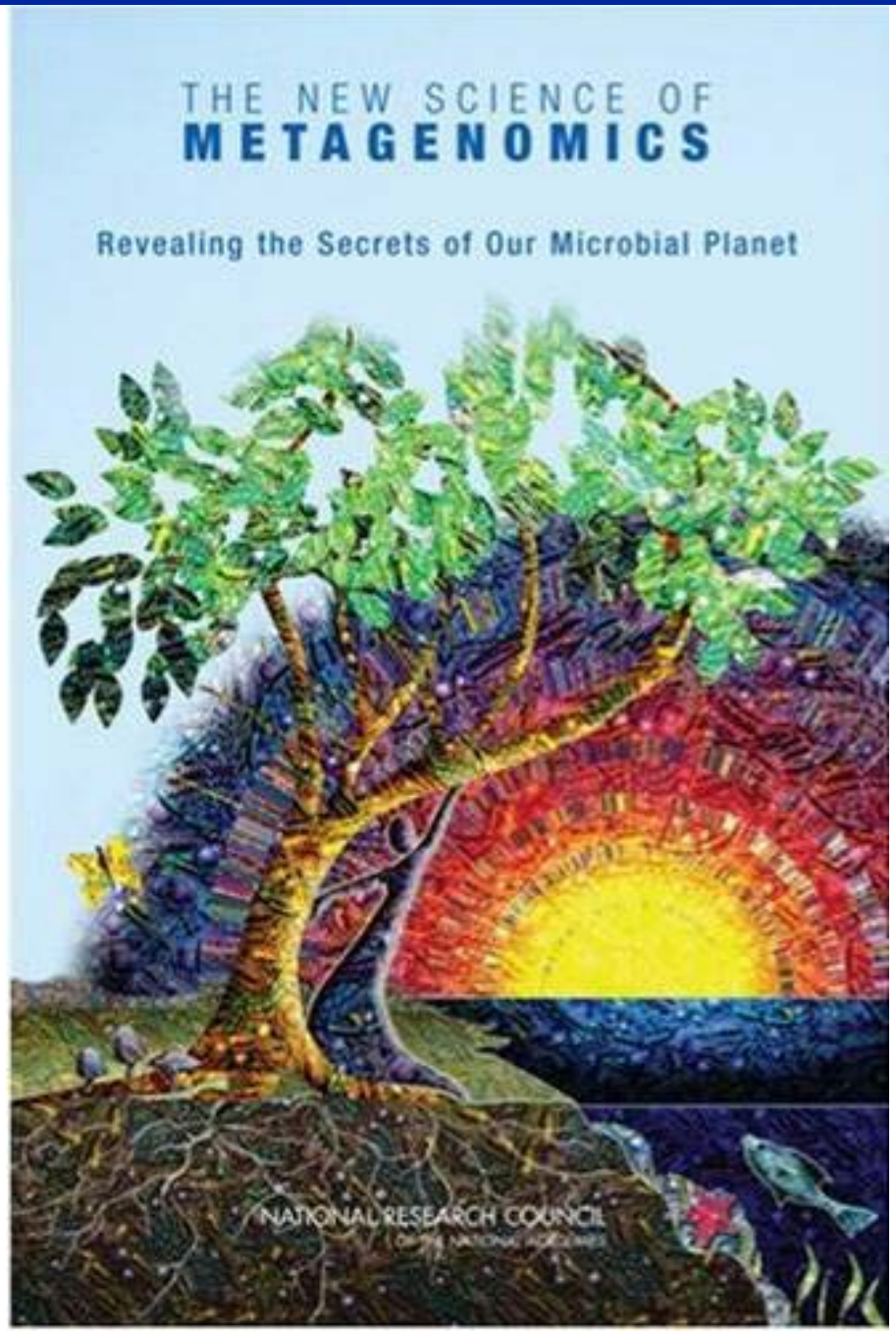
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The New Science of Metagenomics

