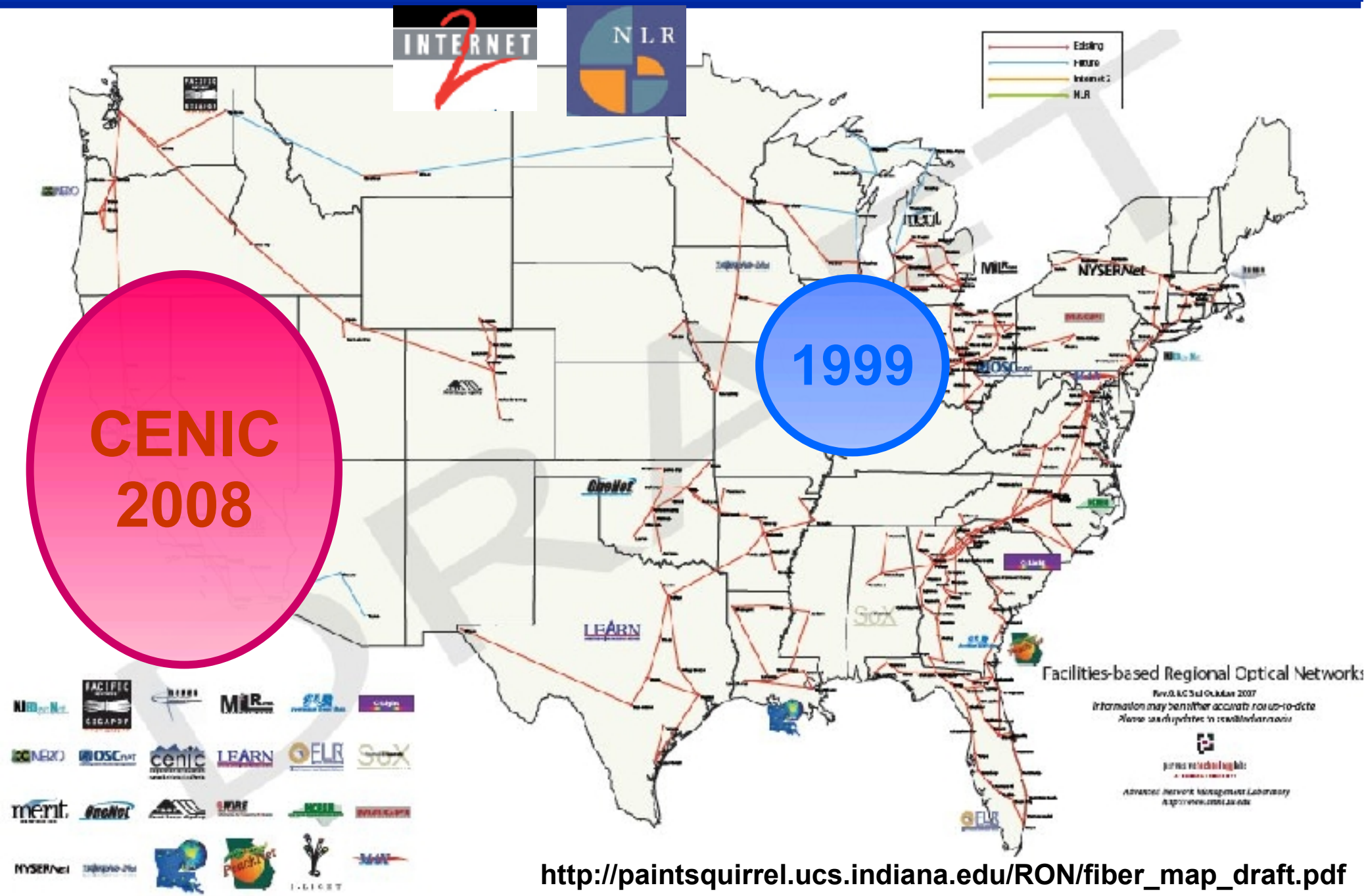
# New Applications of SuperNetworks and the Implications for Campus Networks

**Fall 2007 Internet2 Member Meeting**
**Town and Country Resort and Convention Center**
**San Diego, California**
**October 9, 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

# Interconnecting Regional Optical Networks Is Driving Campus Optical Infrastructure Deployment

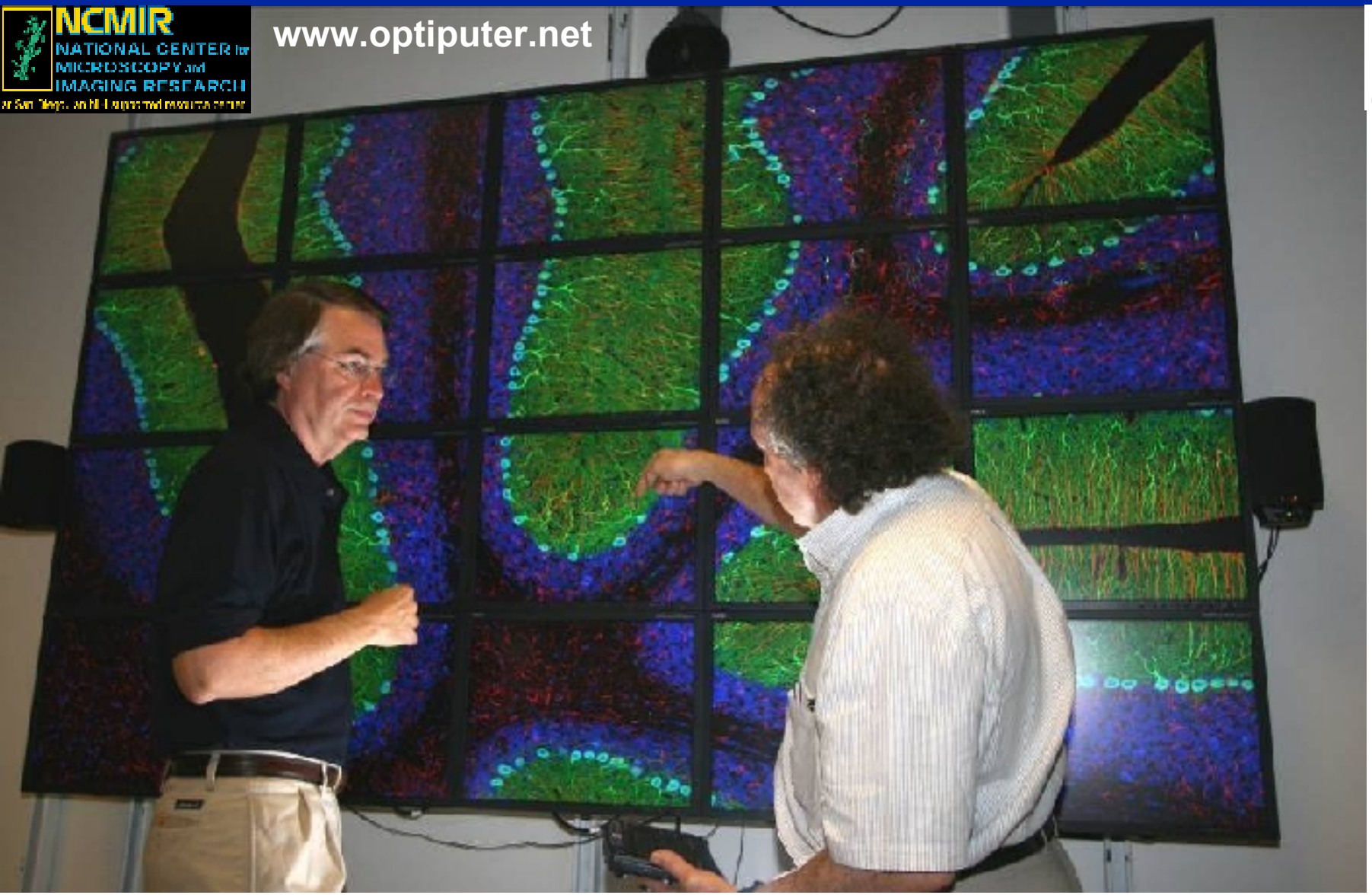


# The OptIPuter Project: Creating High Resolution Portals Over Dedicated Optical Channels to Global Science Data

NCMIR NATIONAL CENTER for MICROSCOPY and IMAGING RESEARCH

www.optiputer.net

OptIPuter



NSF

2002-2008

Picture Source: Mark Ellisman, David Lee, Jason Leigh

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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

