The OptIPuter Project: From the Grid to the LambdaGrid

Invited Talk
IEEE Orange County Computer Society
Irvine, CA
October 24, 2005

Dr. Larry Smarr
Director, California Institute for Telecommunications and Information Technologies
Harry E. Gruber Professor,
Dept. of Computer Science and Engineering
Jacobs School of Engineering, UCSD

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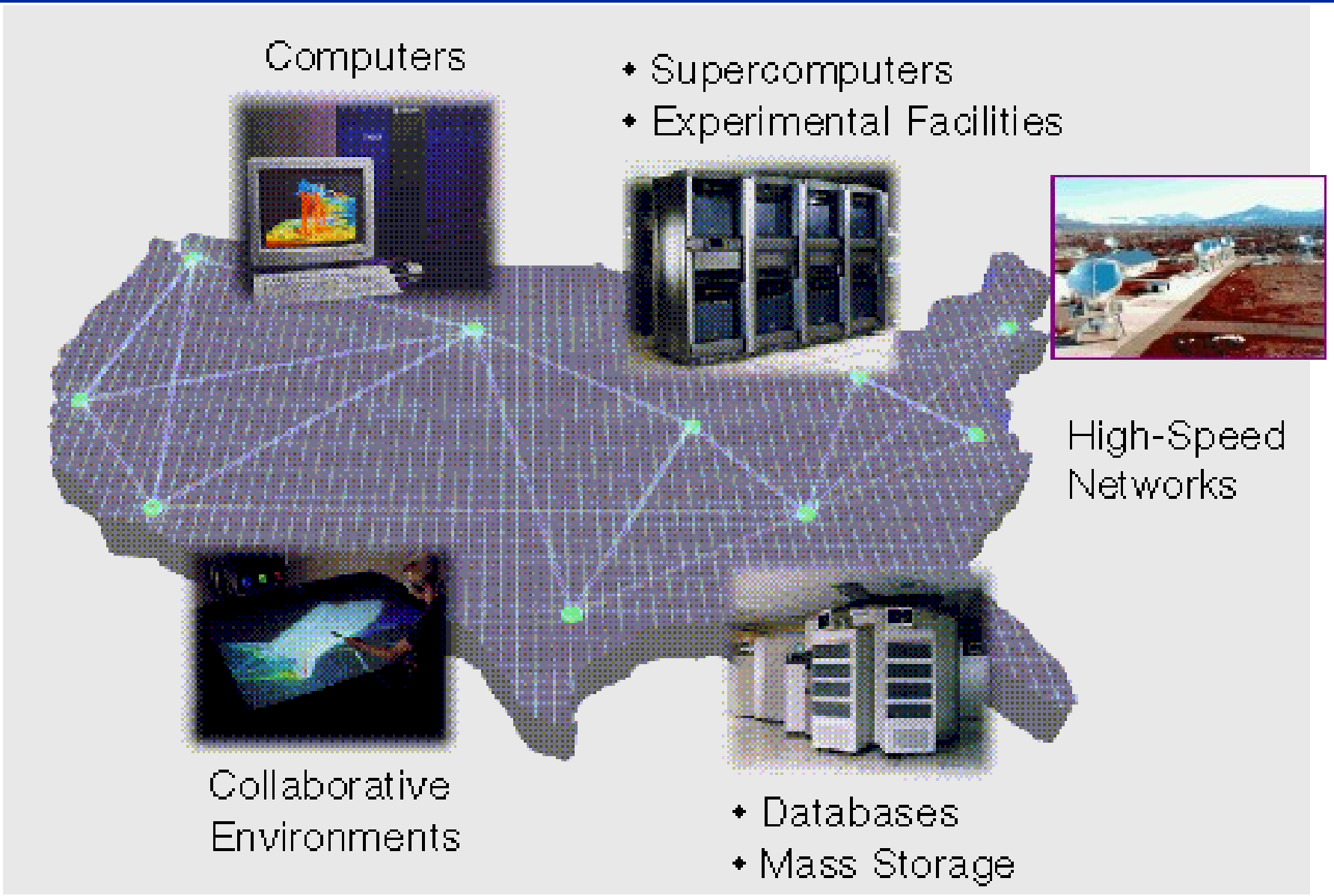
Abstract

While the Internet and the World Wide Web have become ubiquitous, their shared nature severely limits the bandwidth available to an individual user. However, during the last few years, a radical restructuring of optical networks supporting e-Science projects is beginning to occur around the world. Amazingly, scientists are now able to acquire the technological capability for private, high bandwidth light pipes (termed "lambdas") which create deterministic network connections coming right into their laboratories. These dedicated connections have a number of significant advantages over shared internet connections, including high bandwidth (10Gbps+), controlled performance (no jitter), lower cost per unit bandwidth, and security. By connecting scalable Linux clusters with these lambdas, one essentially creates supercomputers on the scale of a nation or even the planet Earth.

One of the largest research projects on LambdaGrids is the NSF-funded OptIPuter (www.optiputer.net), which uses large medical and earth sciences imaging as application drivers. The OptIPuter has two regional cores, one in Southern California and one in Chicago, which has now been extended to Amsterdam. One aim of the OptIPuter project is to make interactive visualization of remote gigabyte data objects as easy as the Web makes manipulating megabyte-size data objects today. Providing access to individual user laboratories on our university campuses will require new planning for dedicated optical networks as part of the campus fiber build out.

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The Grid Links People with Distributed Resources



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http://science.nas.nasa.gov/Groups/Tools/IPG

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IBM Grid Computing

Charles Schwab

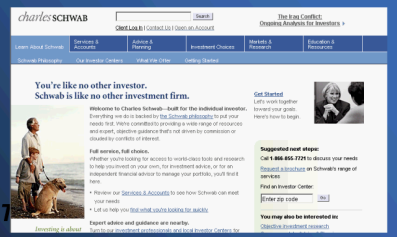
Business Analytics

Challenge

- Reduce the processing time on an existing wealth management application.

Solution

- IBM @server
- Linux
- Globus Toolkit
- IBM Research



Technology Benefits:

- Reduced processing time from more than four minutes to fifteen seconds
- Planning to explore leveraging Grid computing into other areas

Business Benefits:

- Potential to increase customer satisfaction by responding to inquiries at a faster pace
- Potential to enable Schwab to provide more robust wealth management applications

"We believe that Grid computing … has the potential to greatly improve our quality of service and be a truly disruptive technology."
Oren Leiman, Managing Director, Charles Schwab

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Industry is Adopting Grid Technology

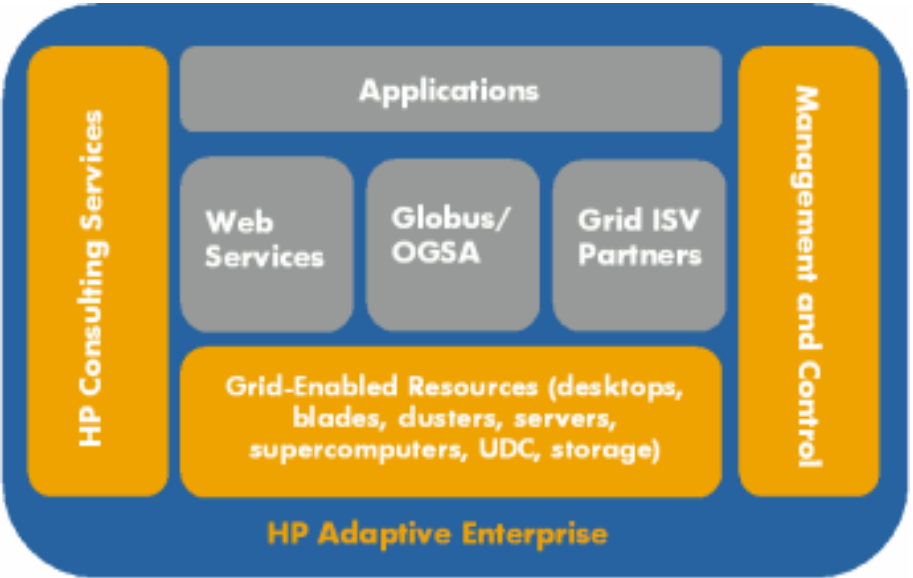
I.B.M. Making a Commitment to Next Phase of the Internet

By STEVE LOHR

The New York Times

I.B.M. is announcing today a new initiative to support and exploit a technology known as grid computing, which the company and much of the computer research community say is the next evolutionary step in the development of the Internet.

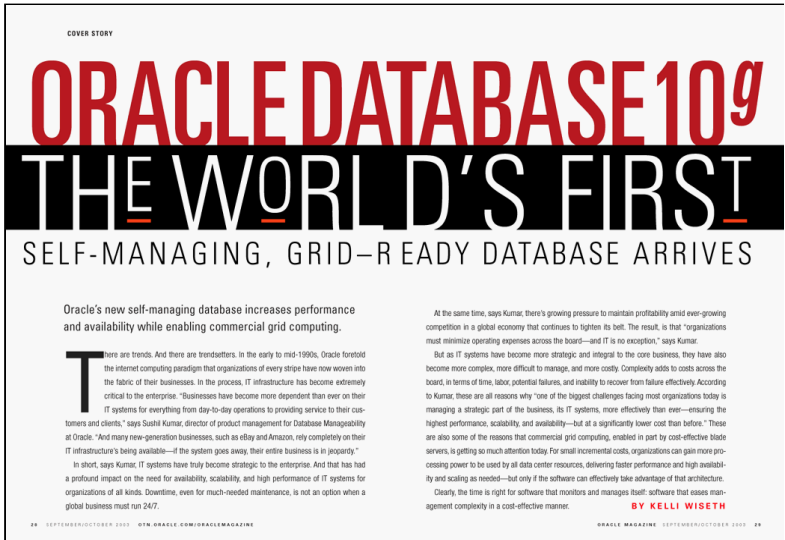
Merrill Lynch



Globus Grid Computing—the Next Internet

by John Roy/Steve Milunovich

The Internet was first a network and is now a communications platform. The next evolutionary step could be to a platform for distributed computing. This ability to manage applications and share data over the network is called "grid computing."


COVER STORY

ORACLE DATABASE 10g

THE WORLD'S FIRST

SELF-MANAGING, GRID-READY DATABASE ARRIVES

Oracle's new self-managing database increases performance and availability while enabling commercial grid computing.

There are trends. And there are trendsetters. In the early to mid-1990s, Oracle foretold the internet computing paradigm that organizations of every stripe have now woven into the fabric of their businesses. In the process, IT infrastructure has become extremely critical to the enterprise. "Businesses have become more dependent than ever on their IT systems for everything from day-to-day operations to providing service to their customers and clients," says Sushil Kumar, director of product management for Database Manageability at Oracle. "And many new-generation businesses, such as eBay and Amazon, rely completely on their IT infrastructure's being available—if the system goes away, their entire business is in jeopardy."

In short, says Kumar, IT systems have truly become strategic to the enterprise. And that has had a profound impact on the need for availability, scalability, and high performance of IT systems for organizations of all kinds. Downtime, even for much-needed maintenance, is not an option when a global business must run 24/7.