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

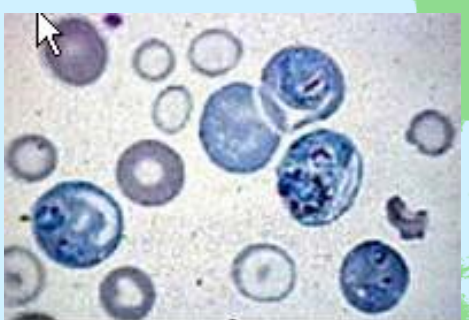
Plus 155 Marine Microbial Genomes



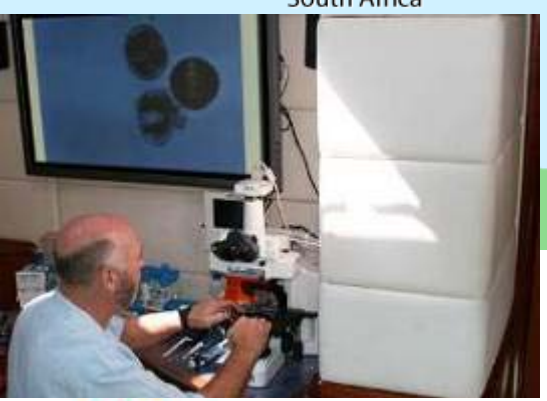
Each Sample ~2000 Microbial Species

Specify Ocean Data

Canada
United States
Mexico
Puerto Rico
Honduras
Costa Rica
Panama
Galapagos Islands
x 10 samples
French Polynesia
Vanuatu
Fiji
Tonga
Cook Islands
New Caledonia
Australia
x 17 samples
x 8 samples
Cocos-Keeling Is.
Tanzania/ Zanzibar
x 7 samples
Seychelles
Madagascar
South Africa



Analyzed
Sampled, but not Analyzed



MARINE MICROBIOLOGY INITIATIVE

camera
Marine Microbial Ecology

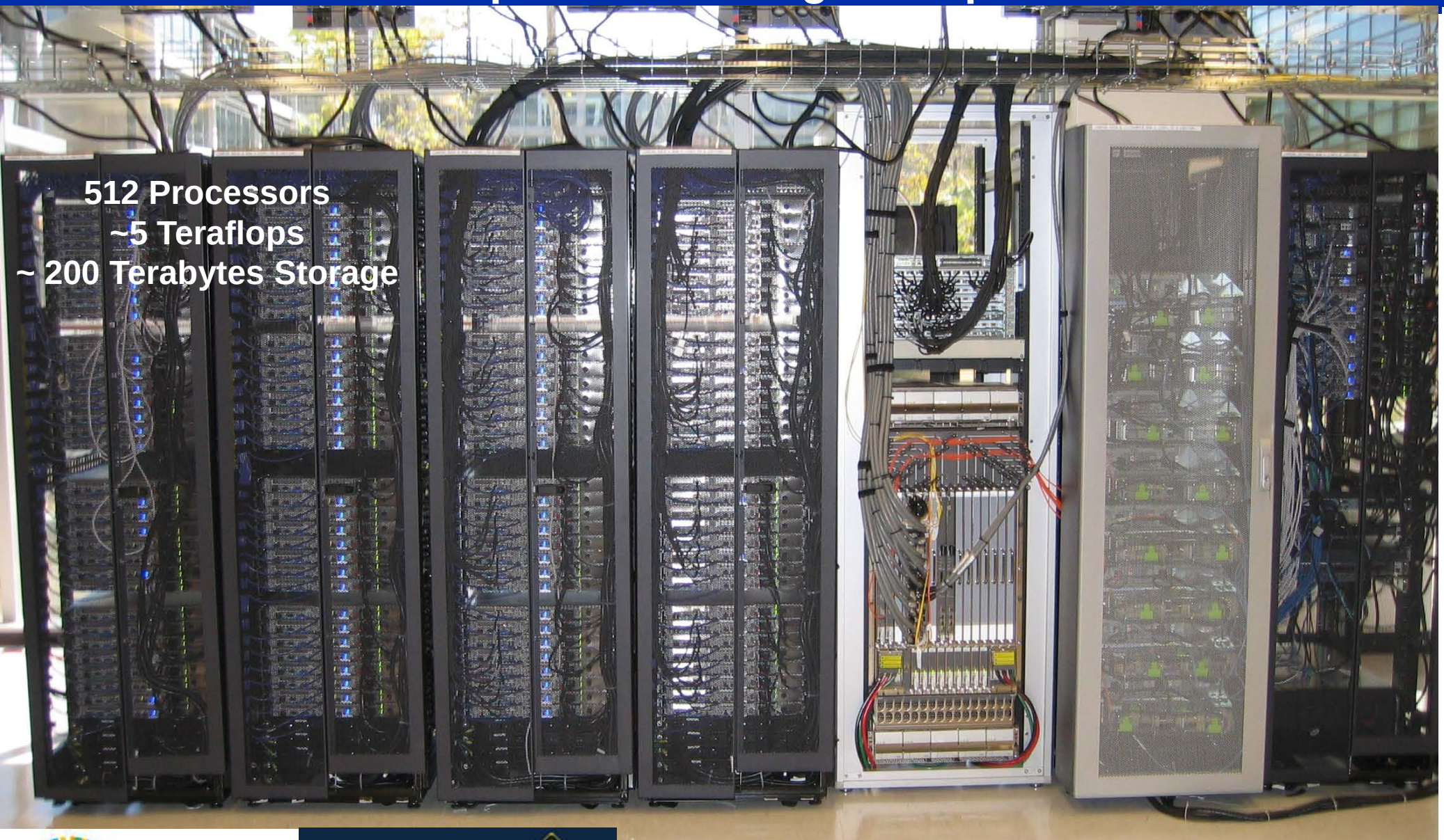
Gordon and Betty MOORE FOUNDATION

Sorcerer II Data Will Double Number of Proteins in GenBank!