it2

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

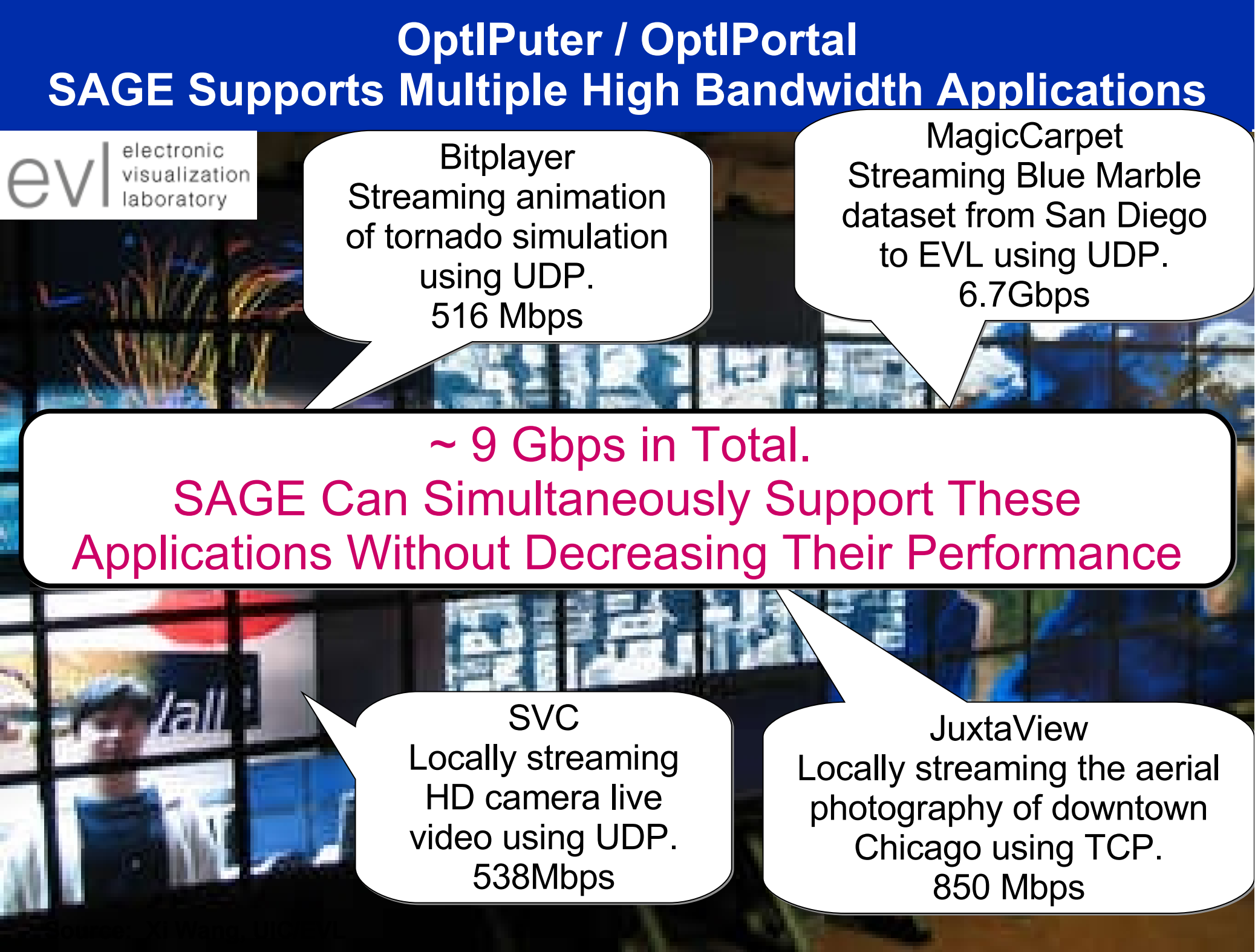
- 20 Dual CPU Nodes, Twenty 24” Monitors, ~$50,000
- 1/4 Teraflop, 5 Terabyte Storage, 45 Mega Pixels--Nice PC!
- Scalable Adaptive Graphics Environment ( SAGE)  Jason Leigh, EVL-UIC



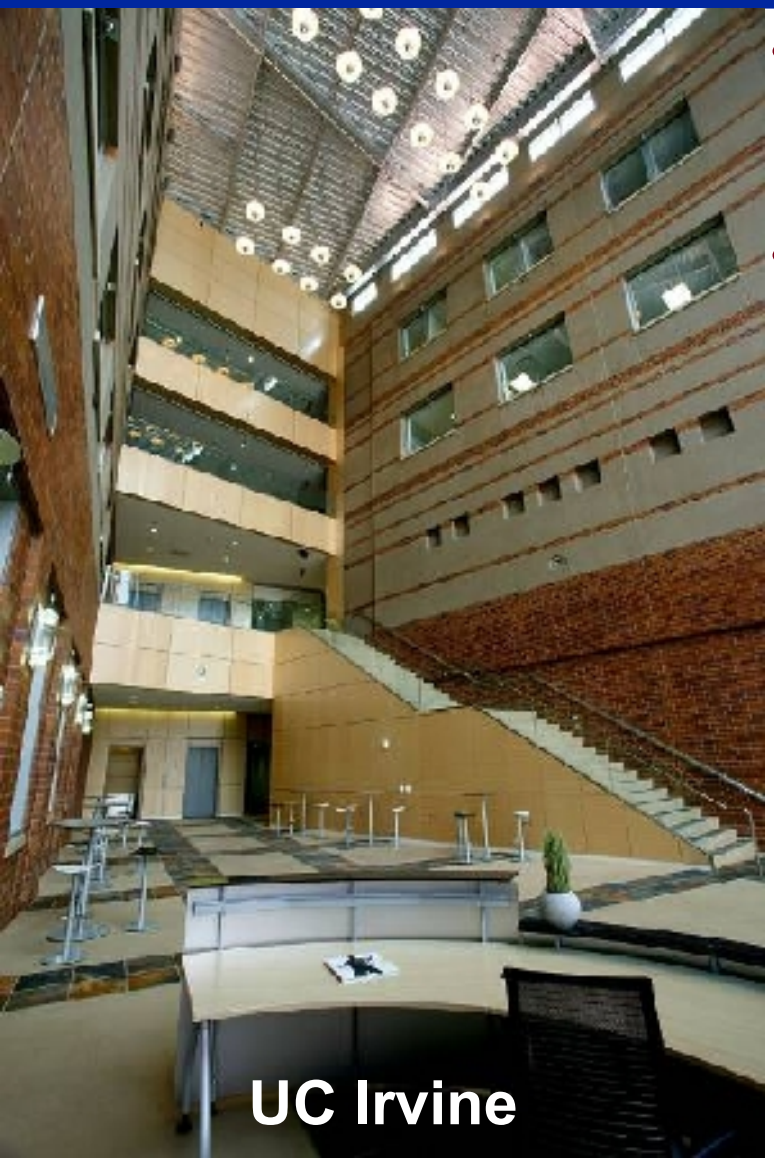


Source: Phil Papadopoulos SDSC, Calit2

# OptIPuter / OptIPortal
# SAGE Supports Multiple High Bandwidth Applications



# 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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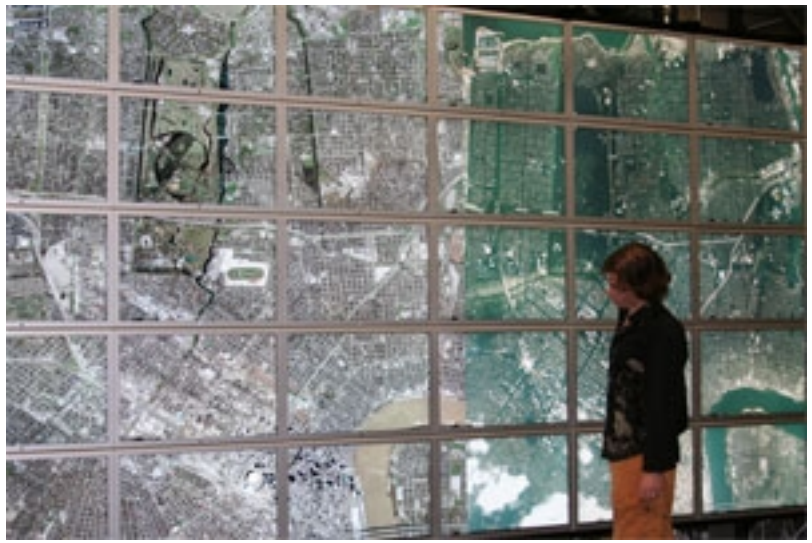
# Nearly One Half Billion Pixels in Calit2 Extreme Visualization Project!

**Connected at 2,000 Megabits/s!**









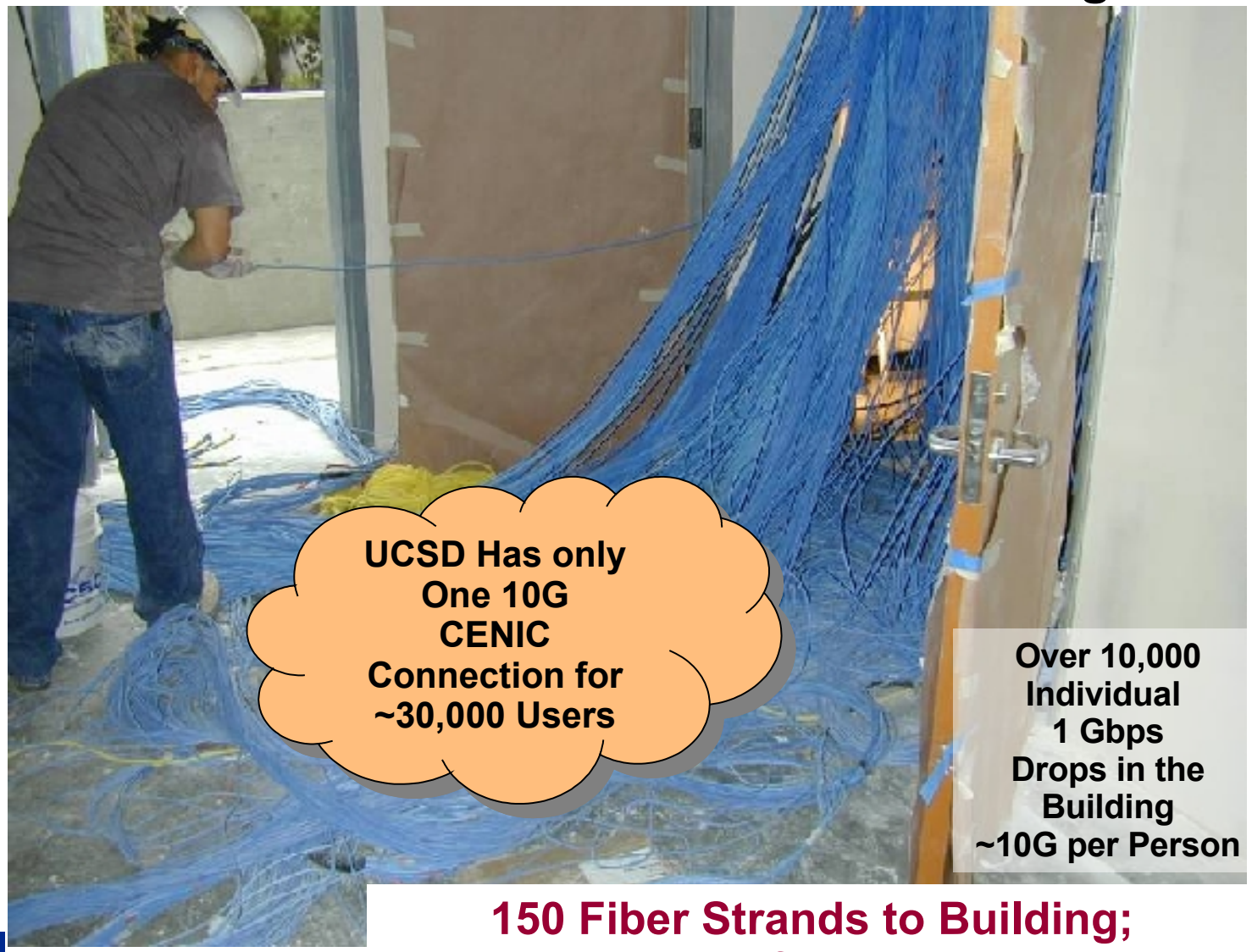
**UCI HIPerWall Analyzing Pre- and Post- Katrina**