At the same time, says Kumar, there's growing pressure to maintain profitability amid ever-growing competition in a global economy that continues to tighten its belt. The result, is that "organizations must minimize operating expenses across the board—and IT is no exception," says Kumar.

But as IT systems have become more strategic and integral to the core business, they have also become more complex, more difficult to manage, and more costly. Complexity adds to costs across the board, in terms of time, labor, potential failures, and inability to recover from failure effectively. According to Kumar, these are all reasons why "one of the biggest challenges facing most organizations today is managing a strategic part of the business, its IT systems, more effectively than ever—ensuring the highest performance, scalability, and availability—but at a significantly lower cost than before." These are also some of the reasons that commercial grid computing, enabled in part by cost-effective blade servers, is getting so much attention today. For small incremental costs, organizations can gain more processing power to be used by all data center resources, delivering faster performance and high availability and scaling as needed—but only if the software can effectively take advantage of that architecture.

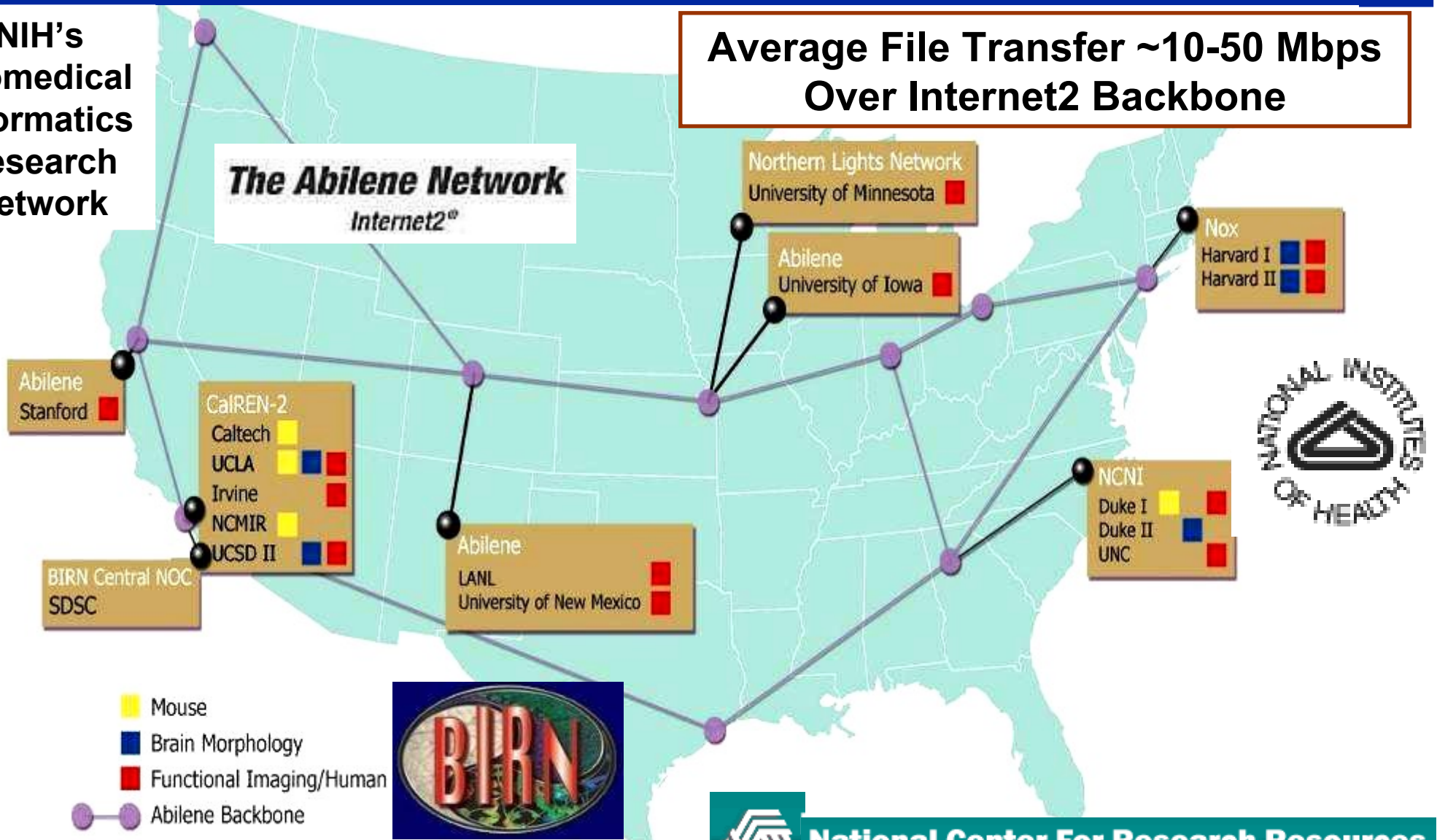
Clearly, the time is right for software that monitors and manages itself: software that eases management complexity in a cost-effective manner.

BY KELLI WISETH

Major Challenge for Grid Enabled Science:
Bandwidth Barriers Between User and Remote Resources

NIH's Biomedical Informatics Research Network

Average File Transfer ~10-50 Mbps Over Internet2 Backbone



Part of the UCSD CRBS

Center for Research on Biological Structure

National Center For Research Resources

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NBCR NPACI

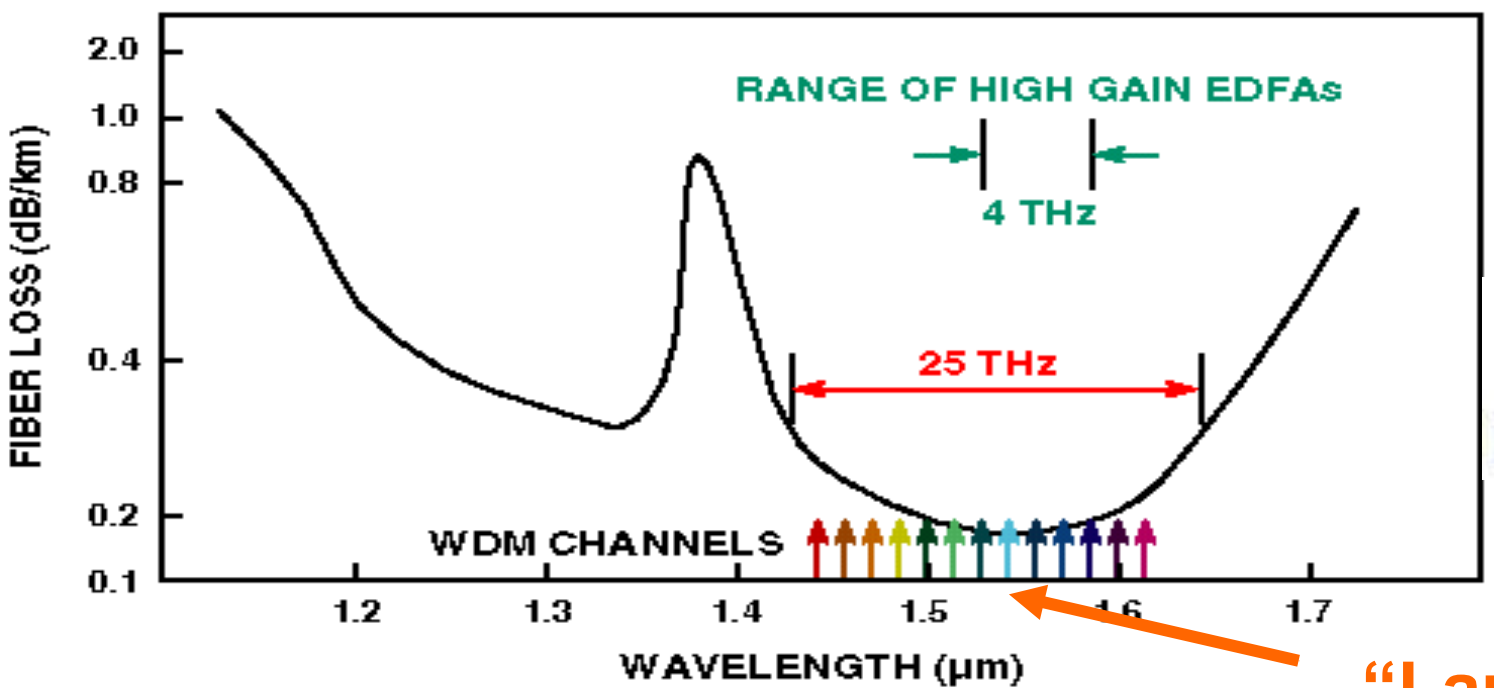
NCMIR NATIONAL CENTER for MICROSCOPY and IMAGING RESEARCH
at San Diego, an NIH supported resource center

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Solution: Individual 1 or 10Gbps Lightpaths -- "Lambdas on Demand"

WAVELENGTH DIVISION MULTIPLEXING (WDM)

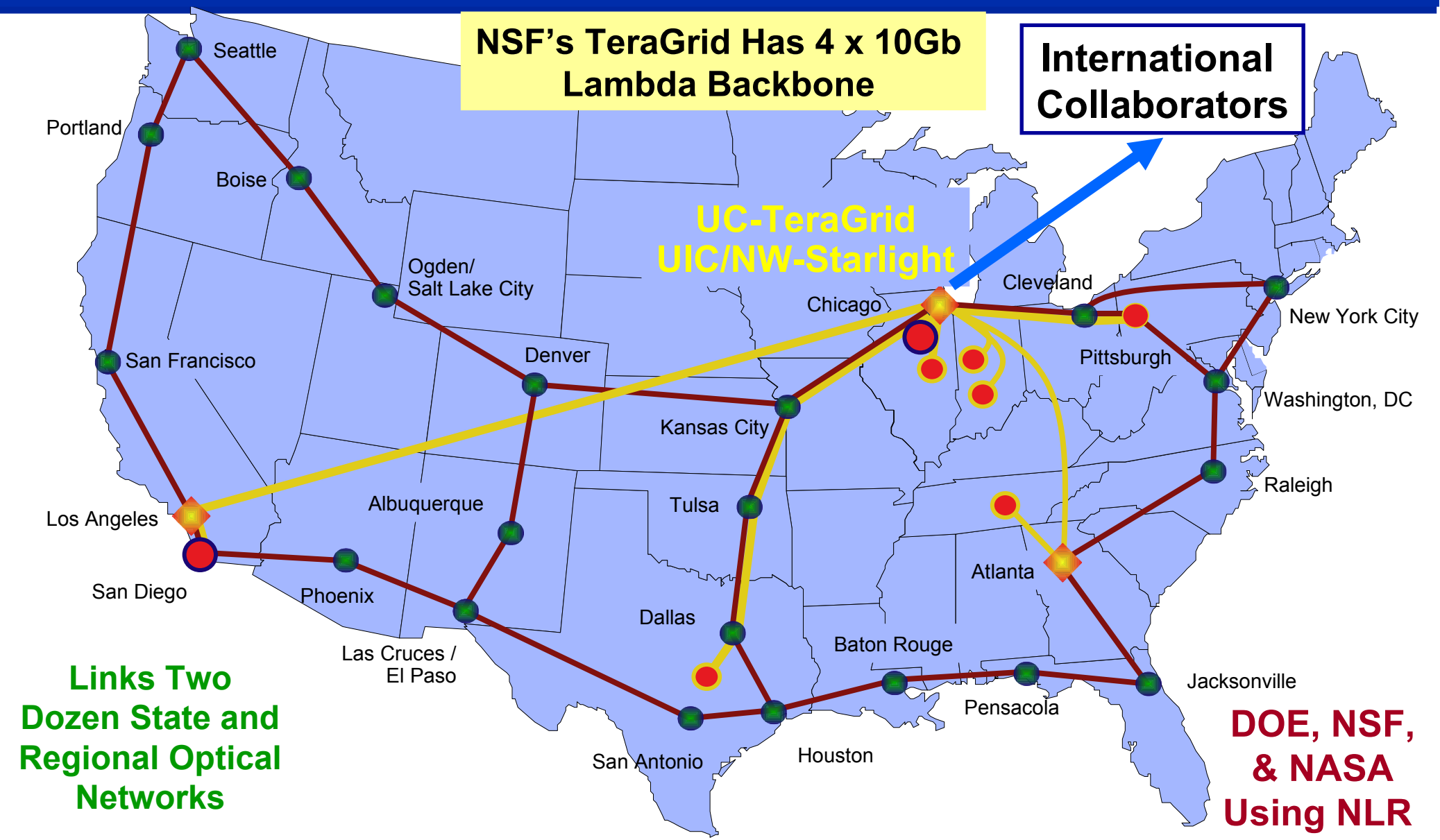
- EXPLOITS
  - ENORMOUS BANDWIDTH OF SILICA FIBER
  - HIGH-GAIN WIDEBAND OPTICAL AMPLIFIERS