J. Craig Venter INSTITUTE

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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

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CAMERA's Global Microbial Metagenomics CyberCommunity—Can We Employ Social Network Software?

Over 1850 Registered Users From Over 50 Countries



camera
Marine Microbial Ecology

J. Craig Venter
INSTITUTE

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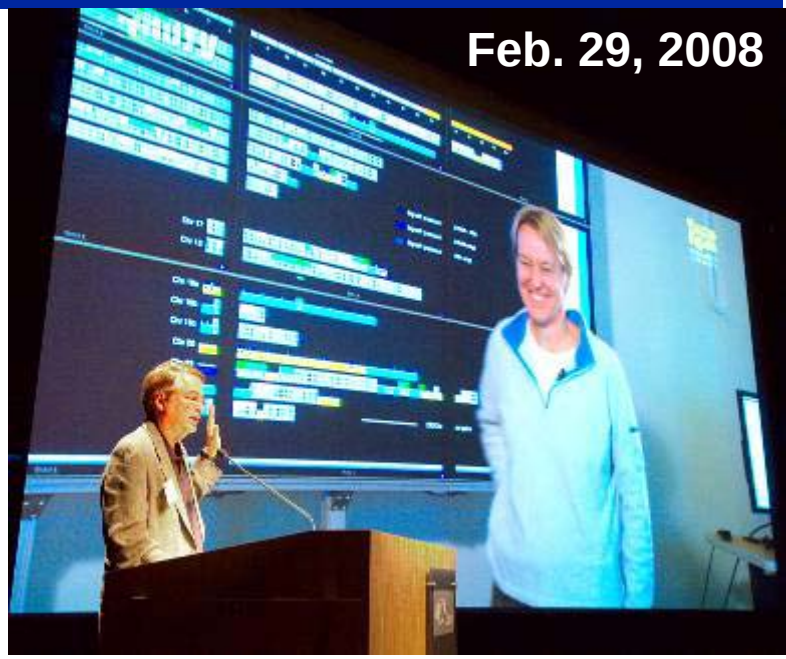
OptIPlanet Collaboratory Persistent Infrastructure Between Calit2 and U Washington