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**Falko Kuester, UCSD; Steven Jenks, UCI**

# The Calit2@UCSD Building is Designed for Prototyping Extremely High Bandwidth Applications

## 1.8 Million Feet of Cat6 Ethernet Cabling




**24 Fiber Pairs to Each Lab**

**150 Fiber Strands to Building;**
**Experimental Roof Radio Antenna Farm**
**Ubiquitous WiFi**

Photo: Tim Beach, Calit2

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# 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

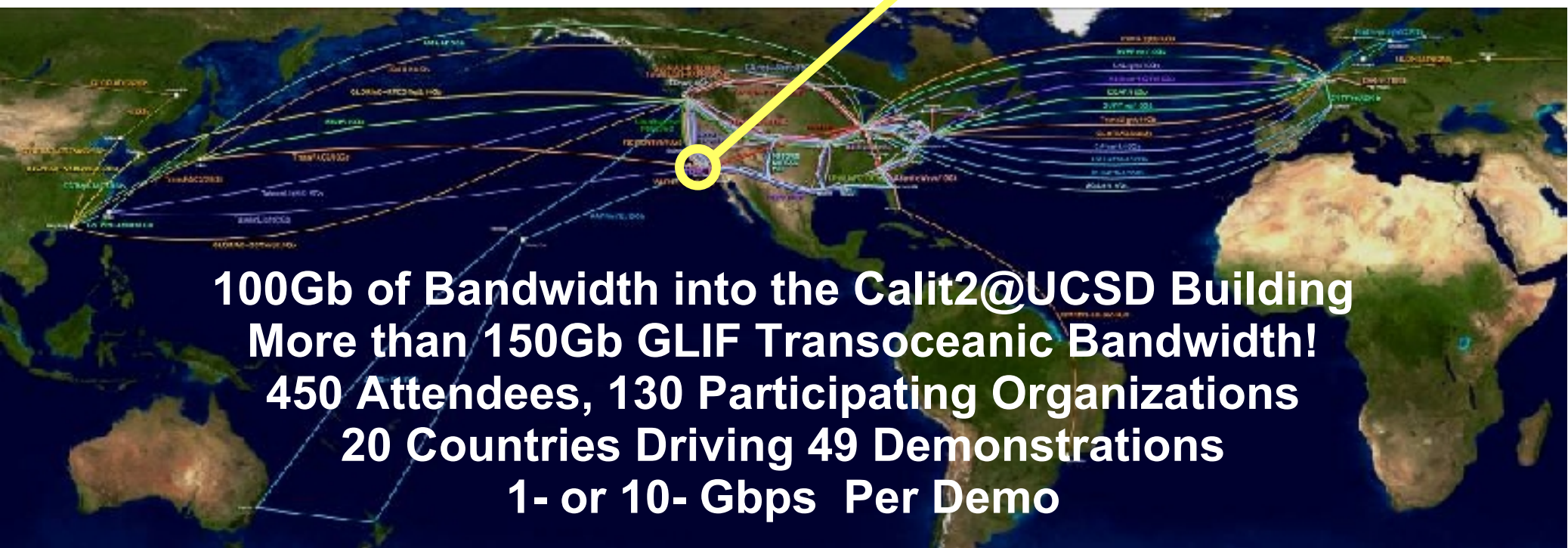


the UC Discovery Grant

**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**

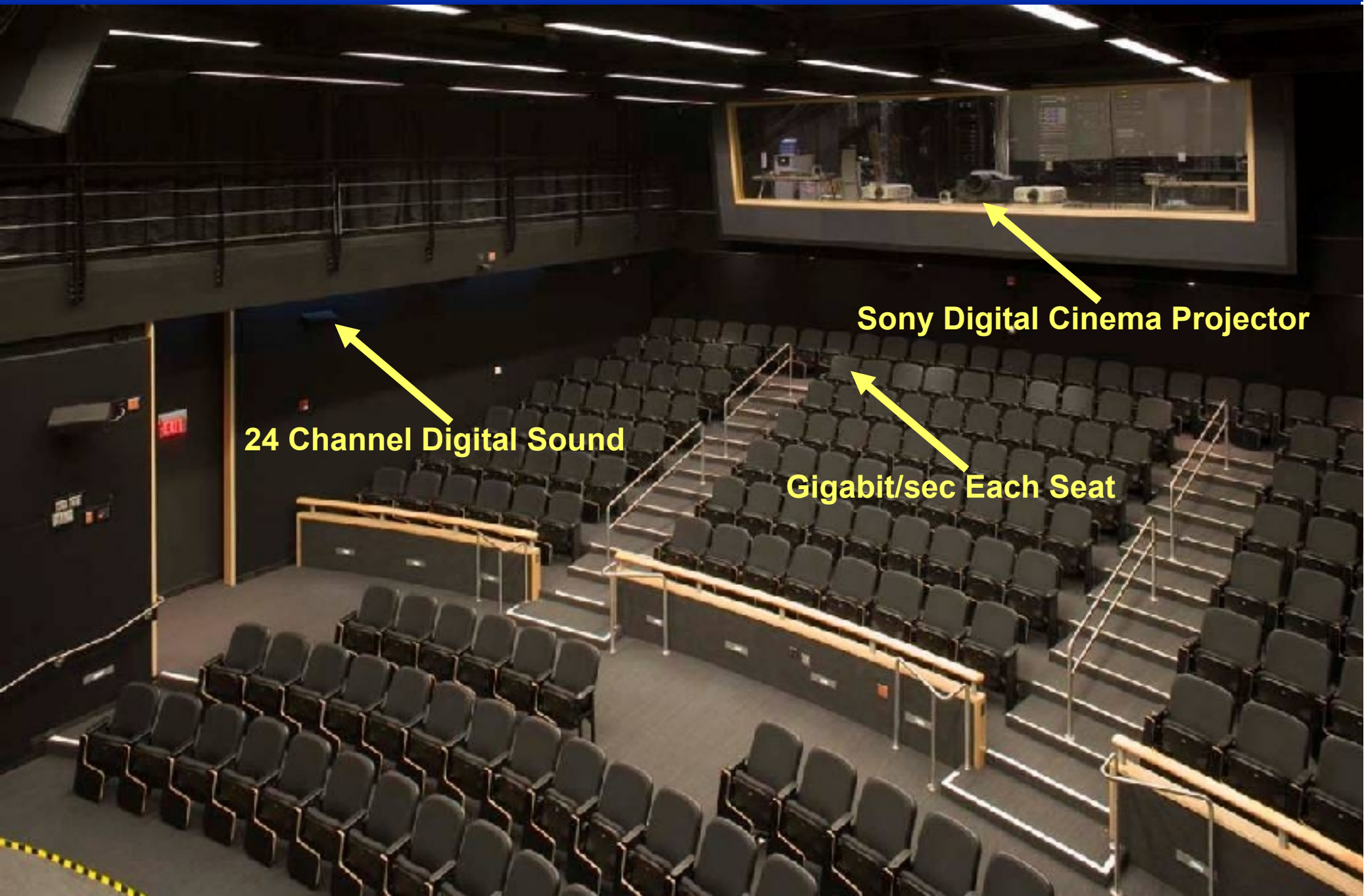
**More than 150Gb GLIF Transoceanic Bandwidth!**