"Lambdas"

Source: Steve Wallach, Chiaro Networks

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

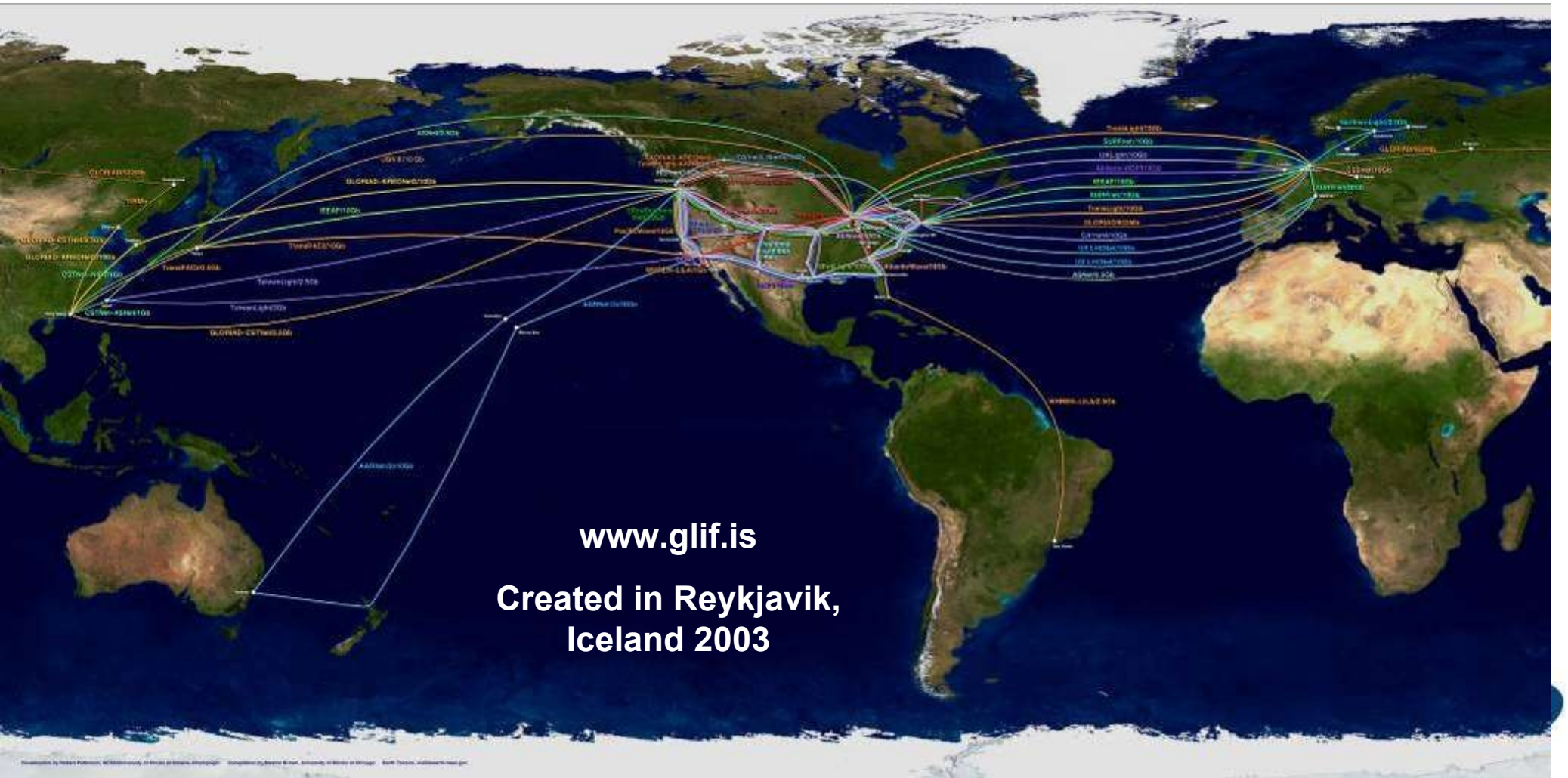


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The Global Lambda Integrated Facility (GLIF) Creates MetaComputers on the Scale of Planet Earth

Many Countries are Interconnecting Optical Research Networks

to form a Global SuperNetwork



The Networking Double Header of the Century Is Driven by LambdaGrid Applications

the UC Discovery Grant

Maxine Brown, Tom DeFanti, Co-Organizers

iGrid 2005

THE GLOBAL LAMBDA INTEGRATED FACILITY



www.startap.net/igrid2005/

September 26-30, 2005

Calit2 @ University of California, San Diego

California Institute for Telecommunications and Information Technology

SC|05 Gateway to Discovery

Washington State Convention and Trade Center Seattle, WA
November 12-18 2005

http://sc05.supercomp.org

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Lambdas Enable First Remote Interactive High Definition Video Exploration of Deep Sea Vents



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Source John Delaney & Deborah Kelley, UWash

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The OptIPuter Project: Sun's Slogan Realized…

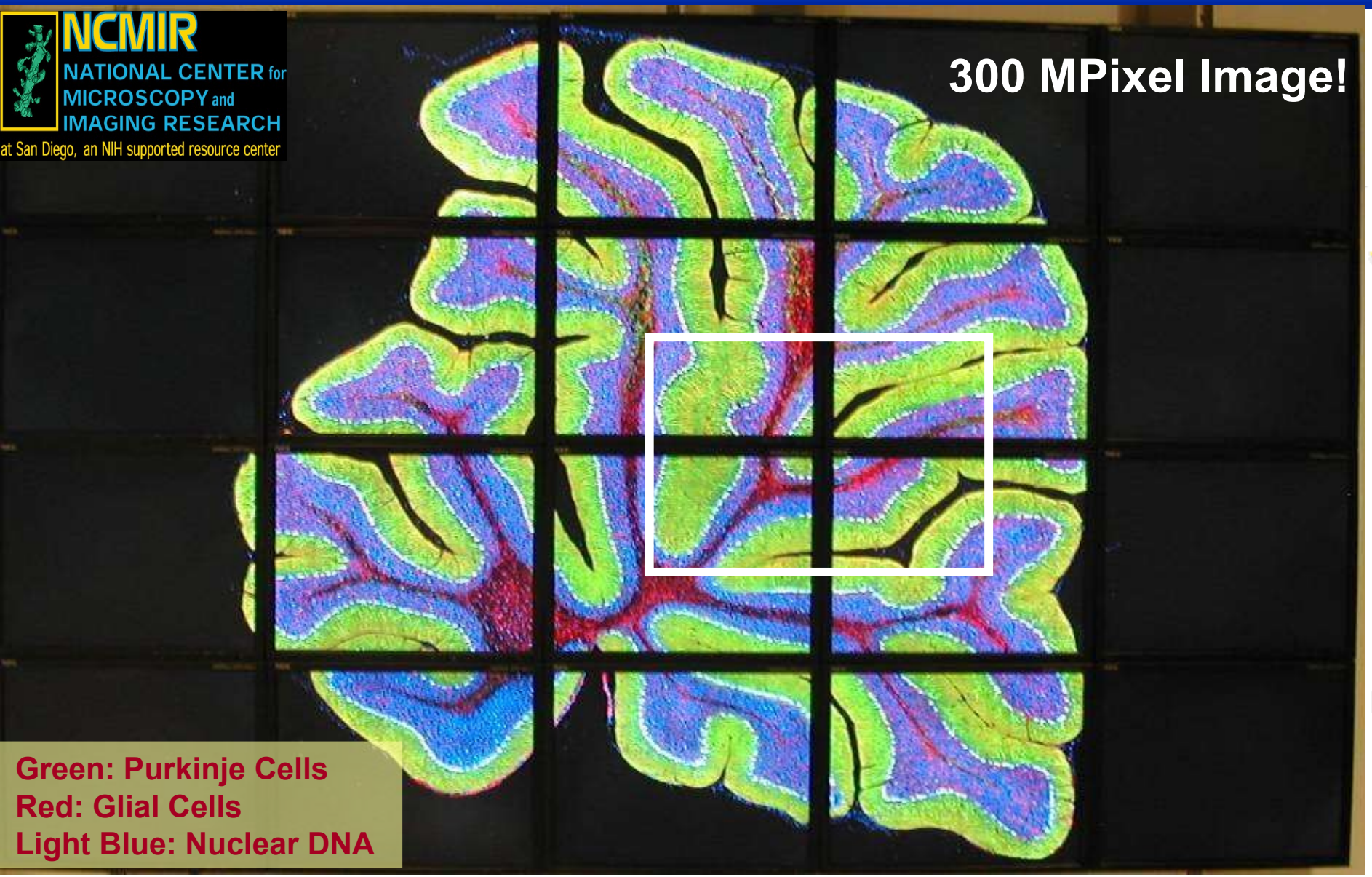


"When the Network is as fast as the computer's internal links, the machine disintegrates across the Net into a set of special purpose appliances"
-Gilder Technology Report June 2000

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The OptIPuter -- From the Grid to the LambdaGrid: High Resolution Portals to Global Science Data

