“Living in a World of True Broadband"

Keynote
QTech Forum
Qualcomm
San Diego, CA
November 1, 2006

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

While the United States has increasing "broadband" to the home (DSL, Cable Modems) or wirelessly (1xEVDO), these bandwidths correspond to a few megabit/sec or lower. Meanwhile, gigabit/s Ethernet, with 1000 times the bandwidth, is becoming the standard input/output on Macs and PCs. Thus a "broadband gap" exists which effectively isolates computing and storage devices from each other, even though they are interconnected by the shared Internet. The California Institute for Telecommunications and Information Technology has a variety of projects underway exploring persistent 1-10 gigabit/s optical paths connecting people and devices on local, regional, national, and global scales. Such bandwidth drives the need for visual user interfaces from megapixels to gigapixels. I will illustrate uses of this "true broadband" information infrastructure with applications from medicine, entertainment, science, and emergency response, all drawn from Calit2 Living Laboratories. Such prototypes of the future may be useful for designing new capabilities into the rapidly expanding wireless world.

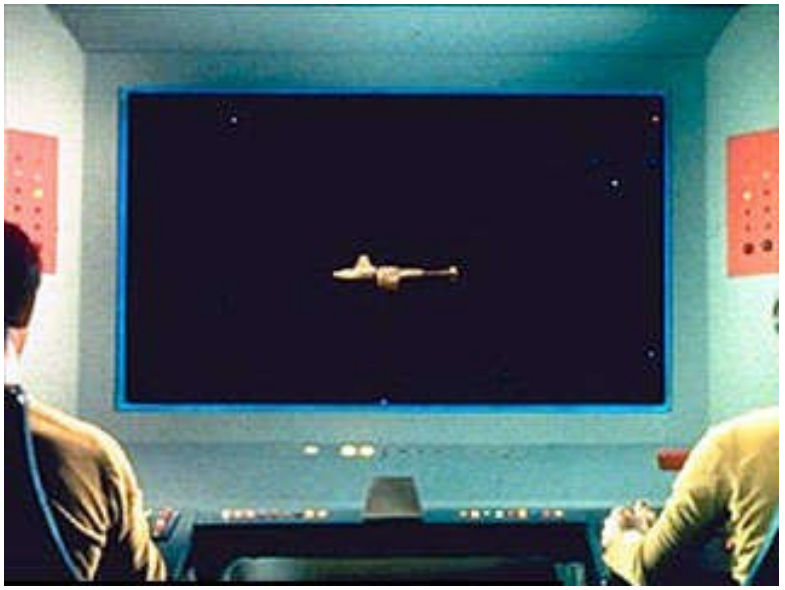
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TV and Movies of 40 Years Ago Envisioned Telepresence Displays









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Source: Star Trek 1966-68; Barbarella 1968

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The Beginnings of Commercialization: PicturePhone Introduced 40 Years Ago



NEW LOOK PICTUREPHONE

Now you can *see* as well as talk The Picturephone has Touch-Tone controls to make calls and control the television screen so you can see the person you're talking to, be seen yourself, or have a darkened screen. Attended service between New York, Washington and Chicago began in 1964.

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www.bellsystemmemorial.com/telephones-picturephone.html

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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

The HP HALO Collaboration Studio is the Leading Edge Commercially Today

- $500,000 per room
- 45 mbps
- Uses TCP/IP protocols
- Developed with Dreamworks
- Announced by HP Dec 2005
- HP Plans 40 Internally by End of 2006
- Dreamworks, AMD, PepsiCo are Customers