**450 Attendees, 130 Participating Organizations**

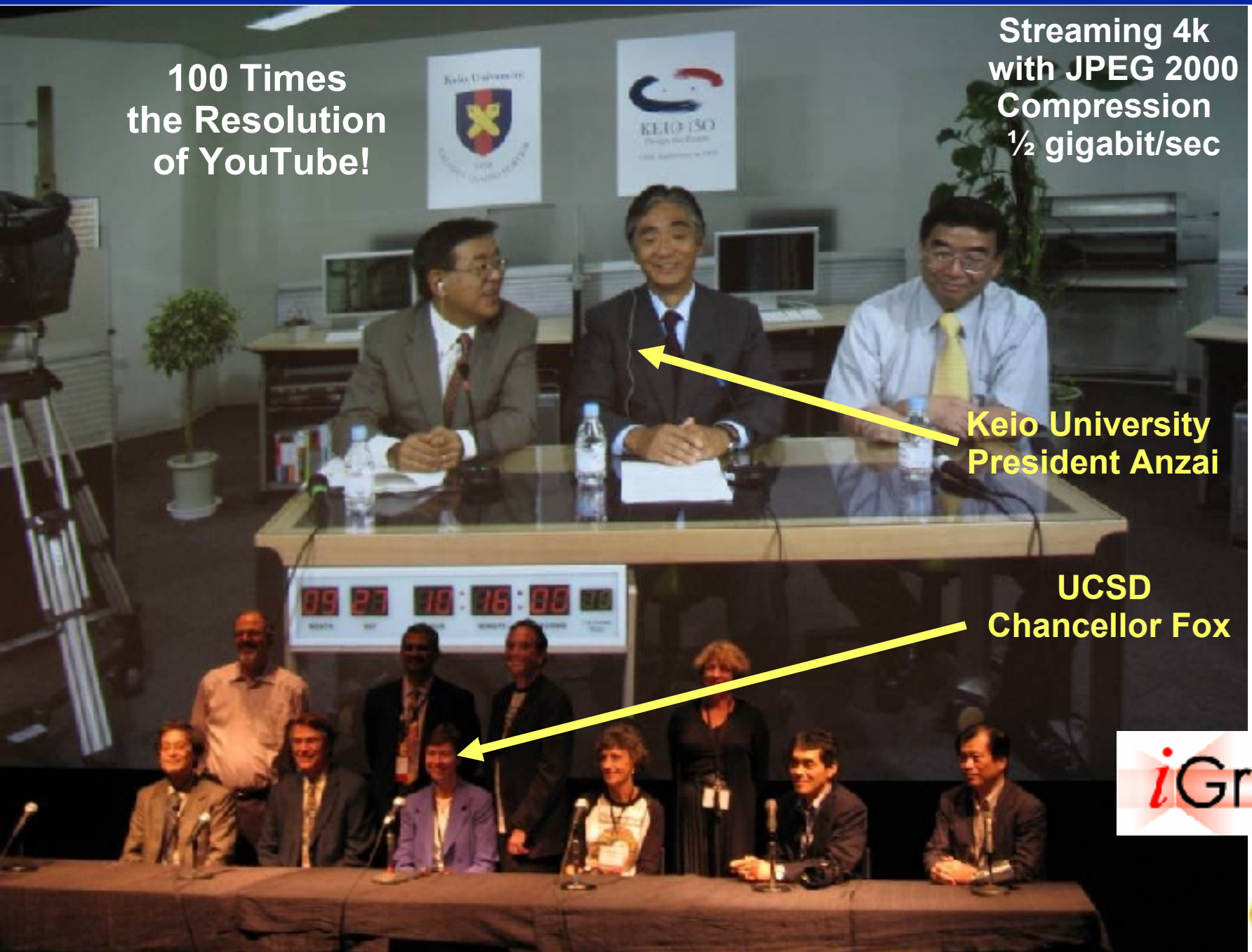
**20 Countries Driving 49 Demonstrations**

**1- or 10- Gbps Per Demo**

# Building a Global Collaboratorium



# 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

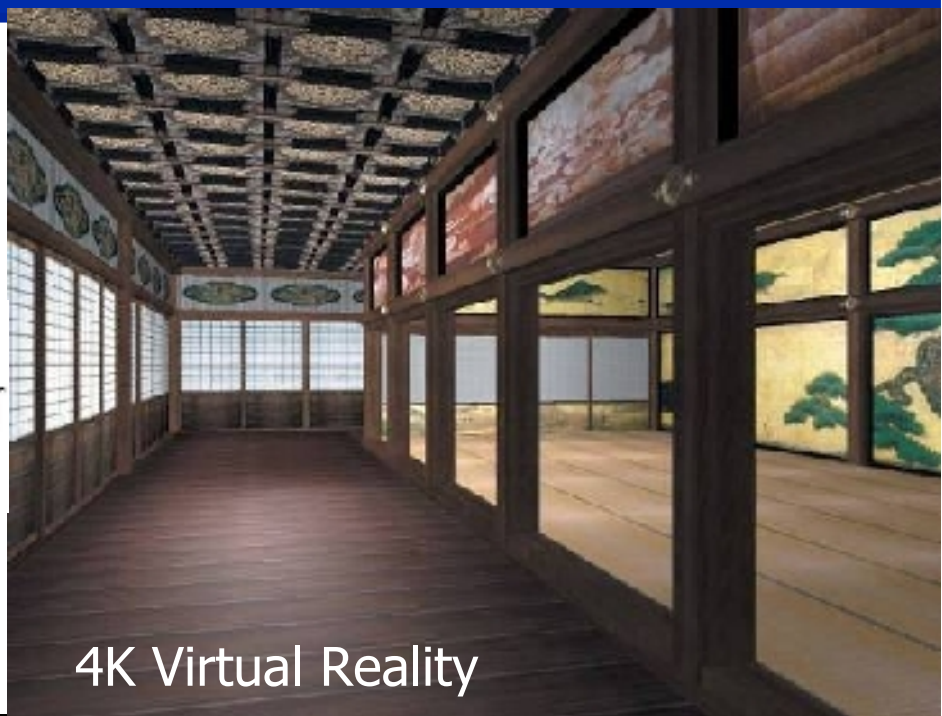
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# CineGrid @ iGrid2005:
# Six Hours of 4K Projected in Calit2 Auditorium

4K Distance Learning

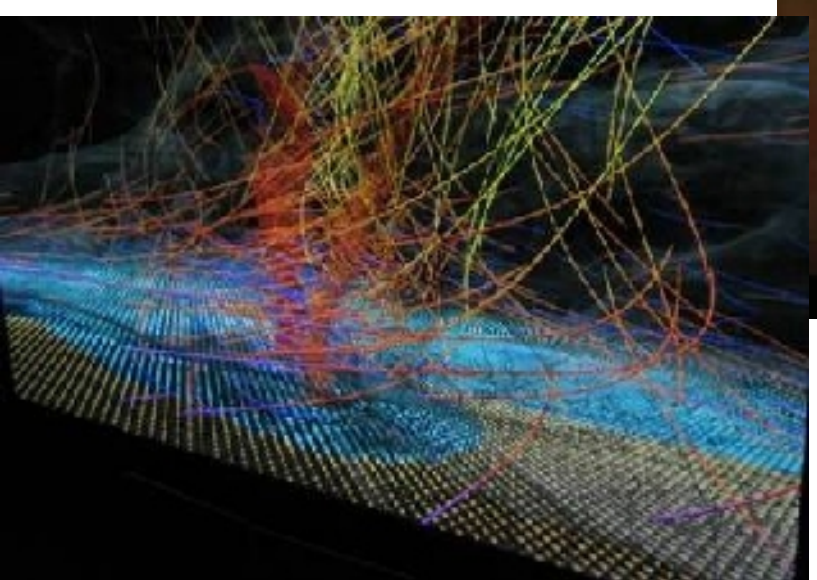


CineGrid



4K Virtual Reality

4K Scientific Visualization





4K Digital Cinema

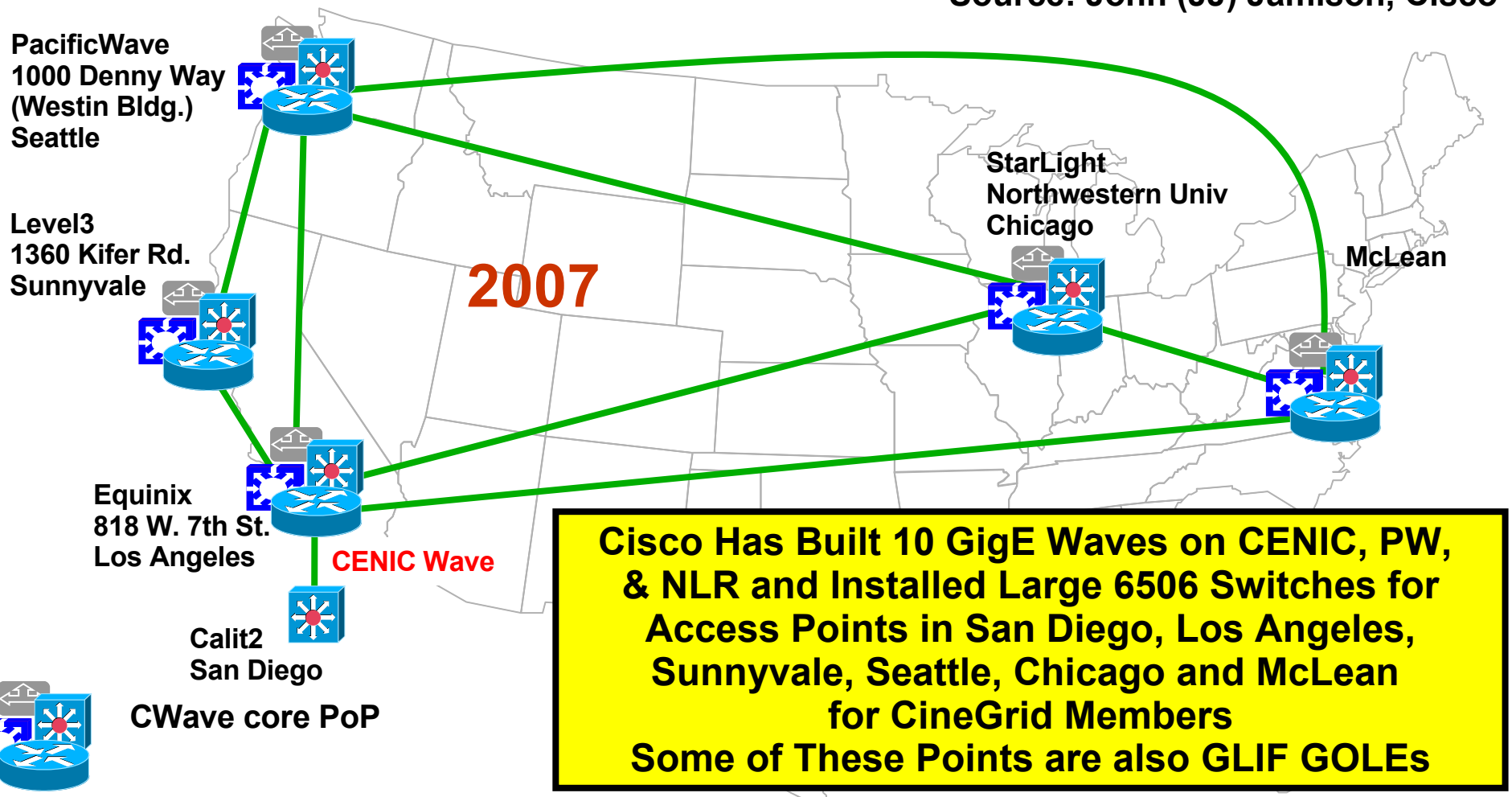
4K *Anime*



**Source: Laurin Herr**

# 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**

# Gigabit Fibers on the Ocean Floor
# -- Controlling Sensors and HDTV Cameras Remotely




**LOOKING is Driven By NEPTUNE CI Requirements**

**LOOKING:**
**(Laboratory for the Ocean Observatory Knowledge Integration Grid)**

**http://lookingtosea.ucsd.edu/**

- **Goal:**
  - **Prototype Cyberinfrastructure for NSF's Ocean Research Interactive Observatory Networks (ORION) Building on OptIPuter**
- **LOOKING NSF ITR with PIs:**
  - **John Orcutt & Larry Smarr - UCSD**
  - **John Delaney & Ed Lazowska –UW**
  - **Mark Abbott – OSU**
- **Collaborators at:**
  - **MBARI, WHOI, NCSA, UIC, CalPoly, UVic, CANARIE, Microsoft, NEPTUNE-Canarie**