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



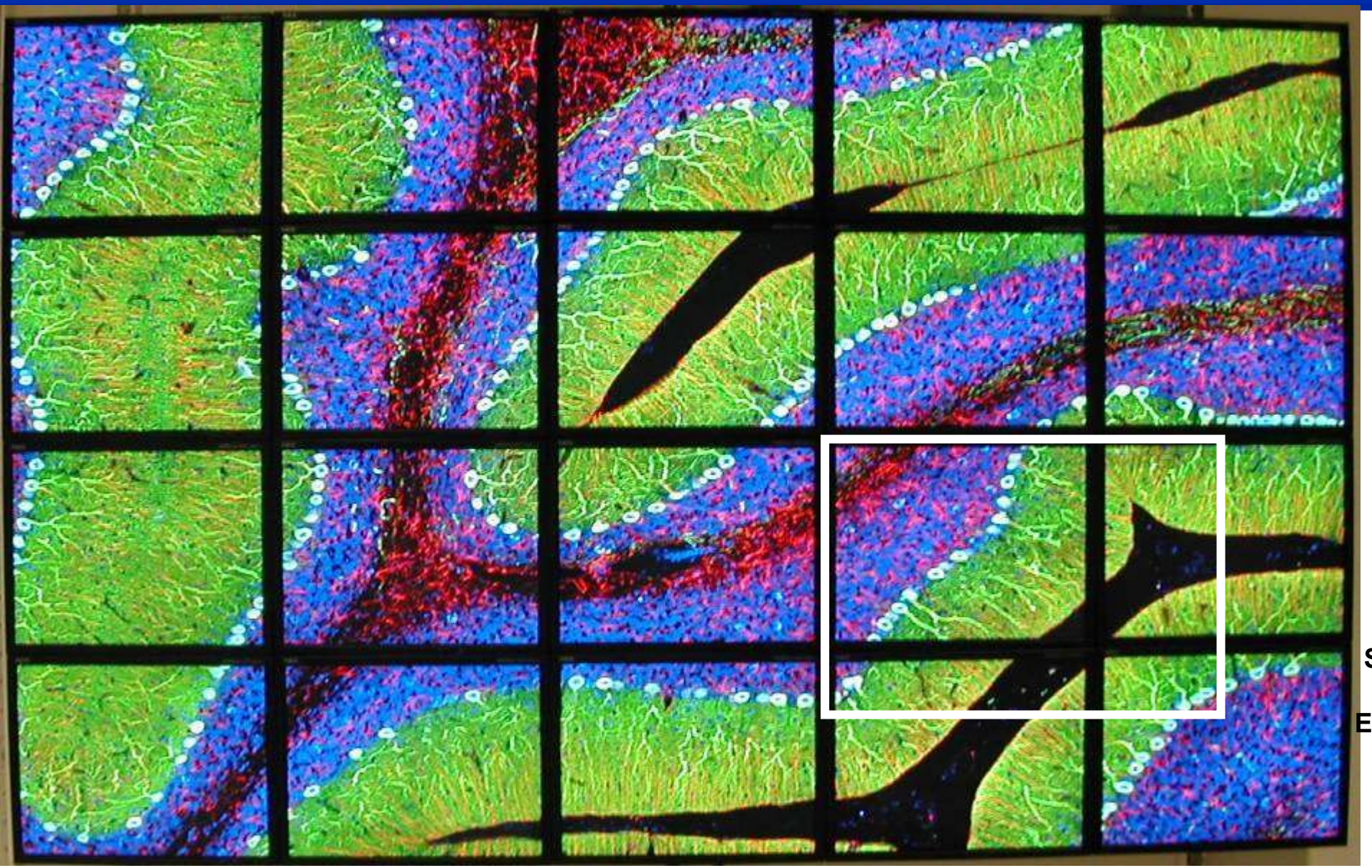
Green: Purkinje Cells
Red: Glial Cells
Light Blue: Nuclear DNA

Source: Mark Ellisman, David Lee, Jason Leigh

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Calit2 (UCSD, UCI) and UIC Lead Campuses—Larry Smarr PI
Partners: SDSC, USC, SDSU, NW, TA&M, UvA, SARA, KISTI, AIST

Scalable Displays Allow Both Global Content and Fine Detail



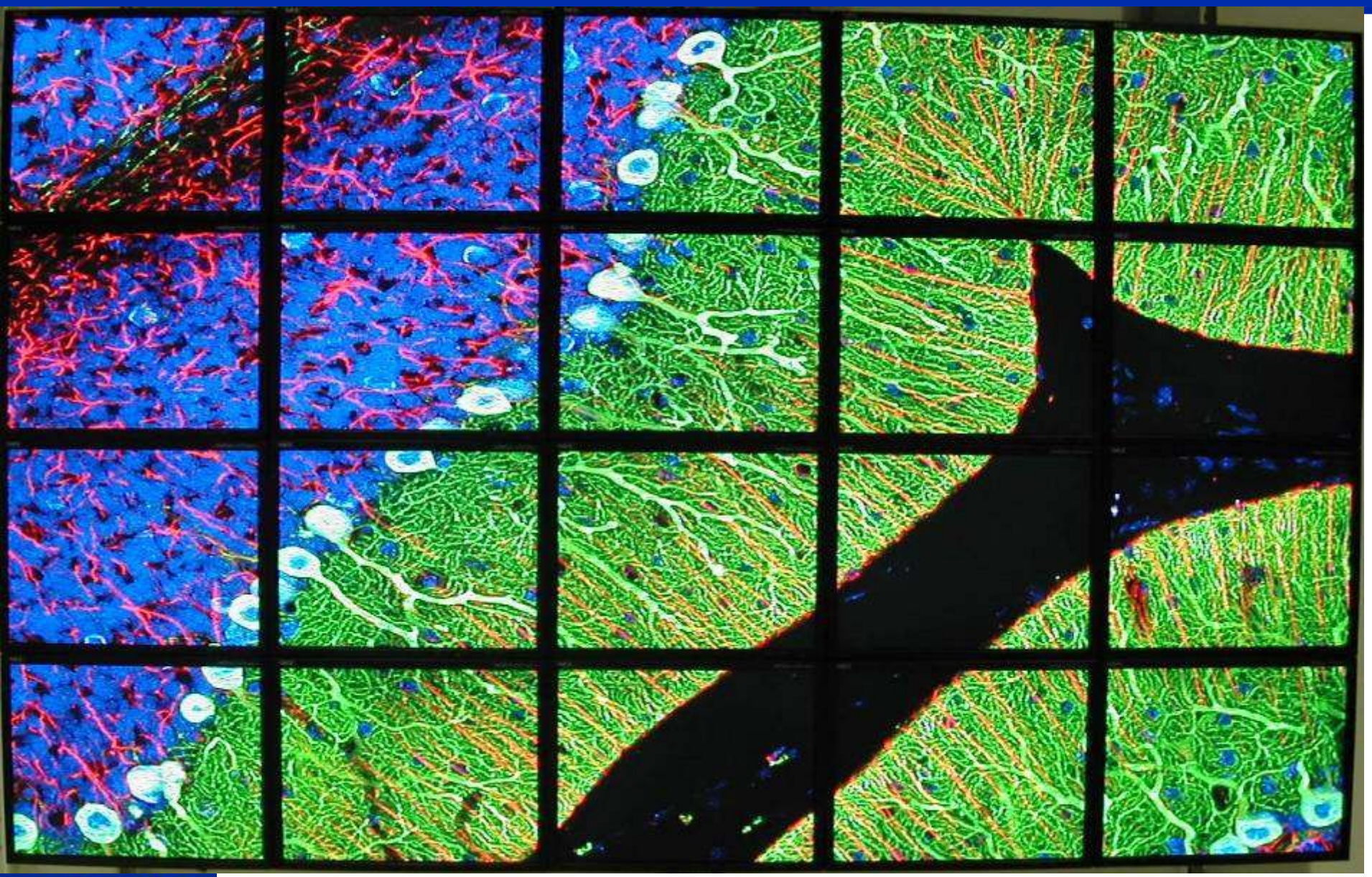
Source: Mark Ellisman, David Lee, Jason Leigh

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30 MPixel SunScreen Display Driven by a 20-node Sun Opteron Visualization Cluster

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Allows for Interactive Zooming from Cerebellum to Individual Neurons



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Source: Mark Ellisman, David Lee, Jason Leigh

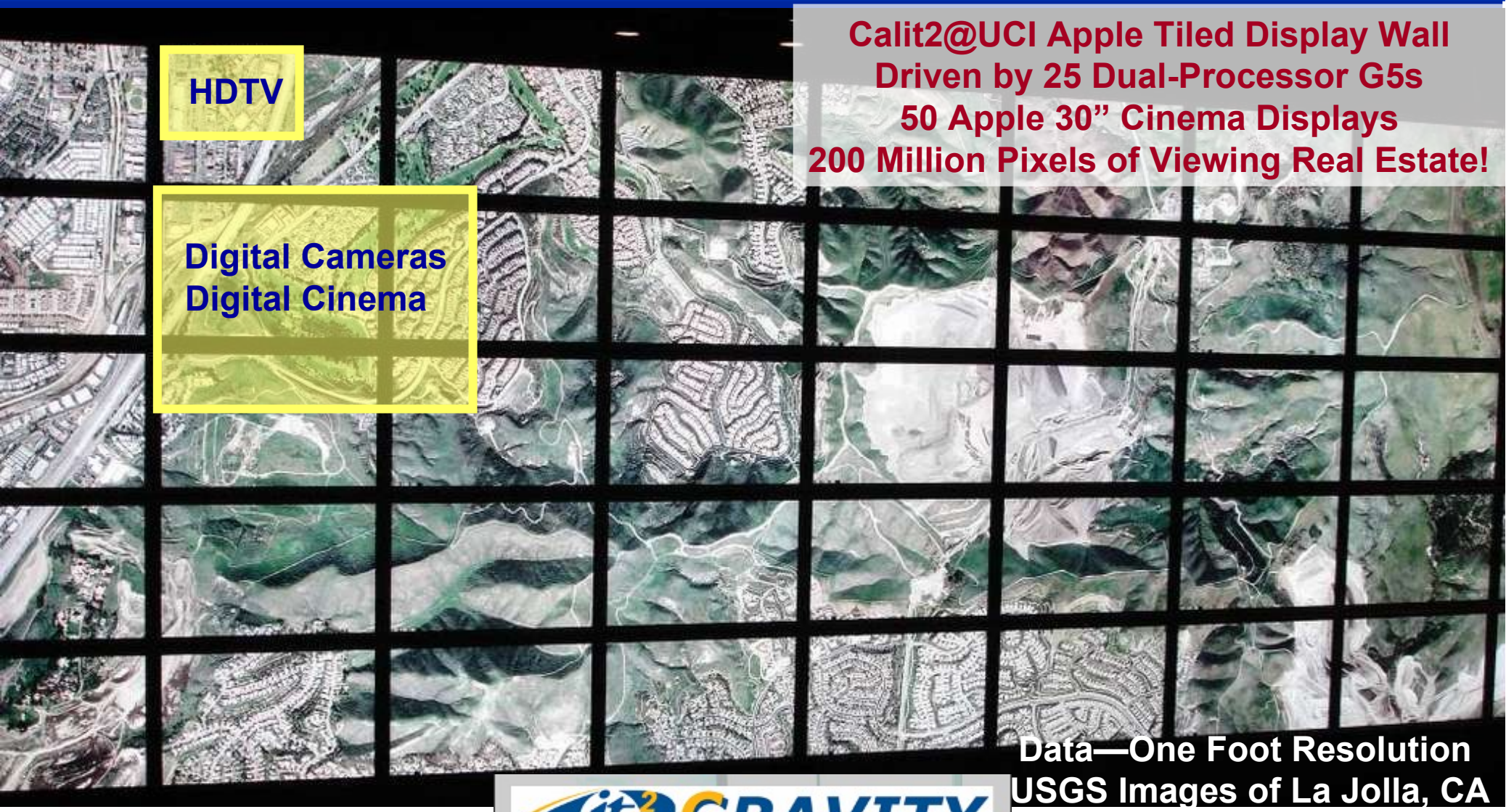
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Calit2 Is Applying OptIPuter Technologies to Post-Hurricane Recovery

Working with NASA, USGS, NOAA, NIEHS, EPA, SDSU, SDSC, Duke, …



Calit2 @ UCI Has the Largest Tiled Display Wall



it² Center of GRAVITY
Center of Graphics, Visualization and Imaging Technology

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Source: Falko Kuester, Calit2@UCI
NSF Infrastructure Grant

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The Great Wall of TV…

www.ocregister.com/ocregister/news/article_726920.php

Sunday, October 23, 2005

The next next big TV

By TAMARA CHUANG
The Orange County Register

ocregister.com

Researchers at UC Irvine have linked 50 Apple monitors to create a great wall of TV, dubbed the HIPerWall, or Highly Interactive Parallelized display. With it, they can show extremely-high-resolution pictures, like satellite images and aerial photos of the campus.