OptIPuter

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

ROCKS



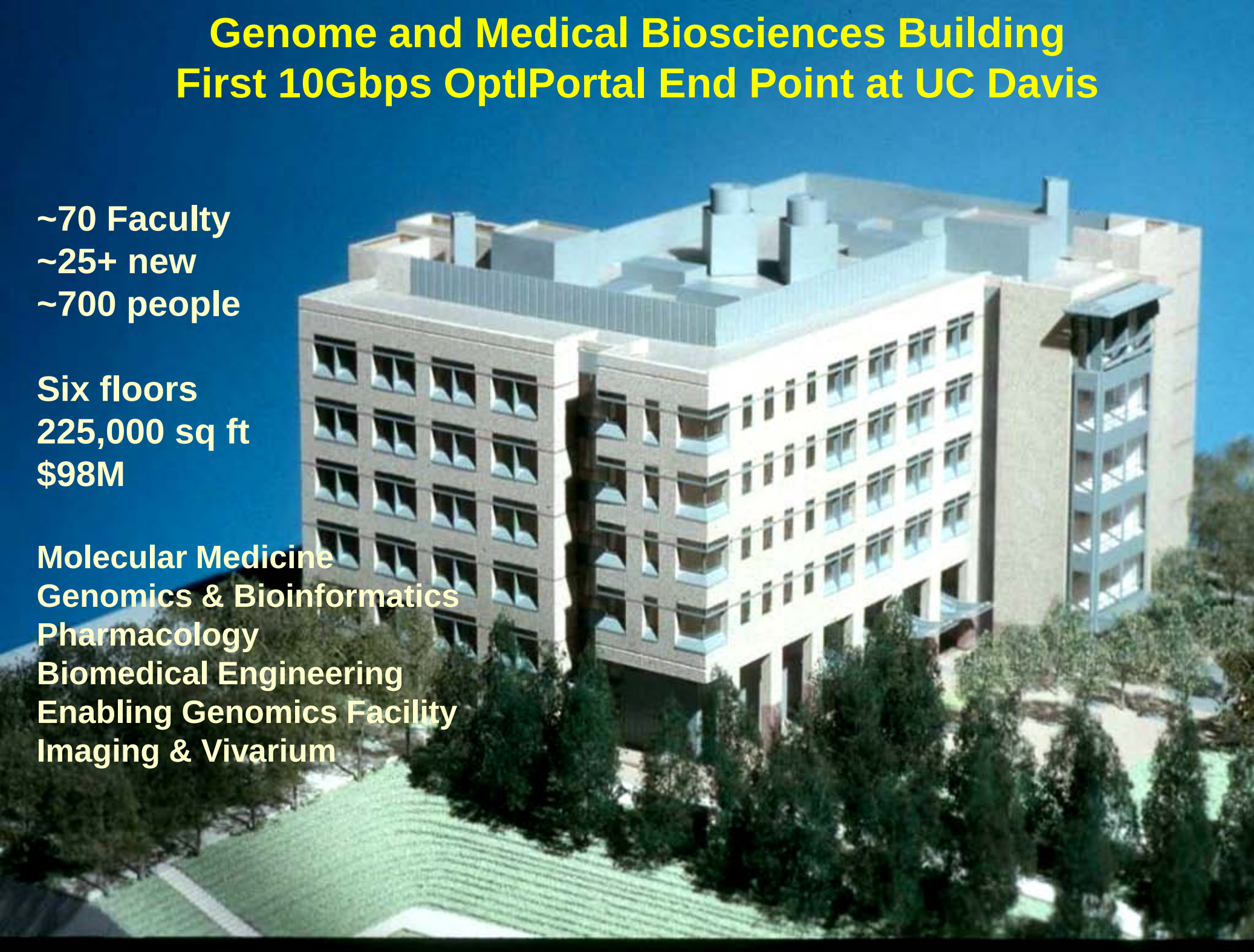




UW's Research Channel
Michael Wellings

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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