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ocean research interactive observatory networks ORION

**Making Management of Gigabit Flows Routine**

it²

# Remote Interactive High Definition Video of Deep Sea Hydrothermal Vents



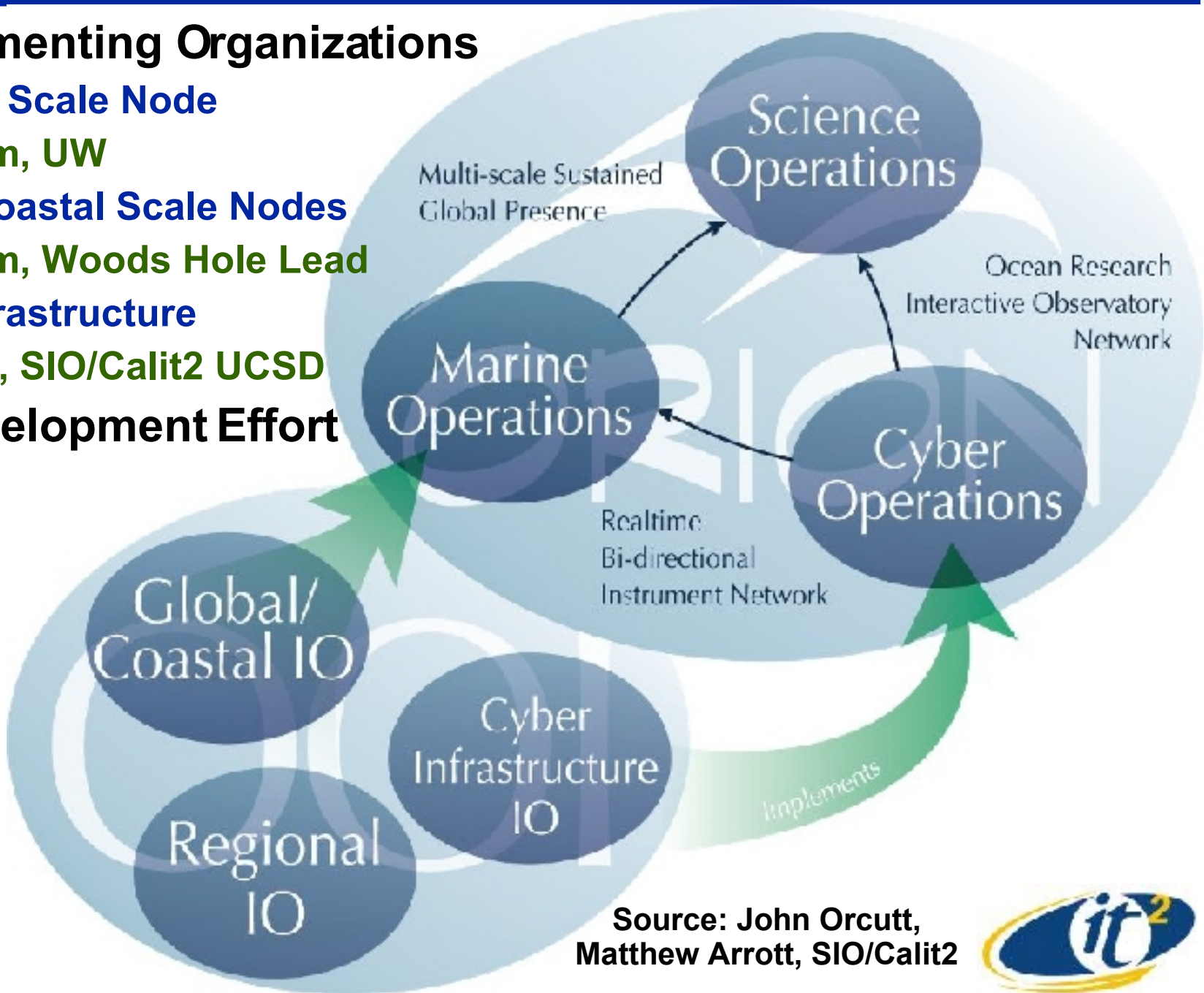
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Source John Delaney & Deborah Kelley, UWash

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# Ocean Observatory Initiative -- Initial Stages

- **OOI Implementing Organizations**
  - **Regional Scale Node**
    - **$150m, UW**
  - **Global/Coastal Scale Nodes**
    - **$120m, Woods Hole Lead**
  - **Cyberinfrastructure**
    - **$30m, SIO/Calit2 UCSD**
- **6 Year Development Effort**

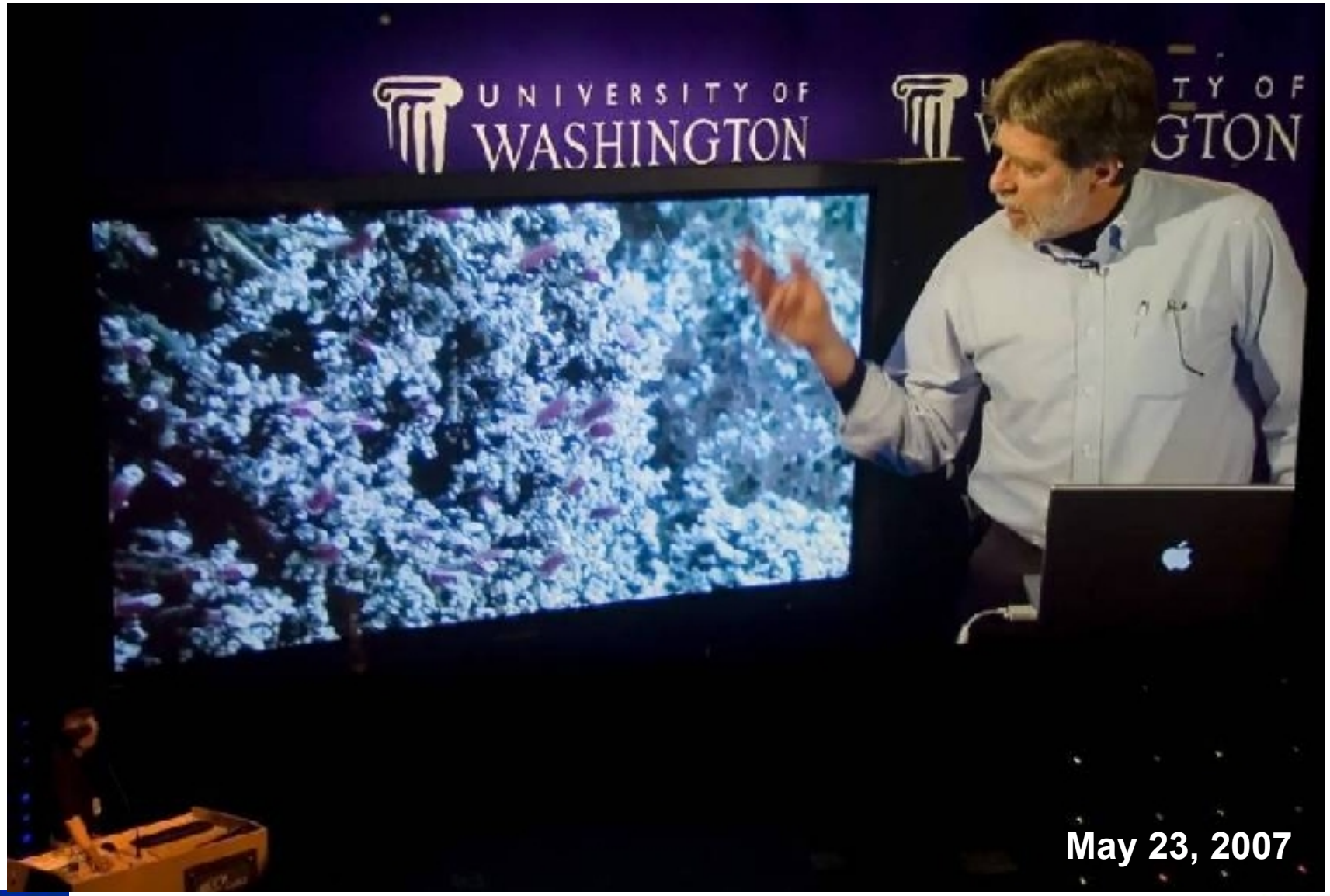



Source: John Orcutt, Matthew Arrott, SIO/Calit2

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# 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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# Goal for SC'07
# iHDTV Integrated into OptIPortal

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

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






**Source: Michael Wellings**
**Research Channel**
**Univ. Washington**

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

**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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# 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:

**Announced January 17, 2006**
**$24.5M Over Seven Years**

# Calit2's Direct Access Core Architecture Creates a SuperNetwork Metagenomics Server

**Sargasso Sea Data**

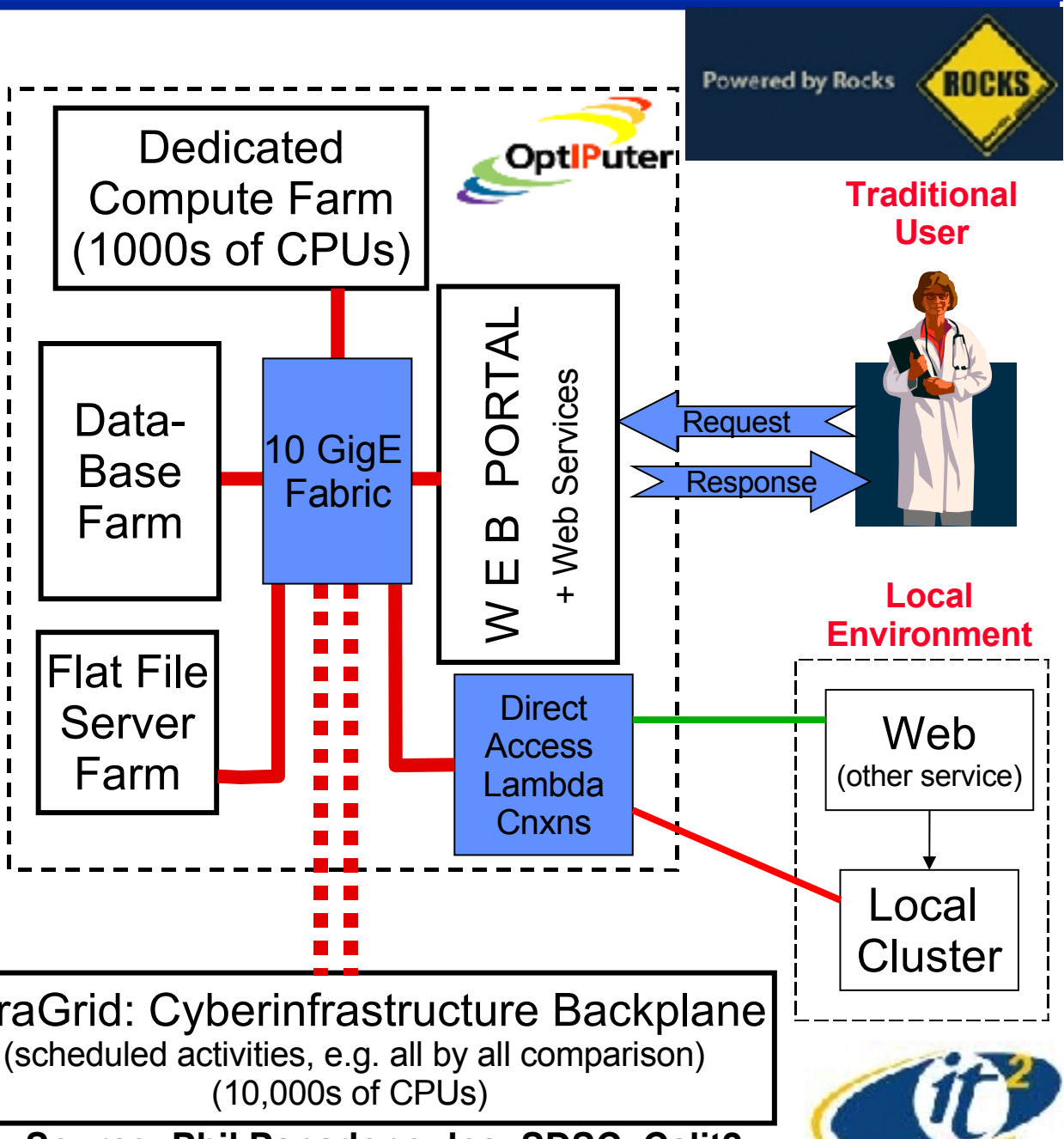
**Sorcerer II Expedition (GOS)**

**JGI Community Sequencing Project**

**Moore Marine Microbial Project**

**NASA and NOAA Satellite Data**

**Community Microbial Metagenomics Data**




**Source: Phil Papadopoulos, SDSC, Calit2**

# “Instant” Global Microbial Metagenomics CyberCommunity

## Over 1300 Registered Users From 48 Countries




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

camera

J. Craig Venter INSTITUTE

it²

# Use of Tiled Display Wall OptIPortal to Interactively View Microbial Genome



camera

OptIPuter

Powered by Rocks ROCKS

**Acidobacteria bacterium Ellin345 Soil Bacterium 5.6 Mb; ~5000 Genes**

**Source: Raj Singh, UCSD**

it²

# Use of Tiled Display Wall OptIPortal to Interactively View Microbial Genome



camera Marine Microbial Ecology

OptIPuter

Powered by Rocks ROCKS

Source: Raj Singh, UCSD

it²

# Use of Tiled Display Wall OptIPortal to Interactively View Microbial Genome




camera Marine Microbial Ecology

OptIPuter

Powered by Rocks ROCKS

Source: Raj Singh, UCSD

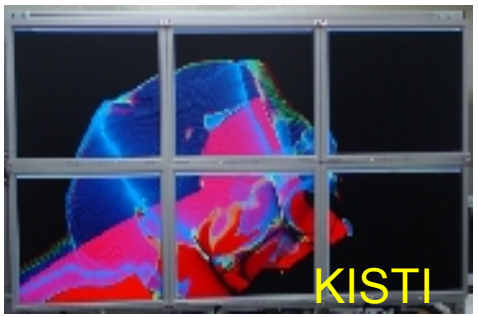
it²

# An Emerging High Performance Collaboratory for Microbial Metagenomics



# Rocks / SAGE OptIPortals Are Being Adopted Globally

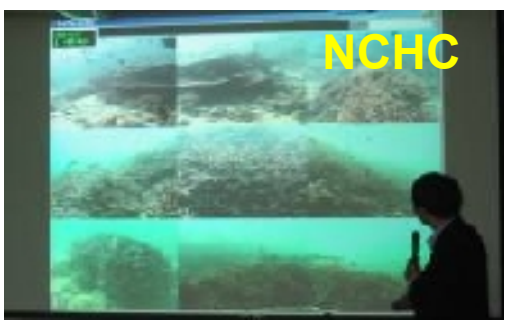
















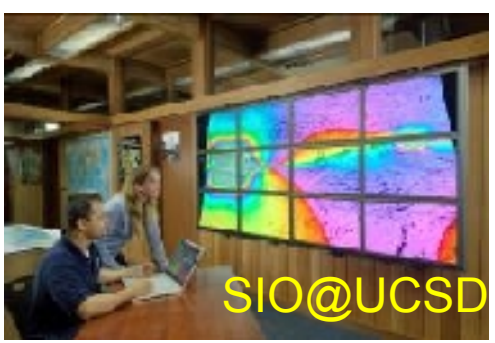











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Powered by Rocks ROCKS

evl electronic visualization laboratory

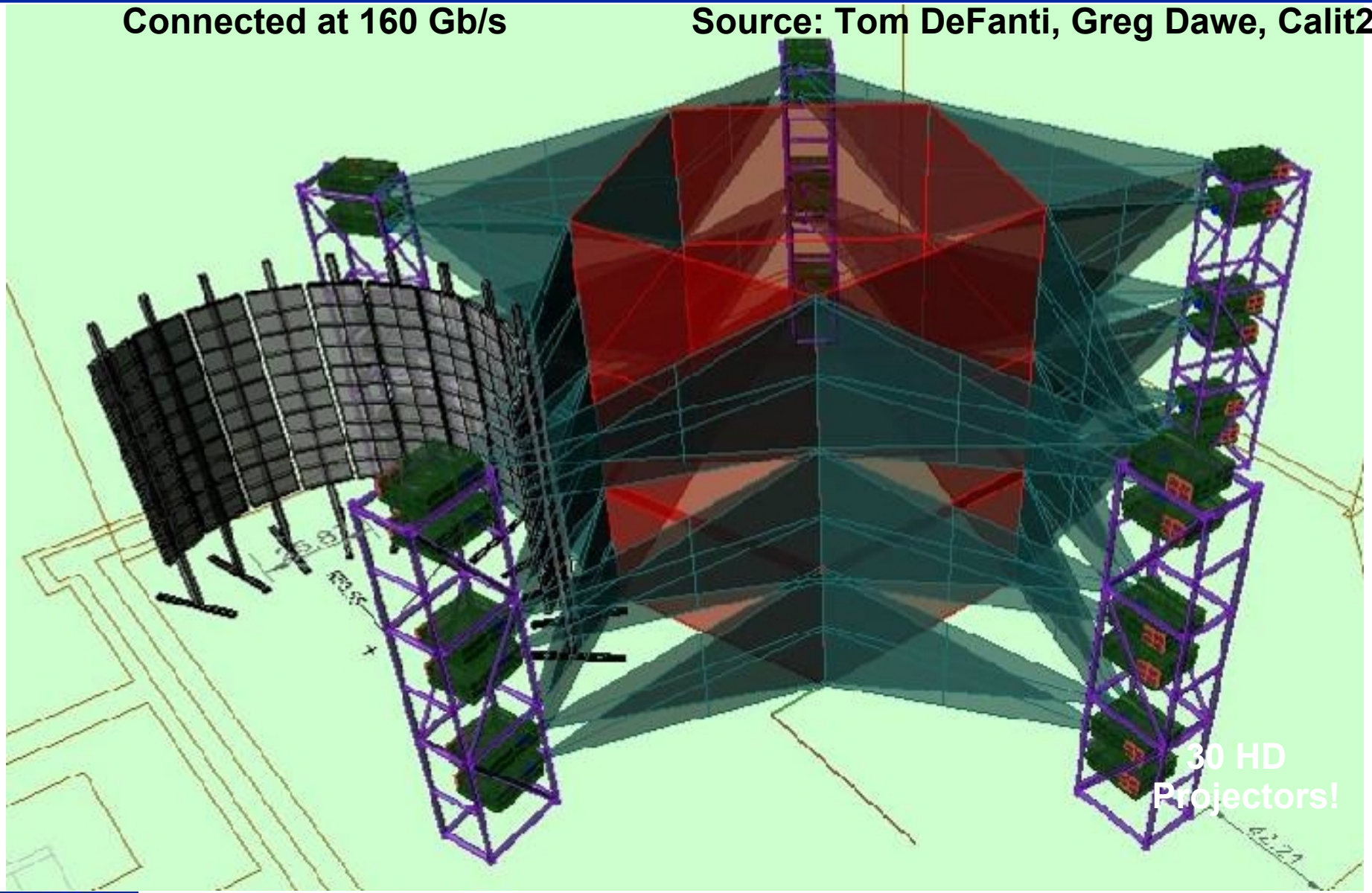
it2

# EVL's SAGE Global Visualcasting to Europe September 2007



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

**Connected at 160 Gb/s** **Source: Tom DeFanti, Greg Dawe, Calit2**




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

it²

# How Do You Get From Your Lab to the Regional Optical Networks?

**"Research is being stalled by 'information overload,' Mr. Bement said, because data from digital instruments are piling up far faster than researchers can study. In particular, he said, campus networks need to be improved. High-speed data lines crossing the nation are the equivalent of six-lane superhighways, he said. But networks at colleges and universities are not so capable. "Those massive conduits are reduced to two-lane roads at most college and university campuses," he said. Improving cyberinfrastructure, he said, "will transform the capabilities of campus-based scientists."**