VIDEO WALL: The HIPerWall team includes, from left, UCI Professor Stephen Jenks, project director Falko Kuester and Christopher Knox, a postdoctoral researcher. The wall uses 50 extremely-high-resolution monitors to effectively form one giant, detailed screen.

LEONARD ORTIZ, THE REGISTER

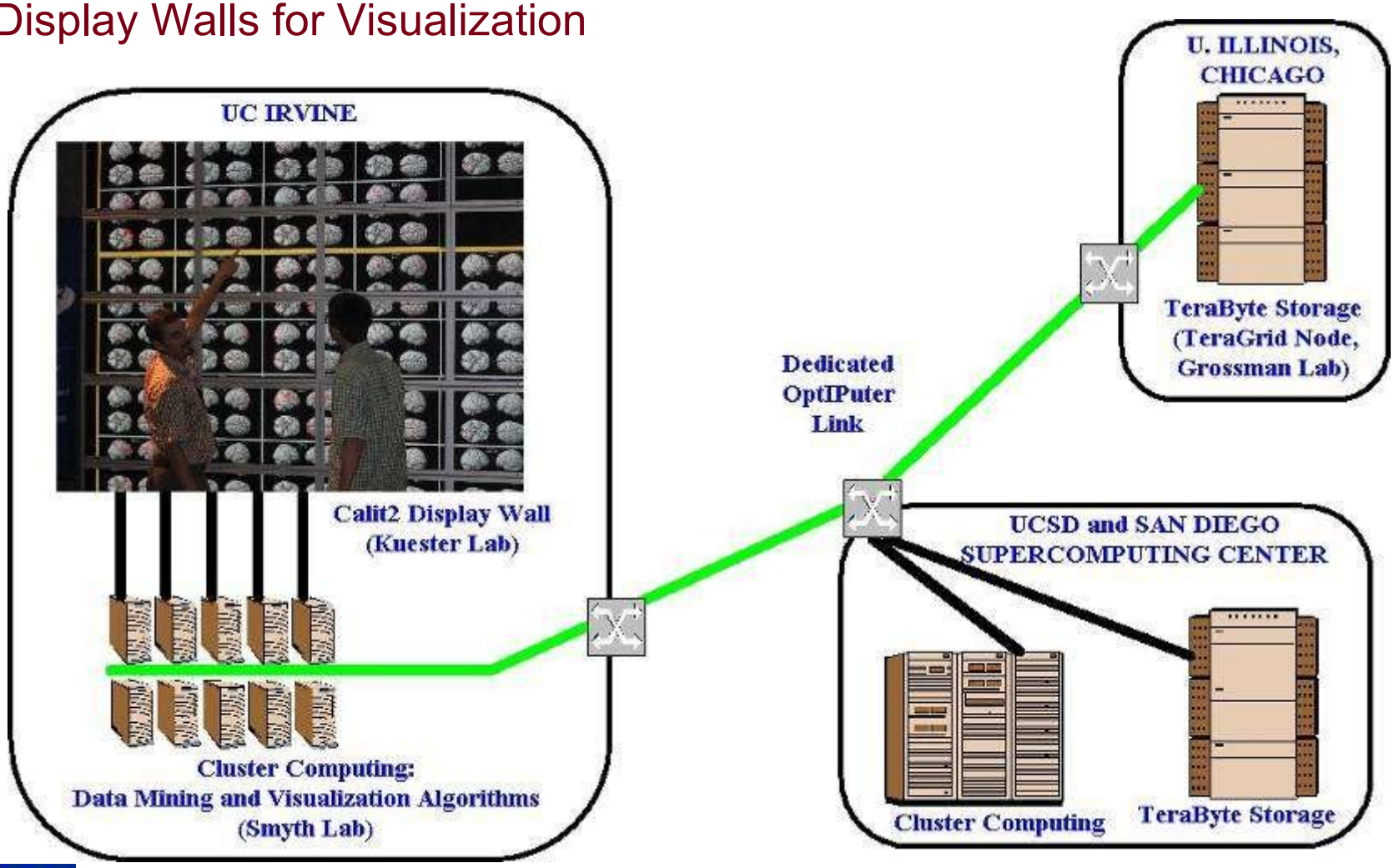
Why would anyone need this? Medical imaging, climate data and satellite photography that could only be viewed partially or slice by slice can now be seen in detail on the big screen, said Falko Kuester, one of the system's designers and a UCI assistant professor of electrical engineering and computer science.

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OptIPuter Research Enables Massive Data Mining

- Developing New Data Mining Algorithms for Massive Scientific Data Sets, Using Optiputer for High-Speed Remote Data Streaming, & Multi-Tile Display Walls for Visualization

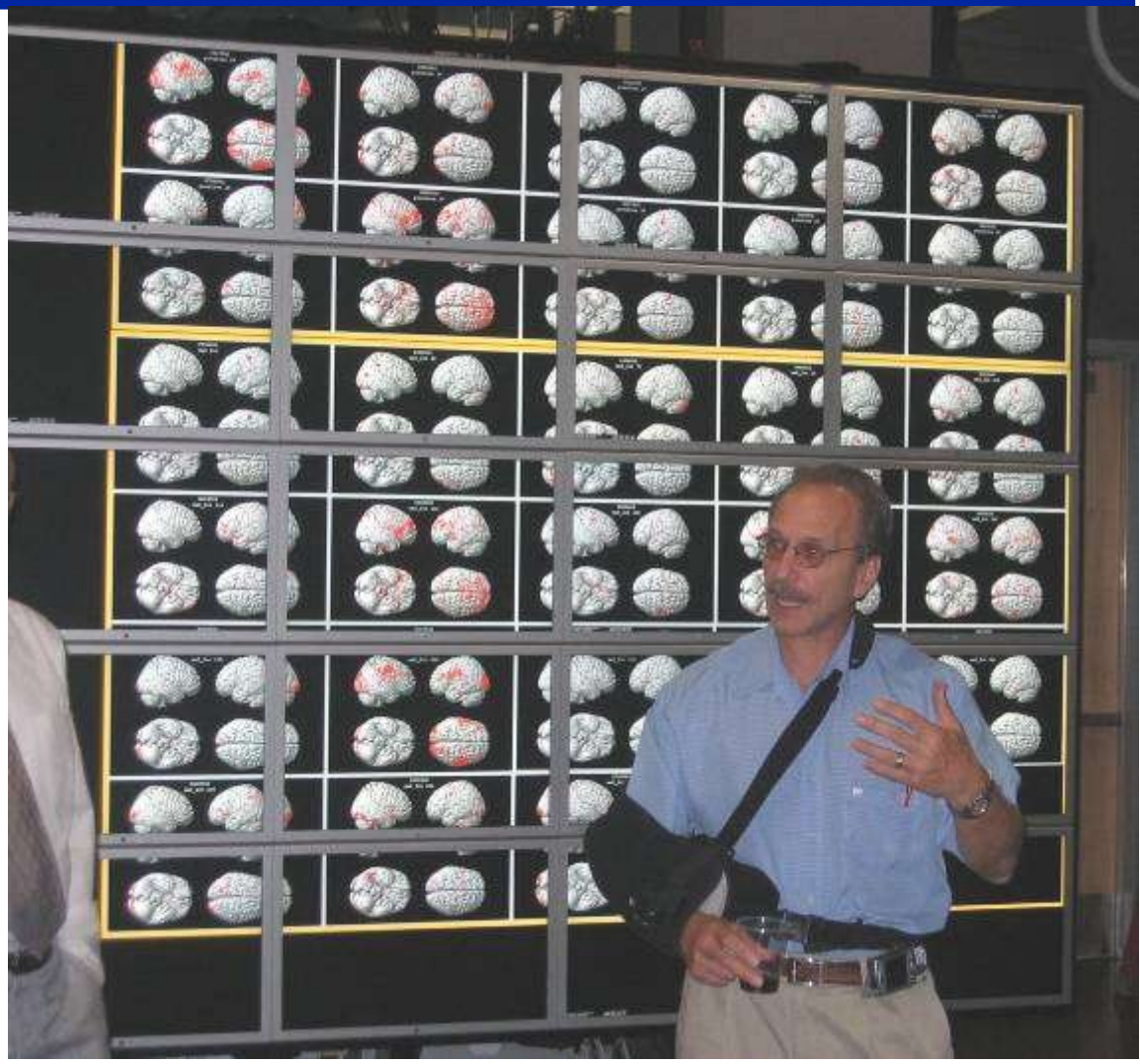


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Source: Padhraic Smyth, UCI

Visualization of Brain Image Data

- Data Streaming in Over OptIPuter Links from Remote Sites
- Research Challenge:
  - How to Effectively Combine:
    - Computational Power,
    - Pixel Real-estate,
    - Human Visual Capabilities
  - To Develop New Paradigms for Exploratory Data Analysis