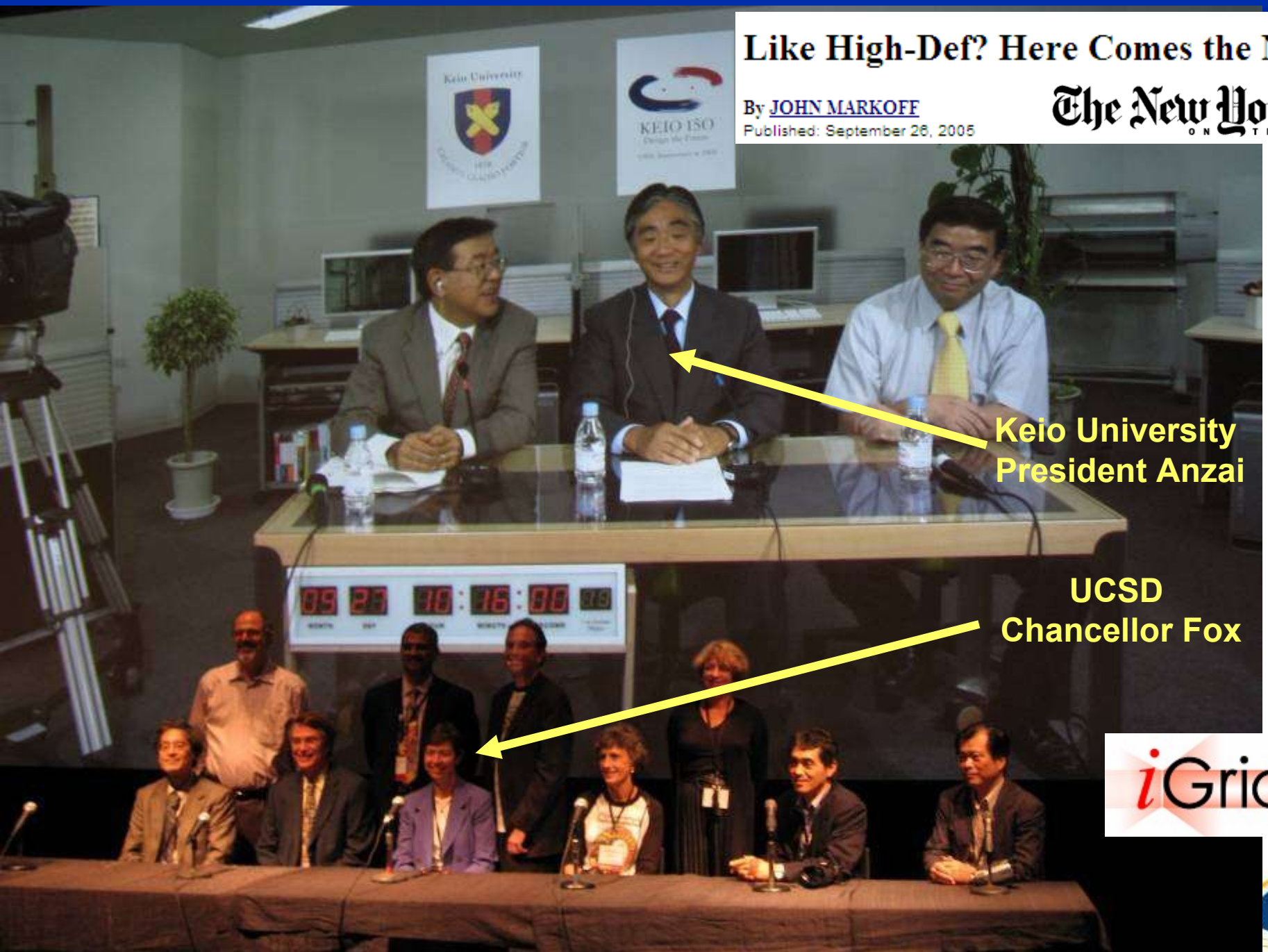


The Halo studios are designed to exact specifications, so that participants on the other side of the video conference appear to be in the same room

-- Calit2 is Exploring Collaboration

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Telepresence Meeting - Calit2 Digital Cinema Auditorium
Dedicated Gigabit/sec, 8M pixels, 24 frames/sec



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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Calit2 Continues to Pursue Its Initial Mission:

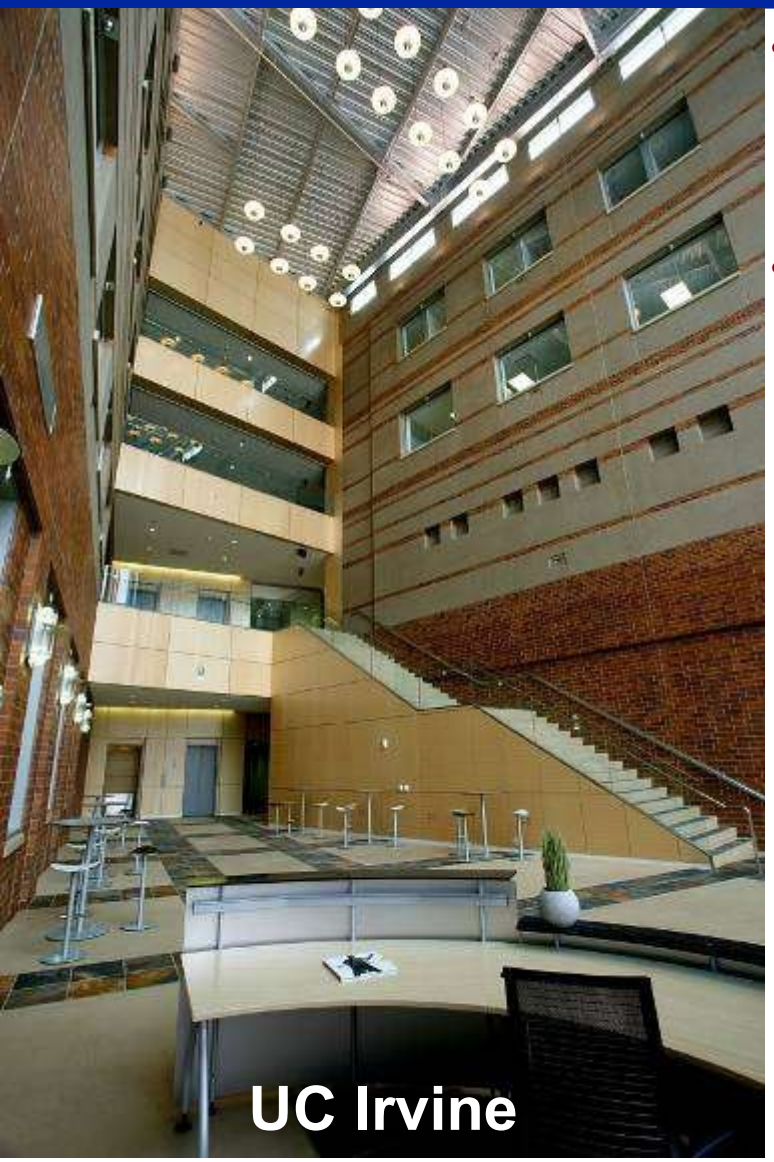
Envisioning How the Extension of Innovative Telecommunications and Information Technologies Throughout the Physical World will Transform Critical Applications Important to the California Economy and its Citizens' Quality Of Life.

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.

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Two New Calit2 Buildings Will Provide Major New Laboratories to Their Campuses



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

Richard C. Atkinson Hall Dedication Oct. 28, 2005



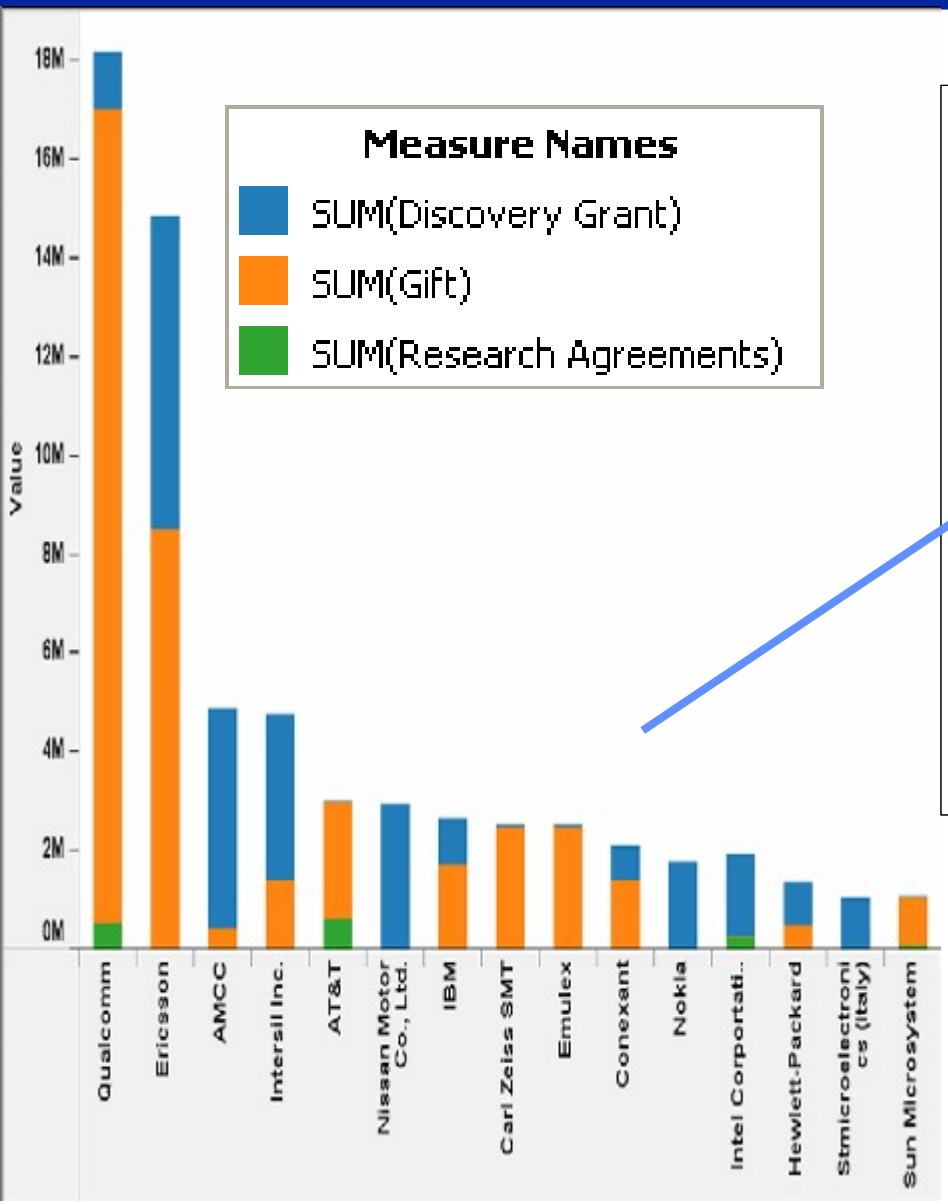
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Preparing for an World in Which Distance Has Been Eliminated…