**-- Arden Bement, the director of the National Science Foundation**




www.ctwatch.org

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# California (CENIC) Network Directions

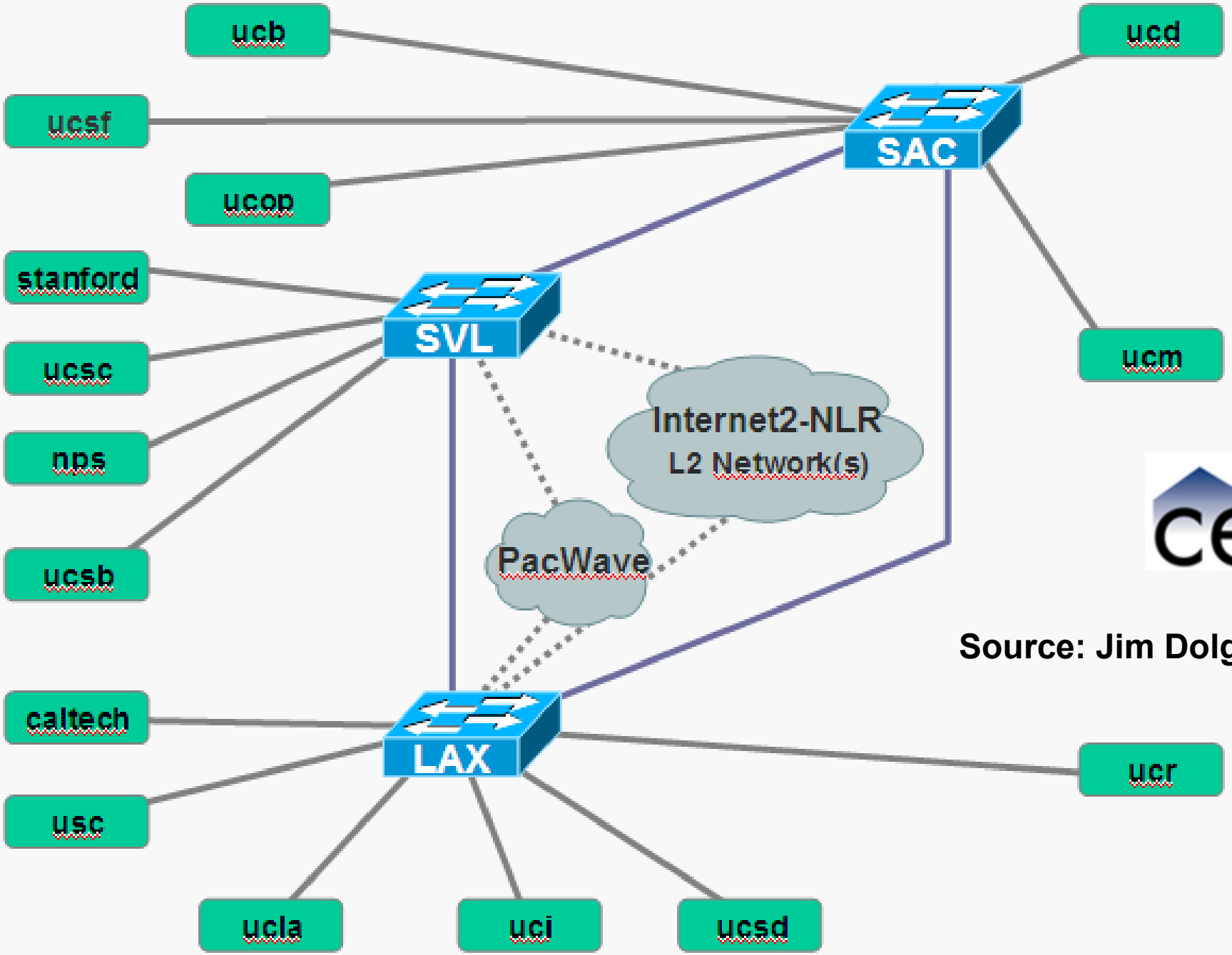
- More Bandwidth to Research University Campuses
  - One or Two 10GE Connections to Every Campus
- More Bandwidth on the Backbone
  - 40Gbps Or 100Gbps
- Support for New Protocols and Features
  - IPv6 Multicast
  - Jumbo Frames: 9000 (or More) Bytes
- "Hybrid Network" Design, Incorporating Traditional 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

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Source: Jim Dolgonas, CENIC

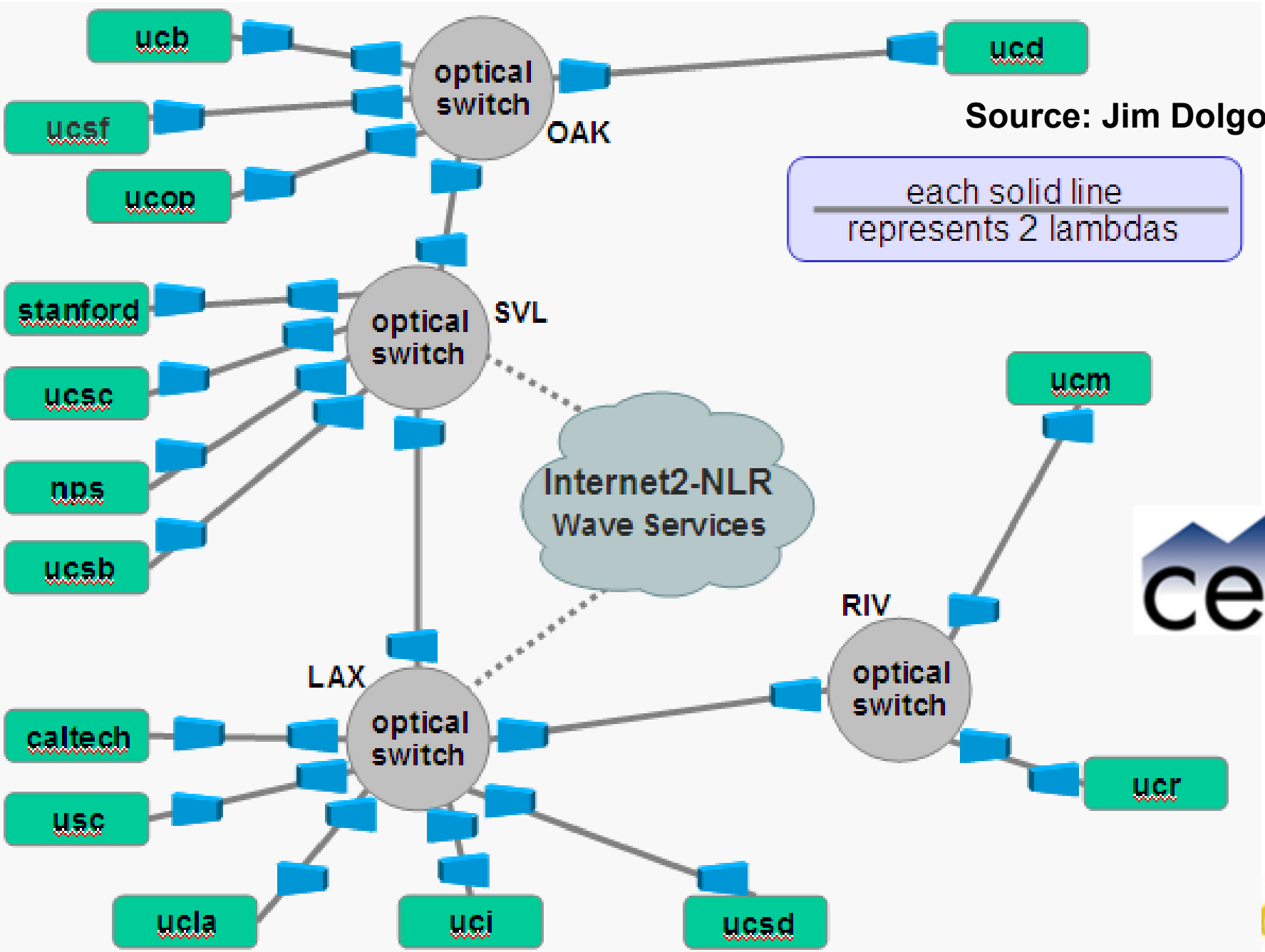
# CENIC Switched Ethernet Network
# HPRng-L2 Design