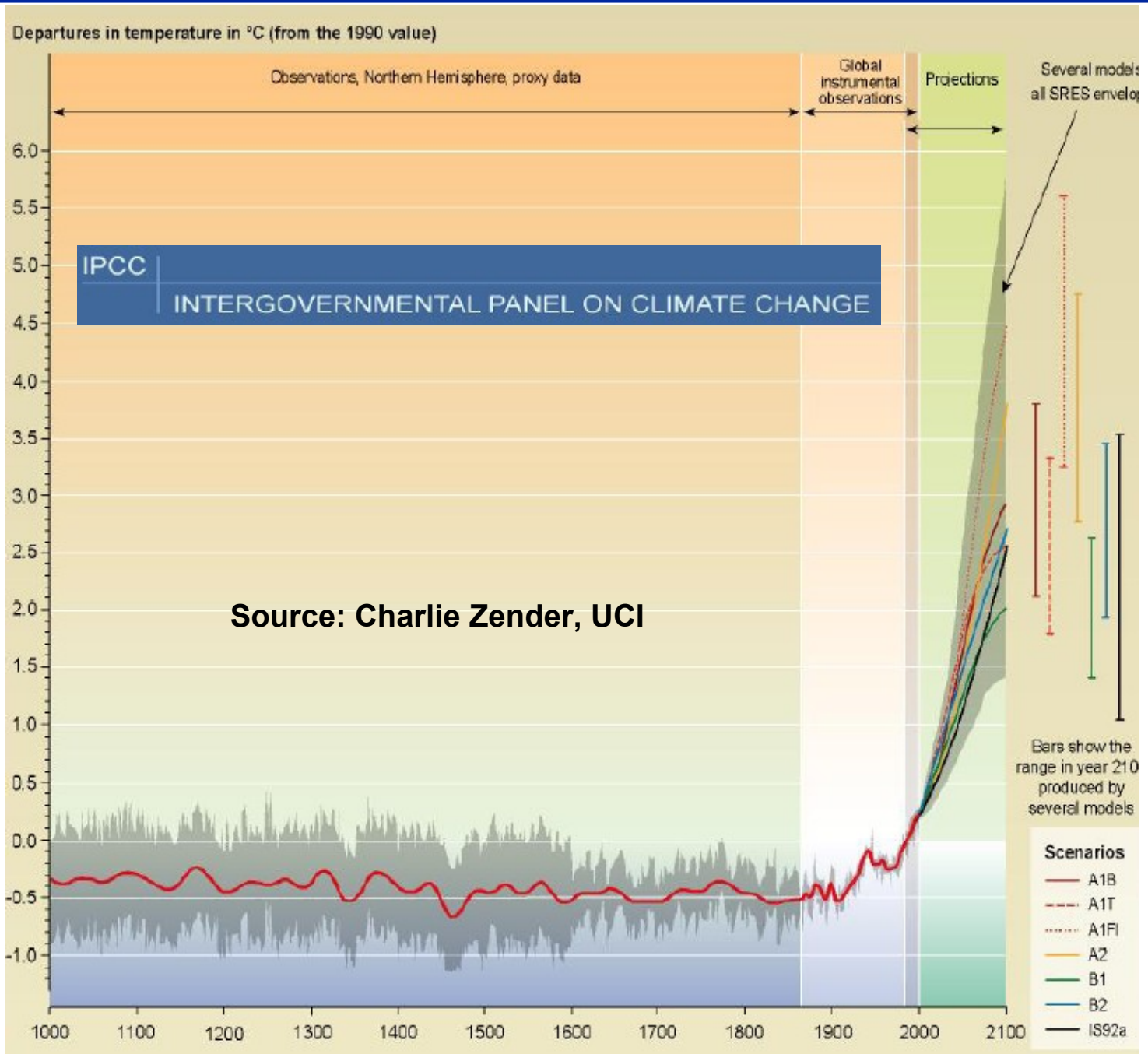
Brain Imaging (Schizophrenia)
Kuester in Collaboration with the UCI Brain Imaging Center (BIC) and BIRN

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Source: Padhraic Smyth, Falko Kuester, UCI

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Variations of the Earth Surface Temperature Over One Thousand Years—THE Challenge of the 21st Century

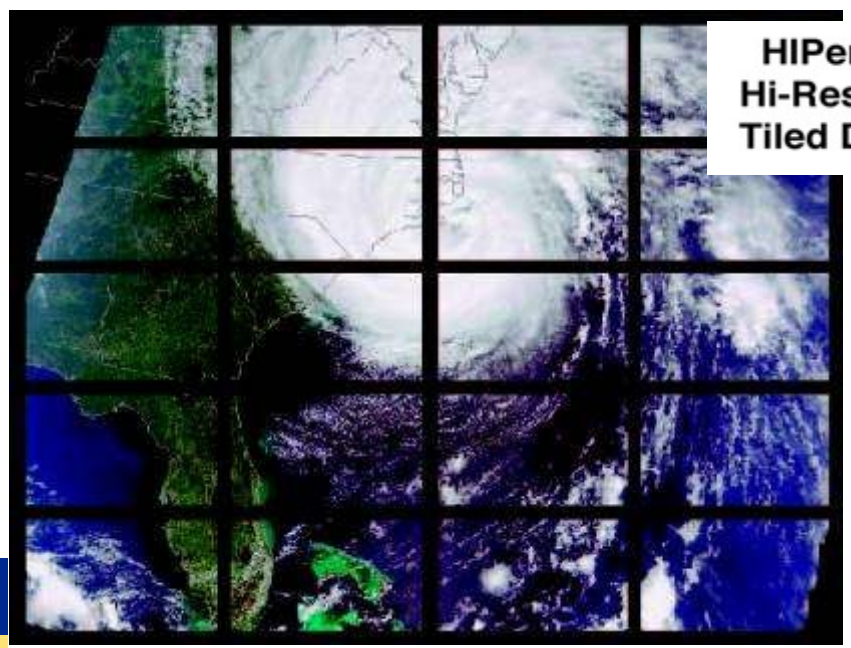


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Applying OptIPuter Technologies to Support Global Change Research

- **UCI Earth System Science Modeling Facility (ESMF)**
  - **NSF's CISE Science and Engineering Informatics Program Funded ESMF and Calit2 to Improve Distributed Data Reduction & Analysis**
    - **Calit2 and UCI is Adding ESMF to the OptIPuter Testbed**
    - **Link to Calt2@UCI HiPerWall**
- **The Resulting Scientific Data LambdaGrid Toolkit will Support the Next Intergovernmental Panel on Climate Change (IPCC) Assessment Report**

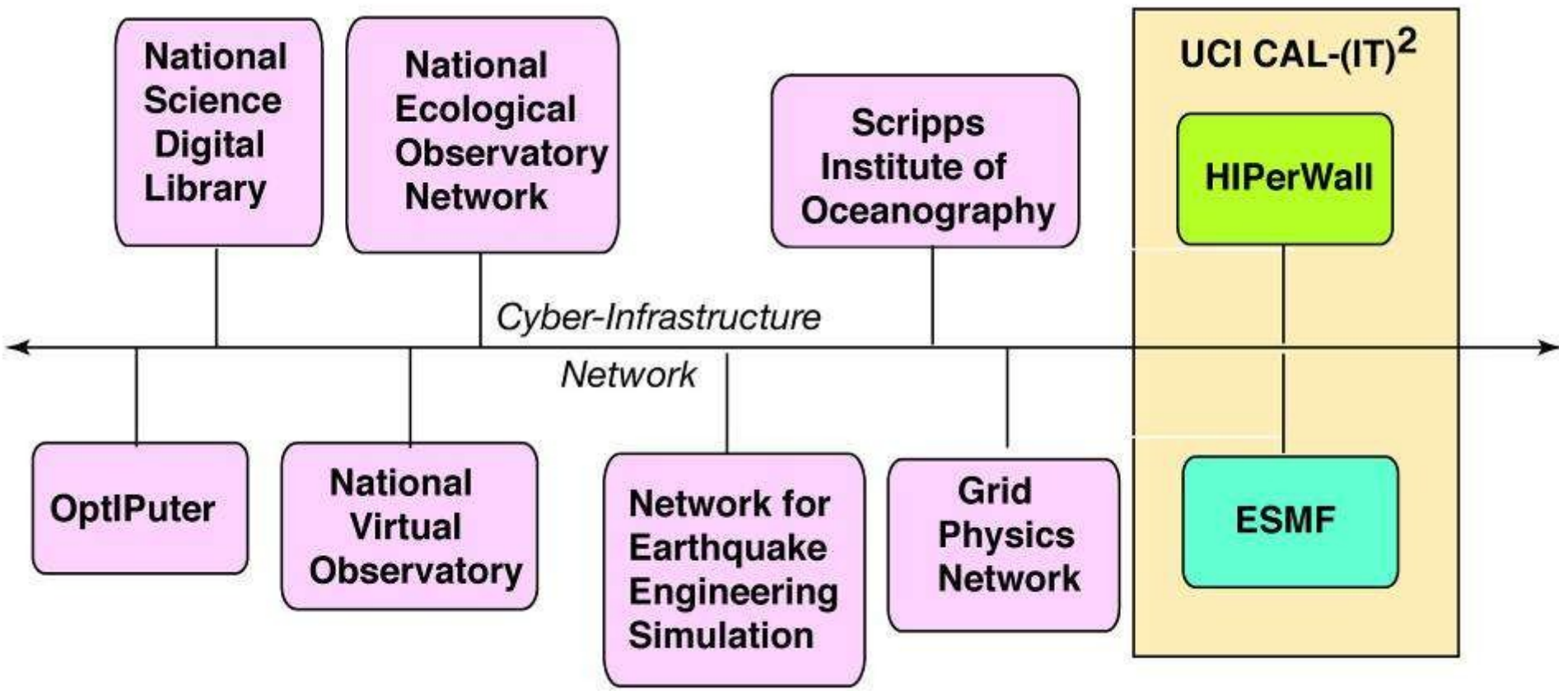


HIPerWall Hi-Resolution Tiled Display ↔ Visualization/ Rendering Cluster ↔ Earth System Modeling Facility