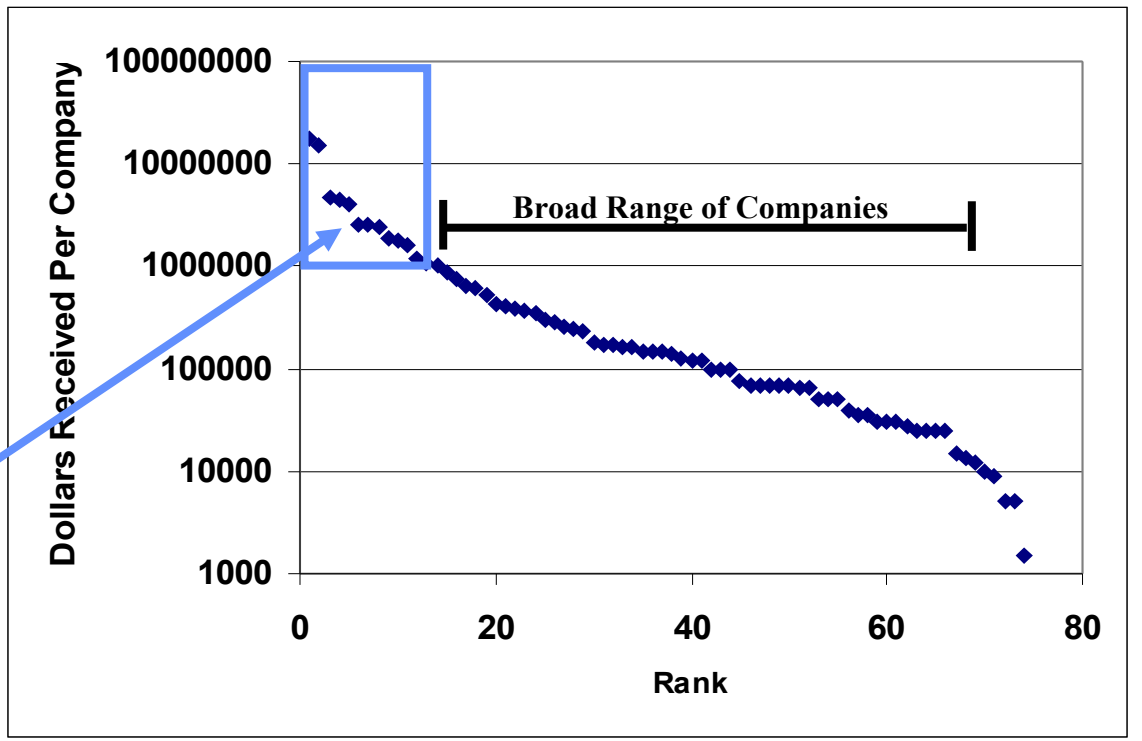
www.calit2.net

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In Spite of the Bubble Bursting, Calit2 Has Partnered with over 130 Companies