Borderless Collaboration
Between Global University Research Centers at 10Gbps

Maxine Brown, Tom DeFanti, Co-Chairs

iGrid 2005

THE GLOBAL LAMBDA INTEGRATED FACILITY

www.igrid2005.org

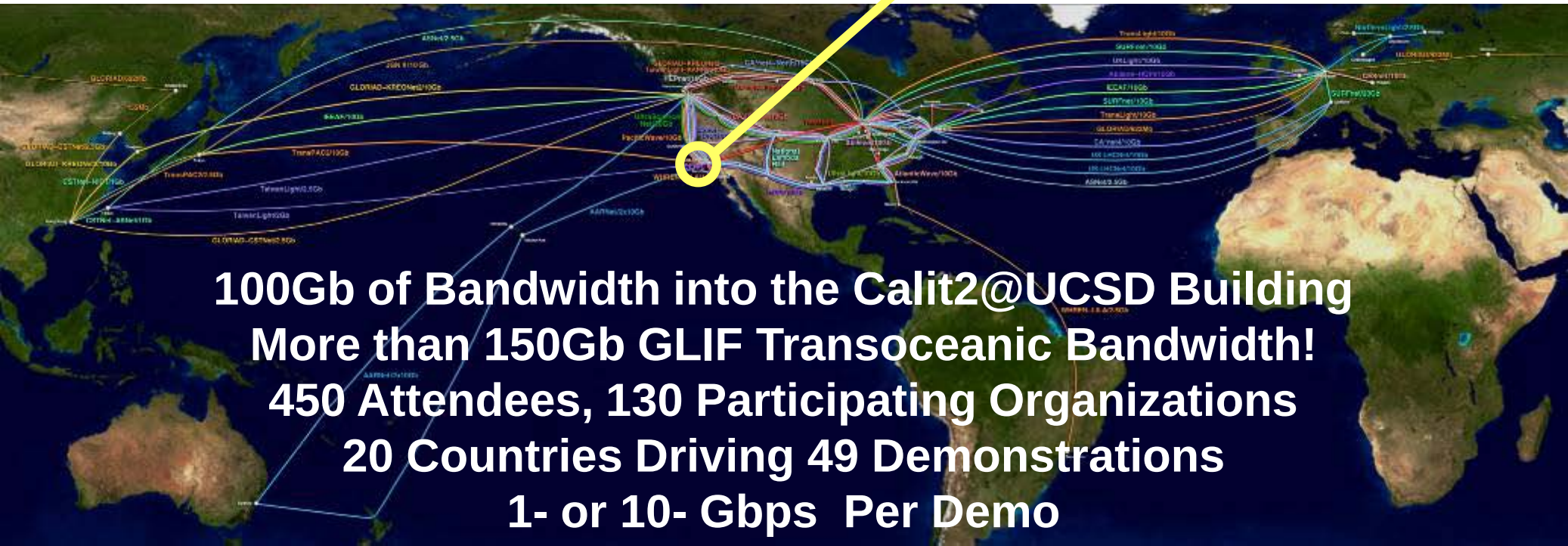


the UC Discovery Grant

September 26-30, 2005

Calit2 @ University of California, San Diego

California Institute for Telecommunications and Information Technology



100Gb of Bandwidth into the Calit2@UCSD Building

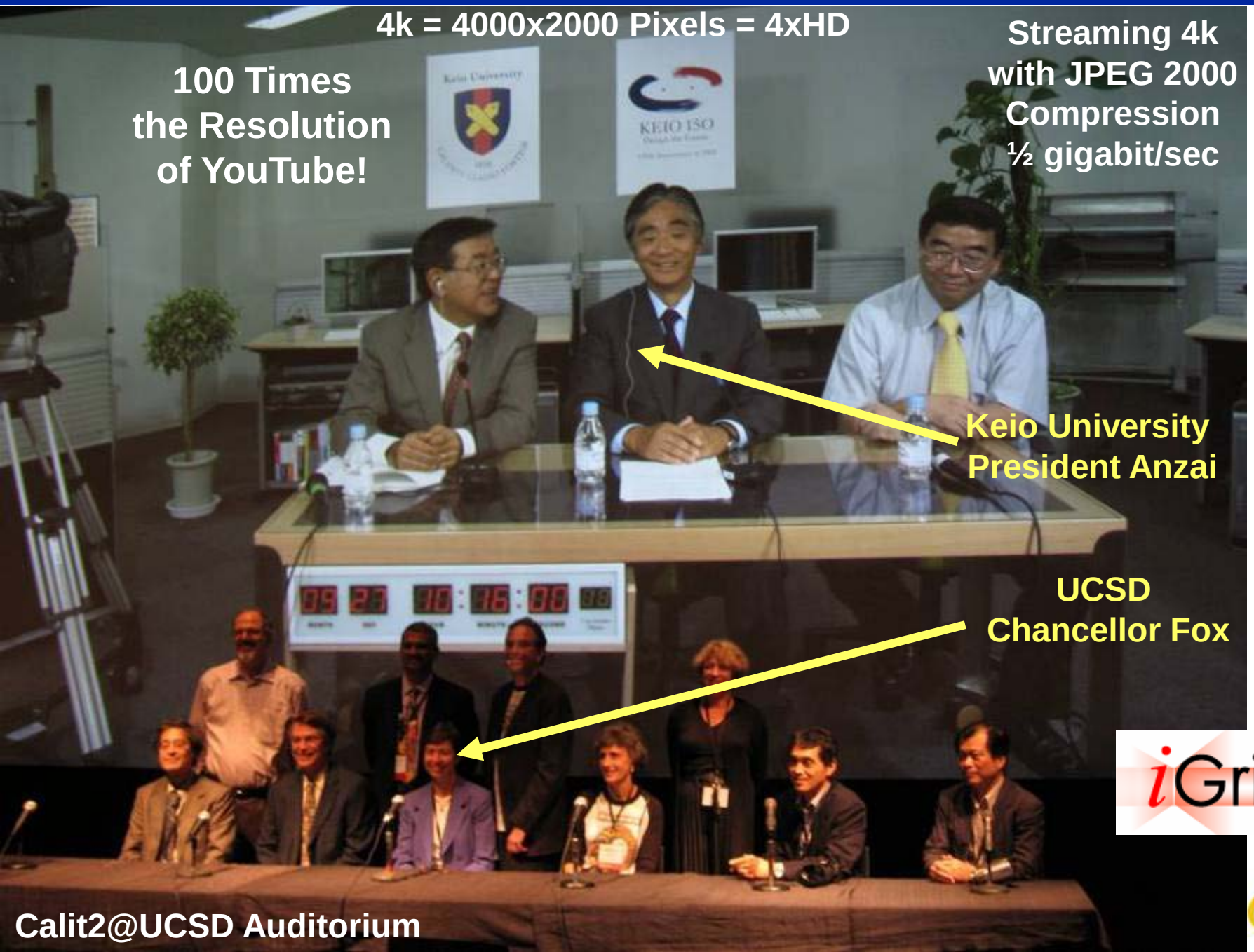
More than 150Gb GLIF Transoceanic Bandwidth!

450 Attendees, 130 Participating Organizations

20 Countries Driving 49 Demonstrations

1- or 10- Gbps Per Demo

First Trans-Pacific Super High Definition Telepresence Meeting Using Digital Cinema 4k Streams