Source: Charlie Zender, UCI

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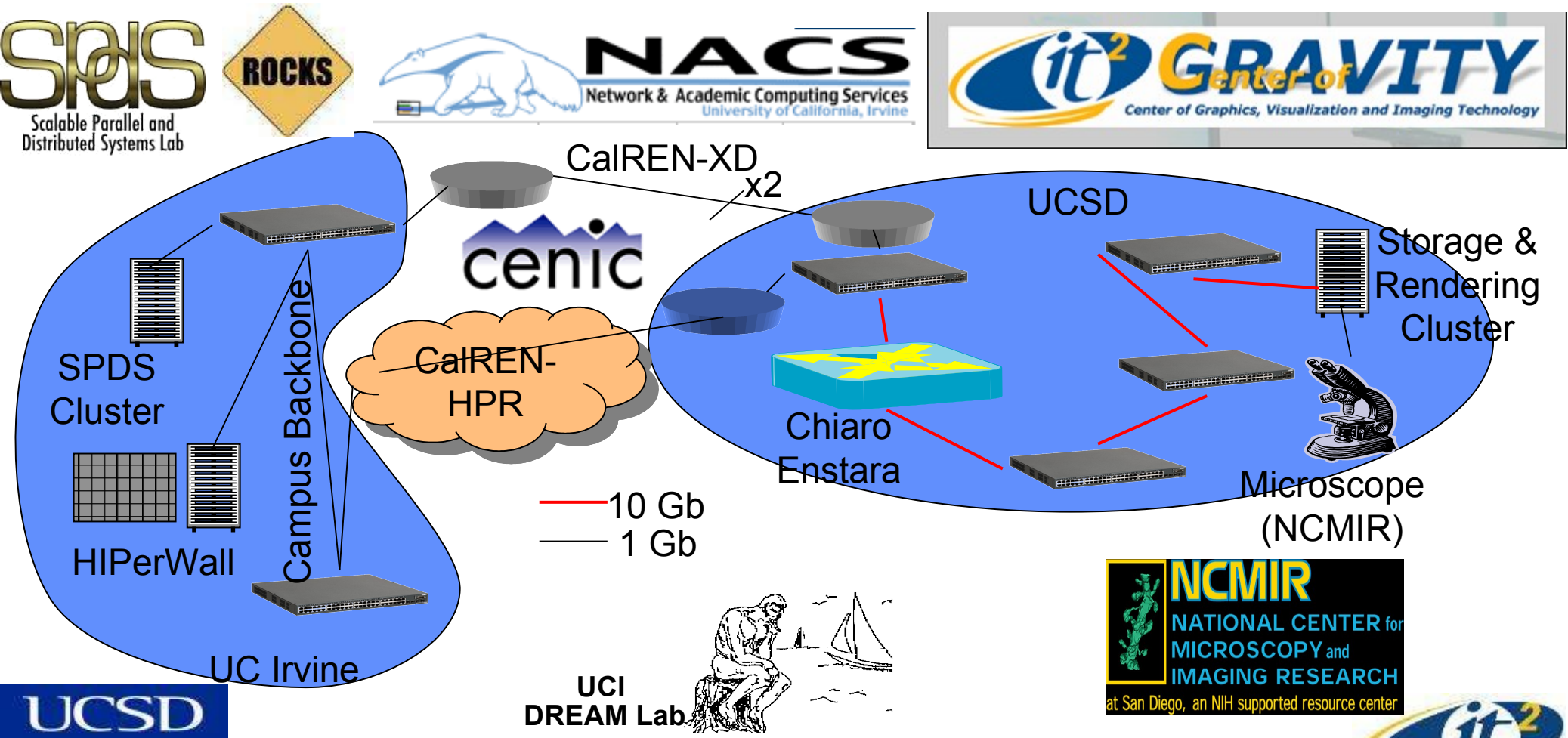
HIPerWall & The Grid
Allows High Performance Linkages to National Digital Assets



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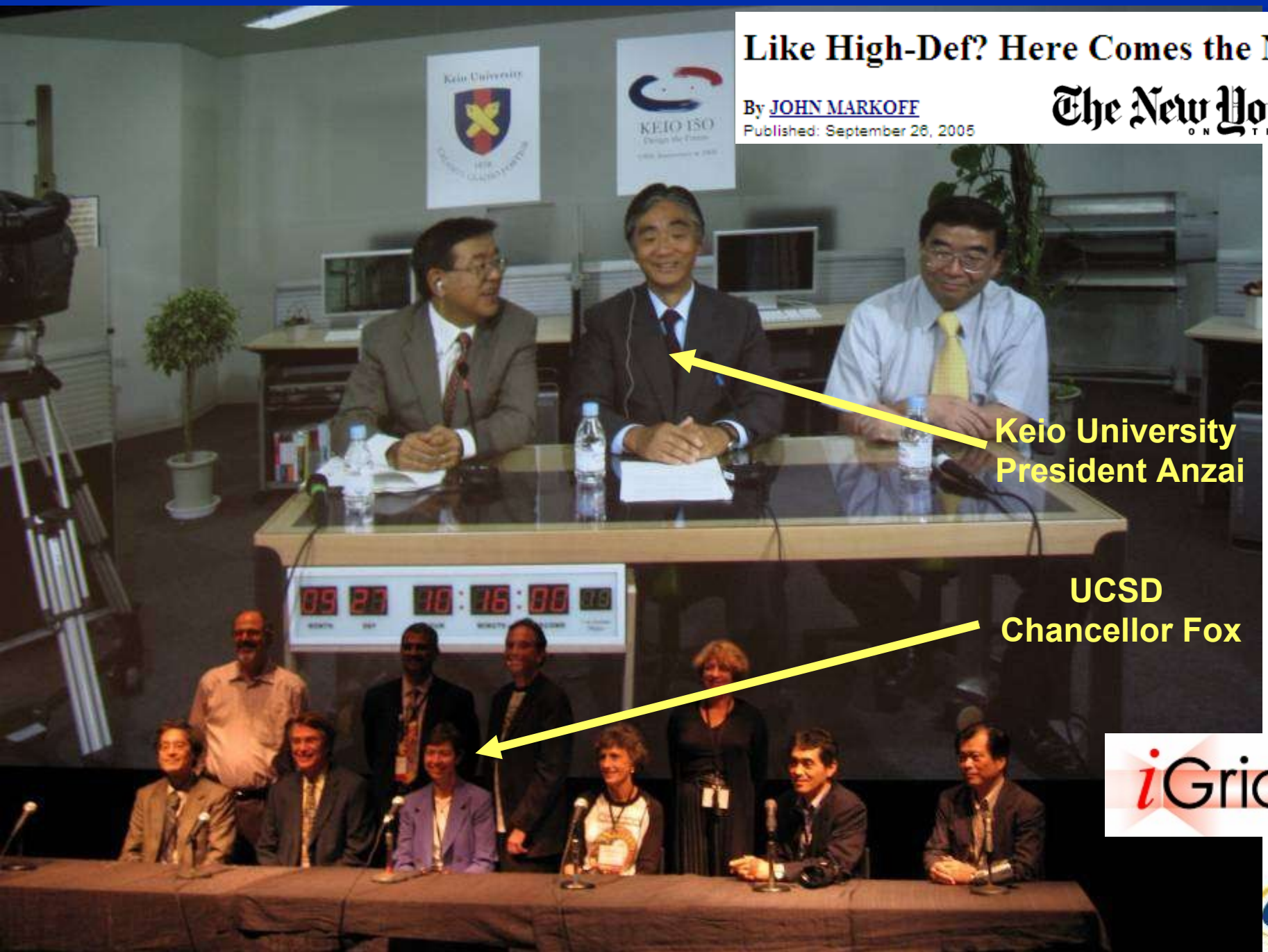
UCI is Adding Real Time Control to the Calit2 OptIPuter Testbed

- **Application Development Experiments Requires Institutional Collaboration**
  - **An Experiment for Remote Access and Control within the UCI Campus**
  - **A Step Toward Preparation of an Experiment for Remote Access and Control of Electron Microscopes at UCSD-NCMIR**



Source: Steve Jenks, Kane Kim, Falko Kuester UCI

First Trans-Pacific Super High Definition Telepresence Meeting in New Calit2 Digital Cinema Auditorium



Like High-Def? Here Comes the Next Level

By JOHN MARKOFF
Published: September 26, 2005

The New York Times ON THE WEB

Keio University President Anzai

UCSD Chancellor Fox

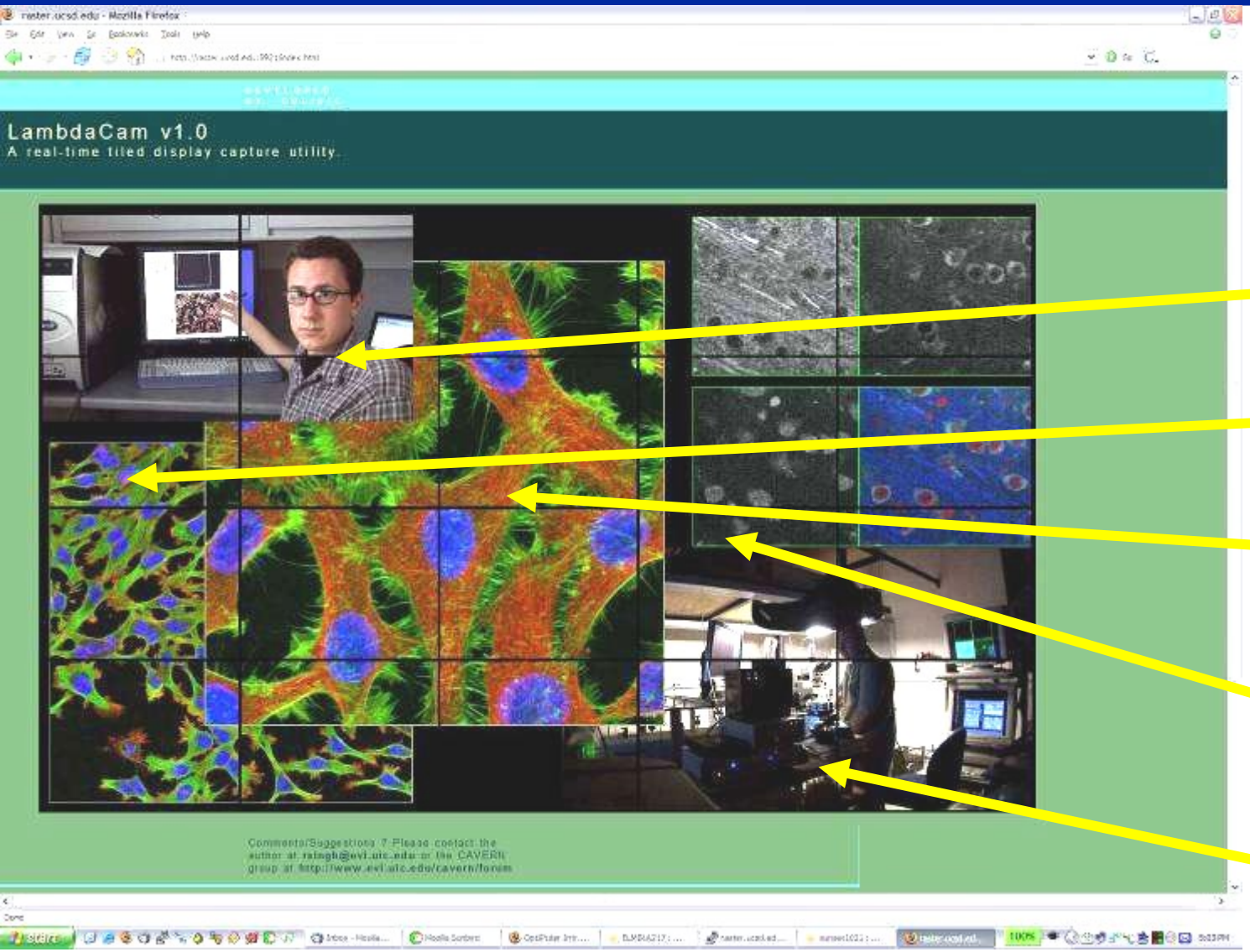
Lays Technical Basis for Global Digital Cinema

Sony
NTT
SGI

iGrid 2005

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OptIPuter Scalable Adaptive Graphics Environment (SAGE) Allows Integration of HD Streams



SAGE Developed Under Jason Leigh, EVL

- HD Video from BIRN Trailer
- Macro View of Montage Data
- Micro View of Montage Data
- Live Streaming Video of the RTS-2000 Microscope
- HD Video from the RTS Microscope Room