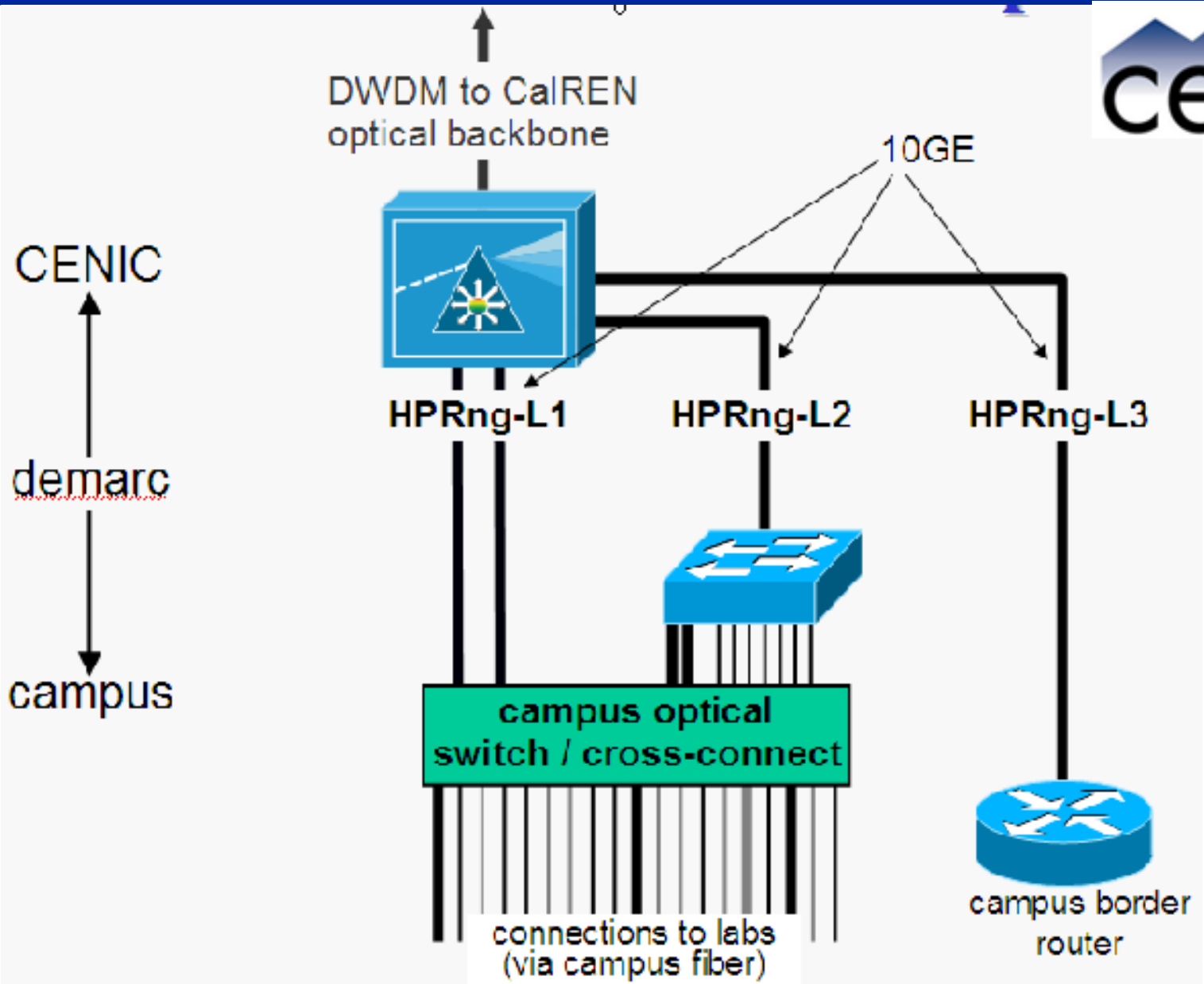

cenic

Source: Jim Dolgonas, CENIC

# CENIC Switched Optical Network
# HPRng-L1 design

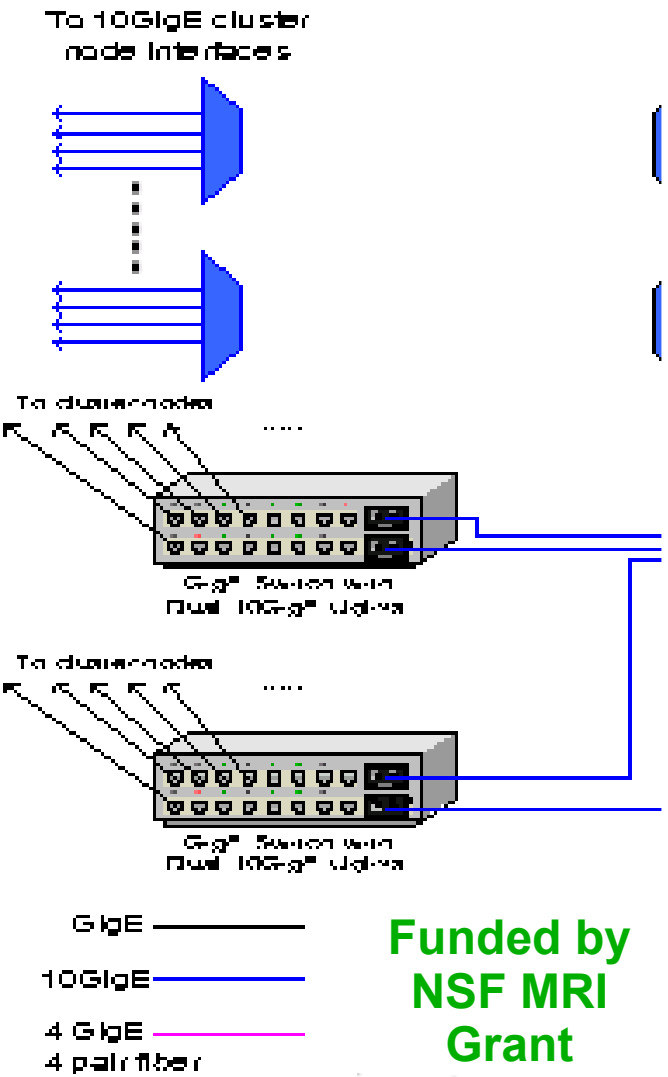


# Campus Preparations Needed to Accept CENIC CalREN Handoff to Campus




Source: Jim Dolgonas, CENIC

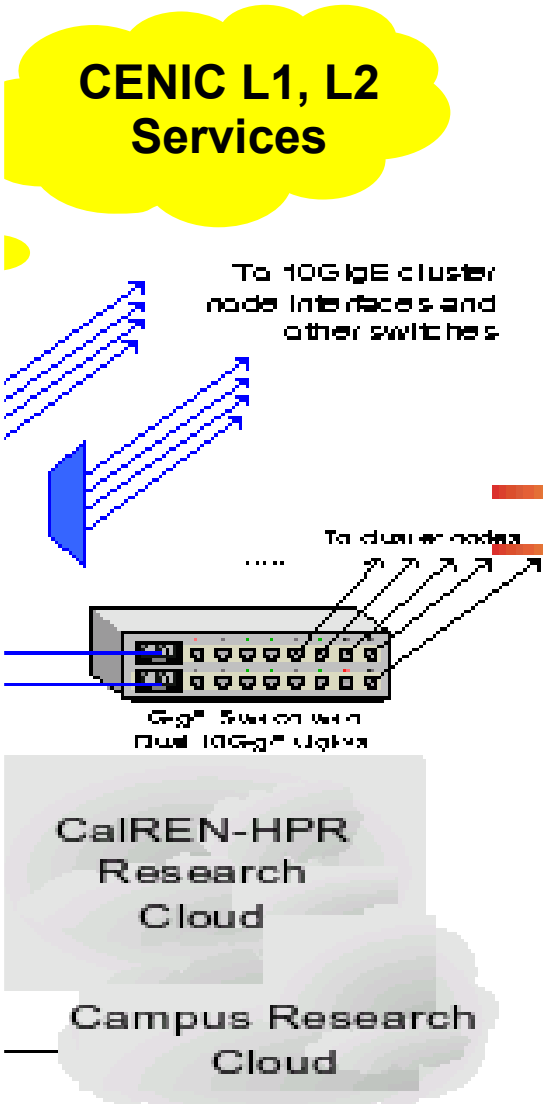
# Current UCSD Experimental Optical Core: Ready to Couple to CENIC L1, L2, L3 Services




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**

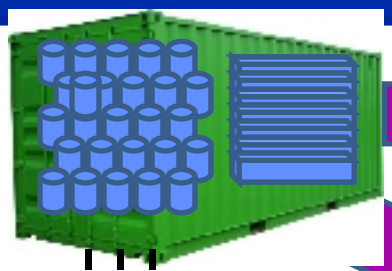



**Funded by NSF MRI Grant**

OptIPuter Border Router

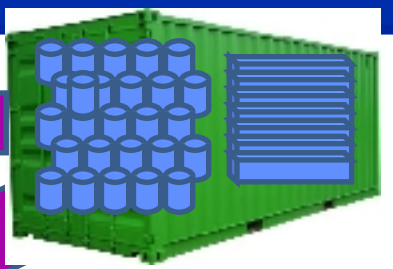
**Source: Phil Papadopoulos, SDSC/Calit2 (Quartzite PI, OptIPuter co-PI)**

# 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

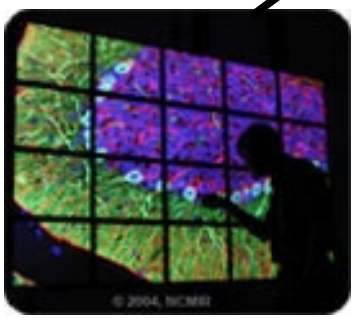
"Network in a box"
- > 200 Connections
- DWDM or Gray Optics

On-Demand Physical Connections

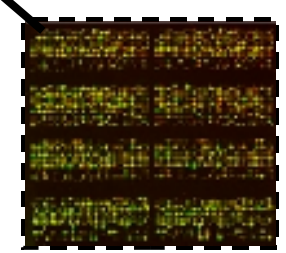
Wide-Area 10G
- CENIC/HPRng
- NLR Cavewave
- I2 NewNet
- Cinegrid
- …

Single 10 Gbit









Microarray

Your Lab Here

camera

NCMIR NATIONAL CENTER for MICROSCOPY and IMAGING RESEARCH

NBCR

UCSD

UCIrvine

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

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**

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Source: Fran Berman, SDSC , Larry Smarr, Calit2

it2