CineGrid

Lays Technical Basis for Global Digital Cinema

Sony
NTT
SGI

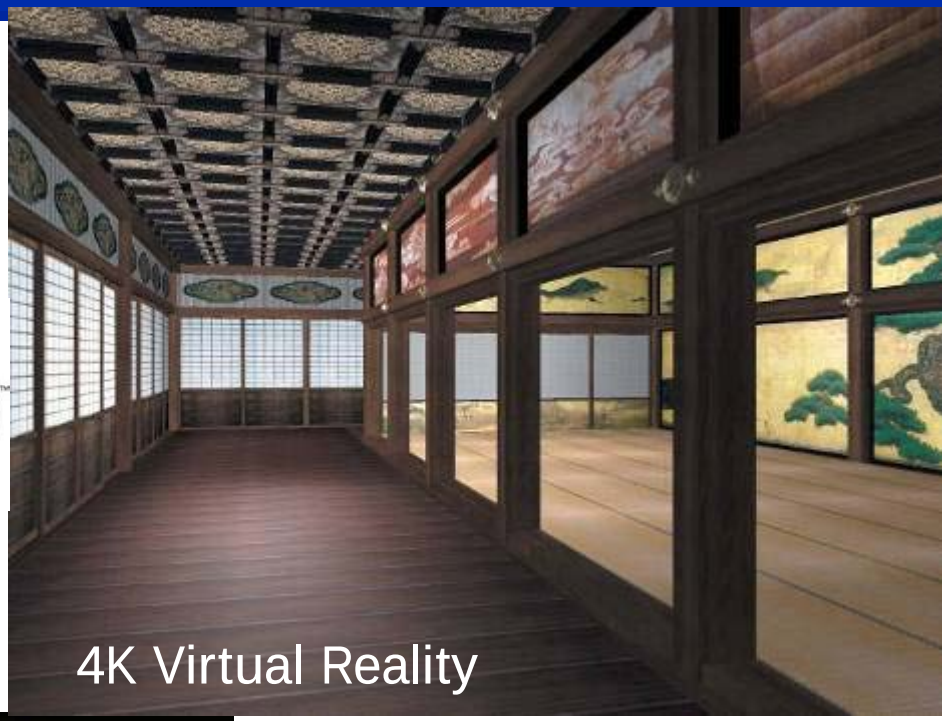
iGrid 2005

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CineGrid @ iGrid2005:
Six Hours of 4K Projected in Calit2 Auditorium