LambdaCam Used to Capture the Tiled Display on a Web Browser

UCSD UCIrvine evl electronic visualization laboratory

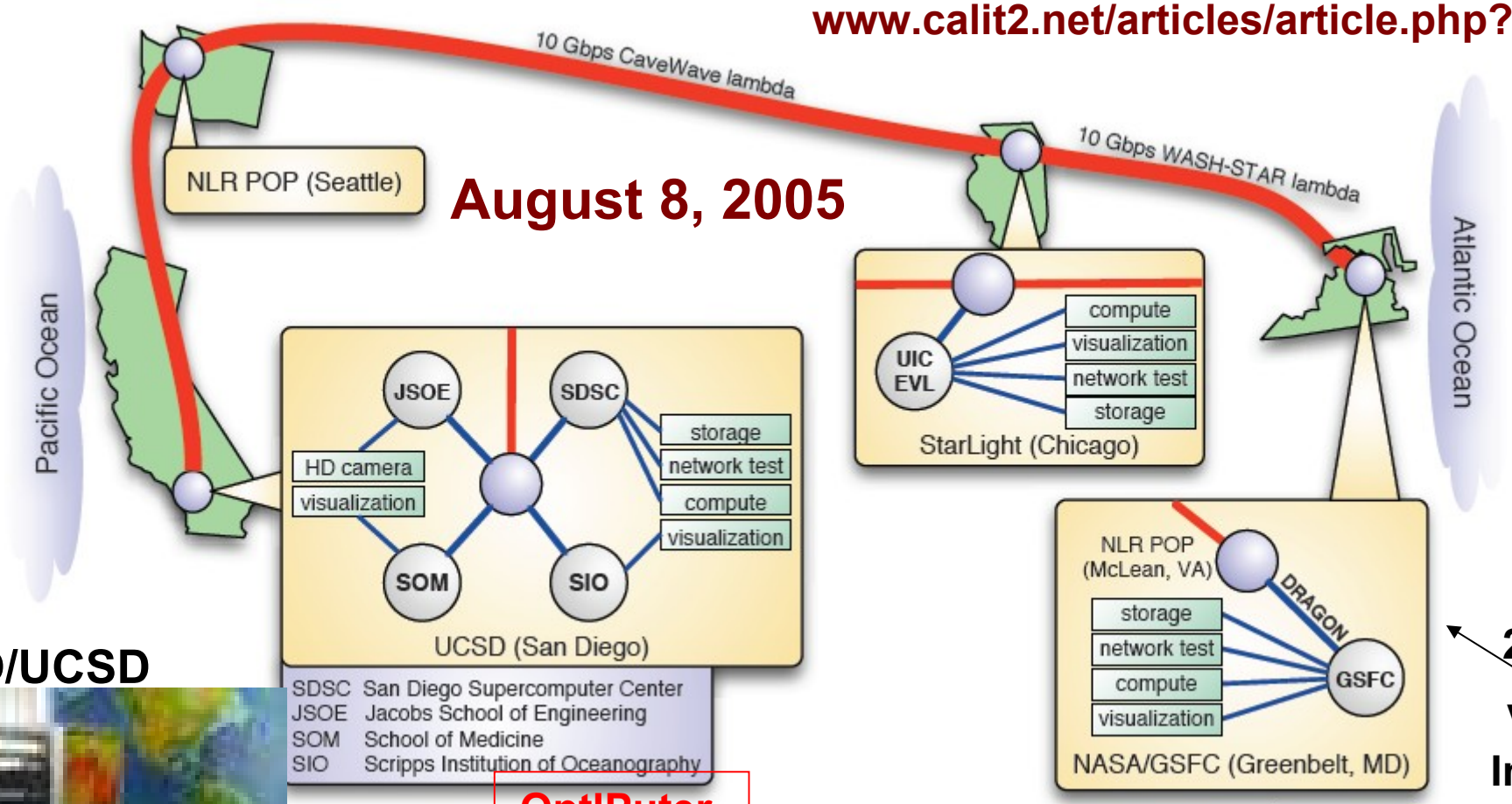
Source: David Lee, NCMIR, UCSD

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

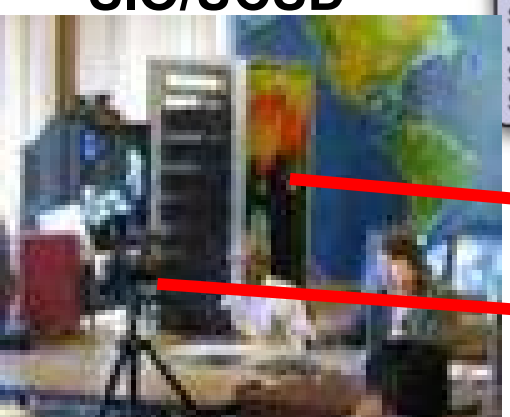
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Extending Telepresence with Remote Interactive Analysis of Data Over NLR

www.calit2.net/articles/article.php?id=660



SIO/UCSD



OptIPuter Visualized Data

HDTV Over Lambda



NASA Goddard

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Two New Calit2 Buildings Will Provide a Persistent Collaboration "Living Laboratory"



- **Over 1000 Researchers in Two Buildings**
  - Linked via Dedicated Optical Networks
  - International Conferences and Testbeds
- **New Laboratory Facilities**
  - Virtual Reality, Digital Cinema, HDTV
  - Nanotech, BioMEMS, Chips, Radio, Photonics, Grid, Data, Applications

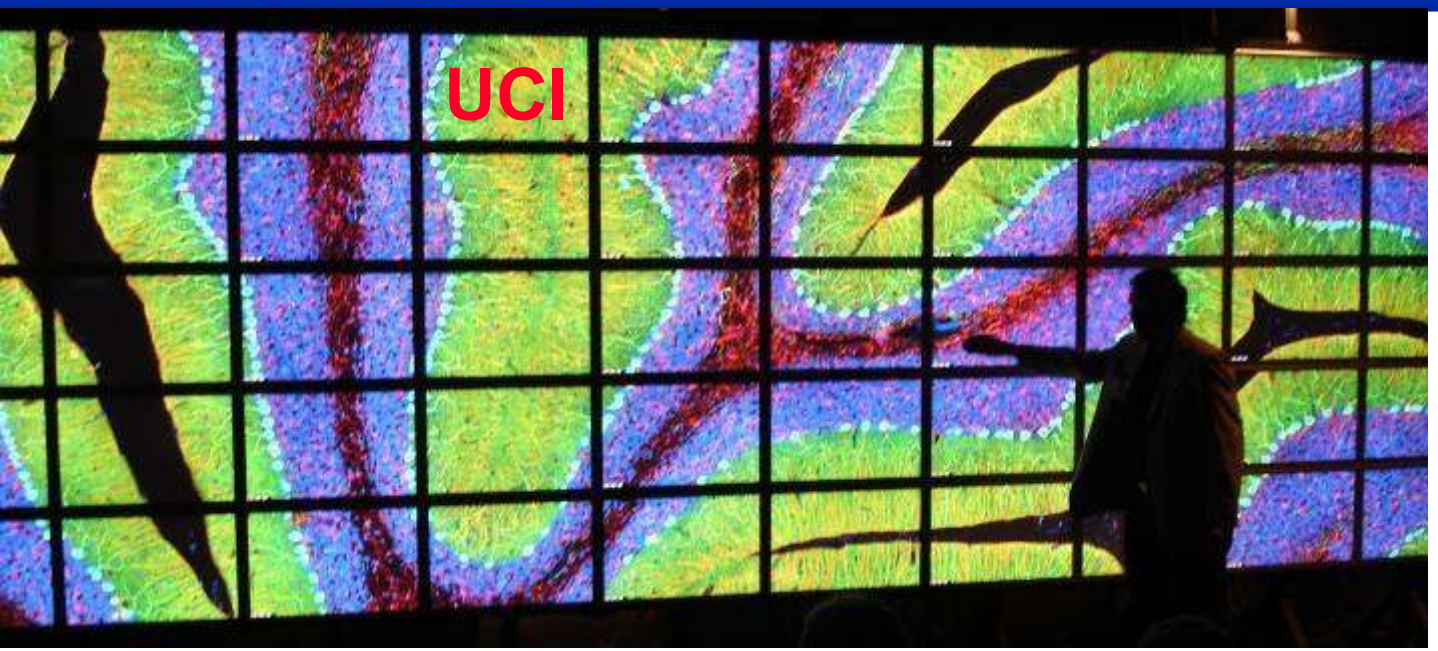


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Learning to Live on Lambdas

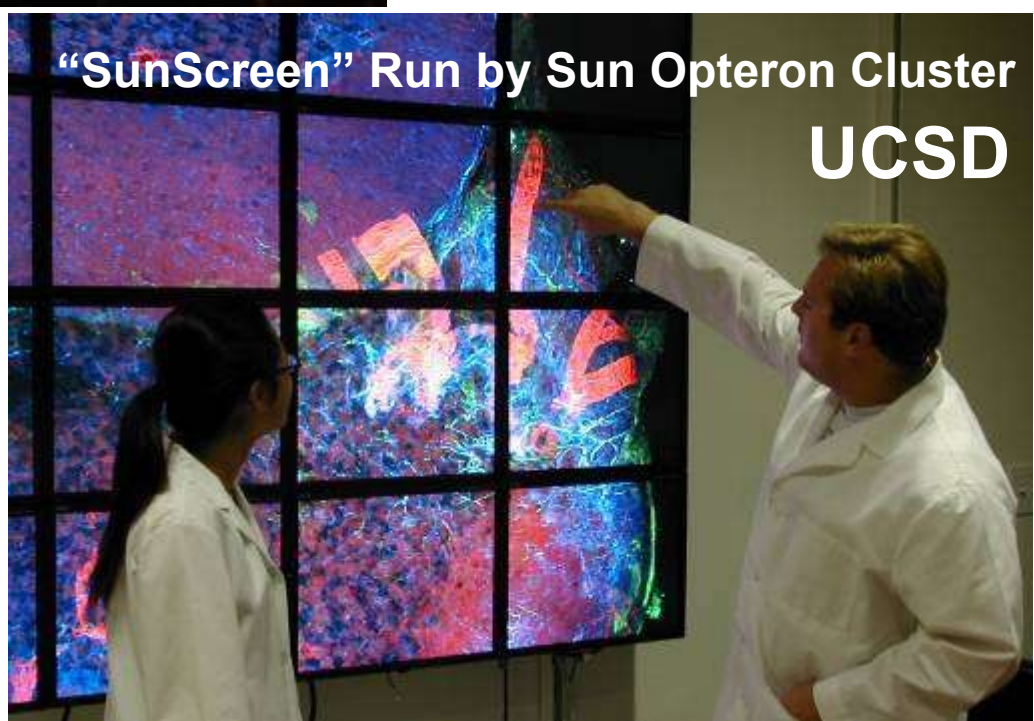
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The OptIPuter Enabled Collaboratory: Remote Researchers Jointly Exploring Complex Data



OptIPuter

OptIPuter will Connect
Falko Kuester's
Calit2@UCI
200M-Pixel Wall and
the 30M-Pixel Display
at UCSD Ellisman's
BIRN Laboratories
With Shared Fast Deep Storage



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