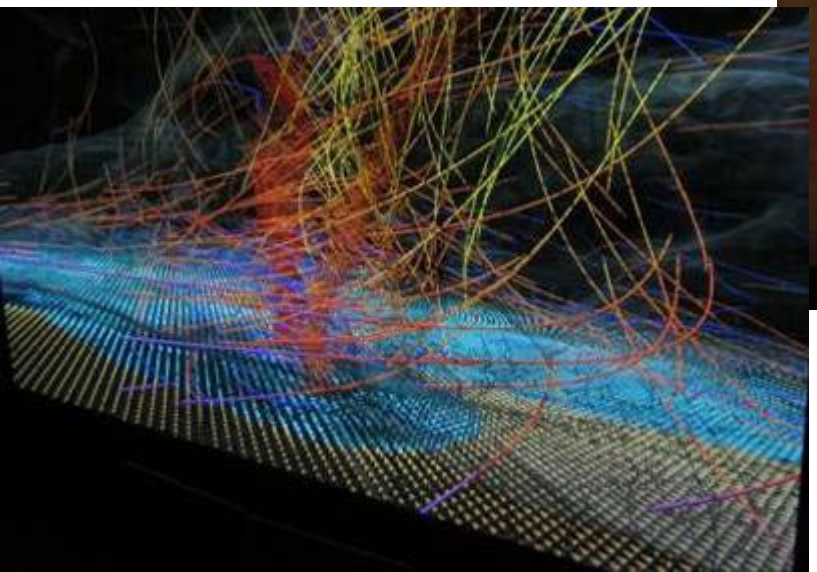
4K Distance Learning





4K Virtual Reality

4K Scientific Visualization





4K Digital Cinema

4K *Anime*



Source: Laurin Herr

CineGrid Founding Members

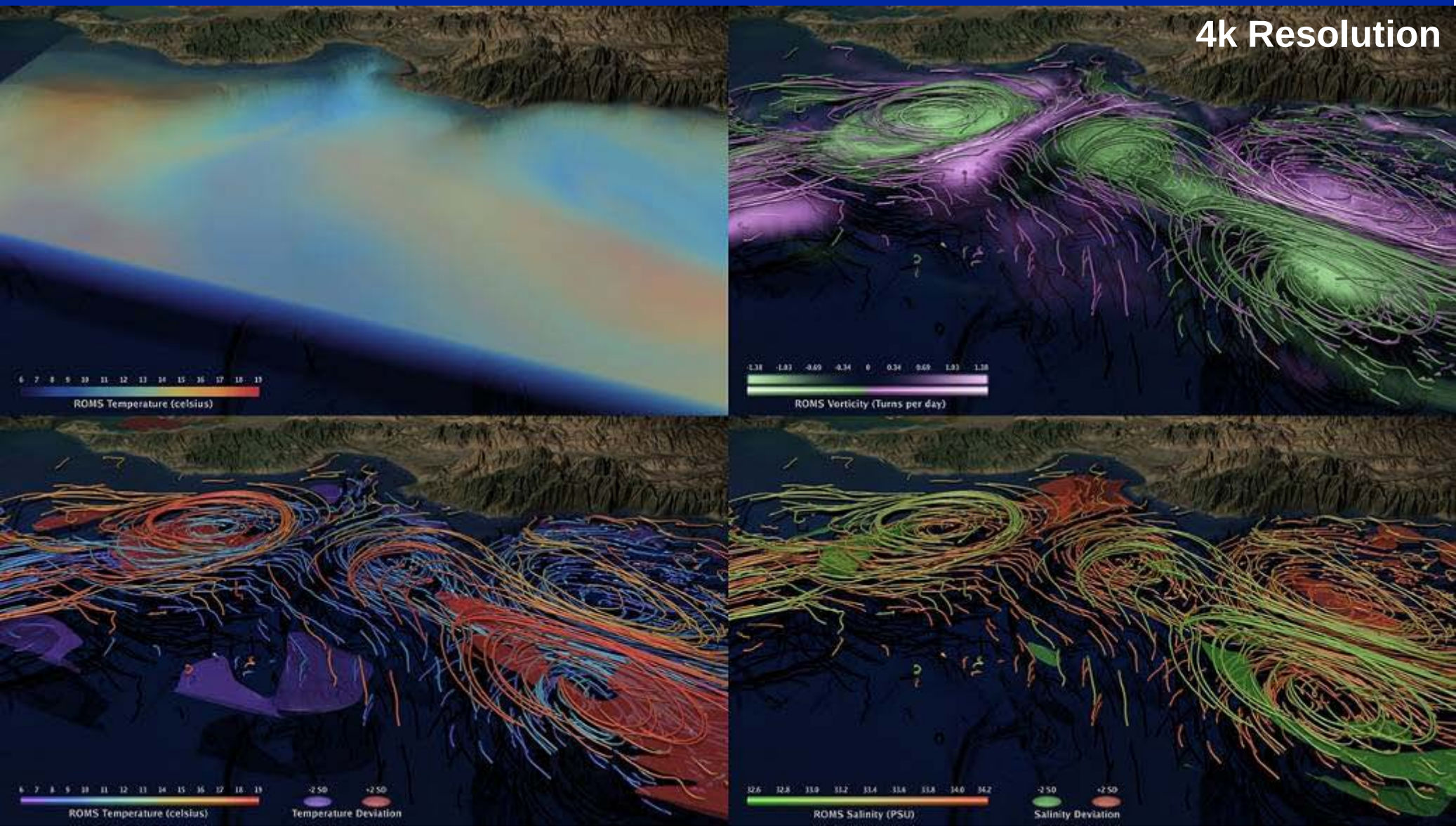
- Cisco Systems
- Keio University DMC
- Lucasfilm Ltd.
- NTT Network Innovation Laboratories
- Pacific Interface Inc.
- Ryerson University/Rogers Communications Centre
- San Francisco State University/INGI
- Sony Electronics America
- University of Amsterdam
- University of California San Diego/Calit2/CRCA
- University of Illinois Chicago/EVL
- University of Illinois at Urbana-Champaign/NCSA
- University of Southern California/School of Cinematic Arts
- University of Washington/Research Channel

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The Founding Members of CineGrid are an extraordinary mix of media arts schools, research universities, and scientific laboratories connected by 1GE and 10GE networks used for research & education

it2

From Digital Cinema to Scientific Visualization: JPL Simulation of Monterey Bay



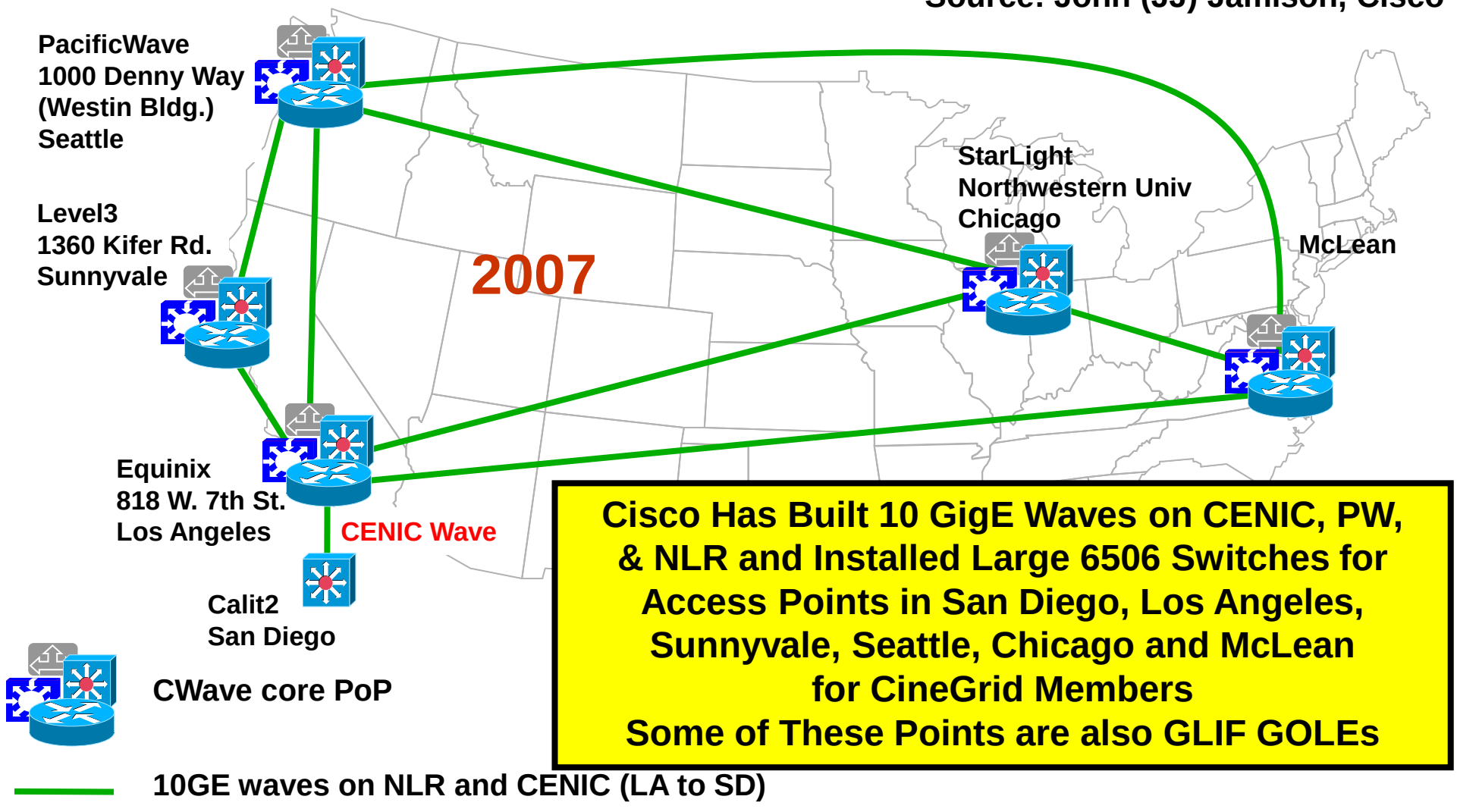
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Source: Donna Cox, Robert Patterson, NCSA
Funded by NSF LOOKING Grant

it²

Cisco CWave for CineGrid: A New Cyberinfrastructure for High Resolution Media Streaming*

Source: John (JJ) Jamison, Cisco

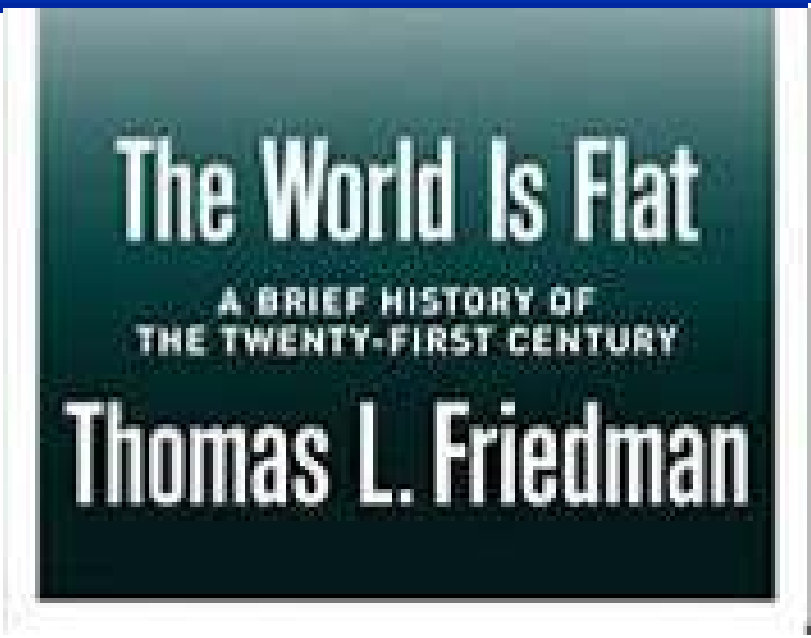


Cisco Has Built 10 GigE Waves on CENIC, PW, & NLR and Installed Large 6506 Switches for Access Points in San Diego, Los Angeles, Sunnyvale, Seattle, Chicago and McLean for CineGrid Members
Some of These Points are also GLIF GOLEs

UCSD UCIrvine *CTWatch QUARTERLY May 2007 CineGrid it2

Ten Years Old Technologies--the Shared Internet & the Web--Have Made the World "Flat"

- **But Today's Innovations**
  - Dedicated Fiber Paths
  - Streaming HD TV
  - Large Display Systems
  - Massive Computing and Storage



- **Are Reducing the World to a "Single Point"**
  - How Will Industry, Universities, and Our Society Reorganize Themselves?

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