More Than 80 Have Provided Funds or In-kind

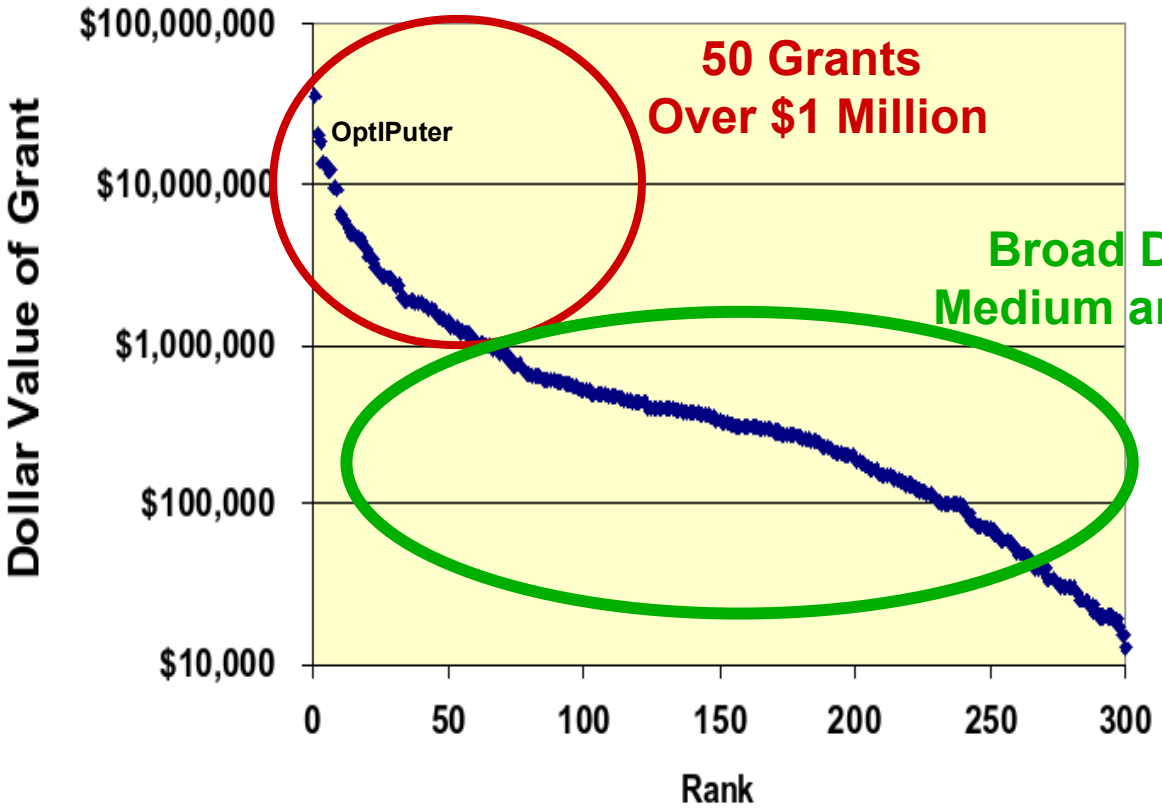


$78 Million From Industry So Far

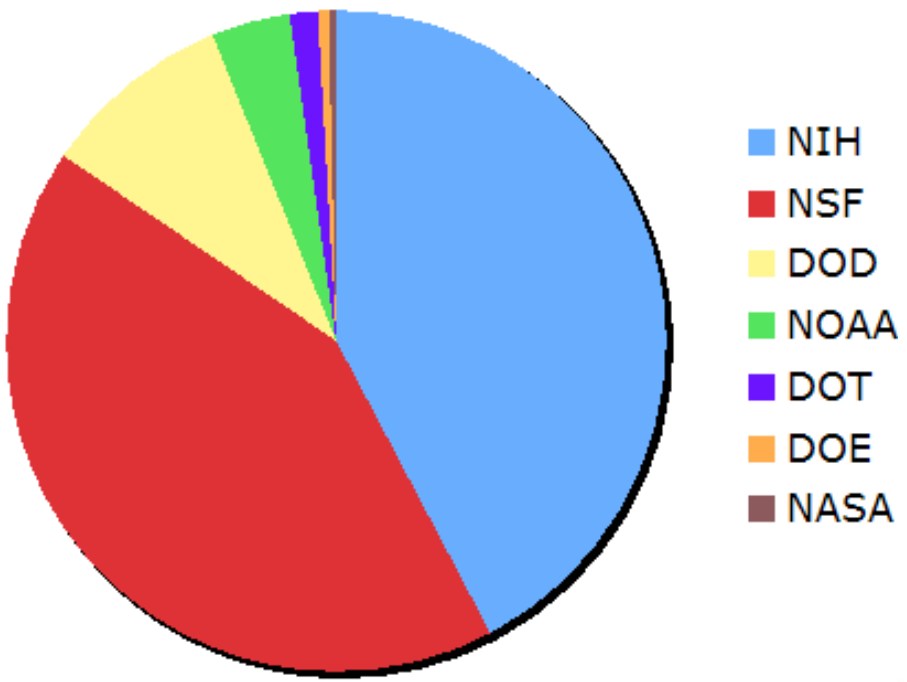
Industrial Partners > $1 Million

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Federal Agencies Have Funded $350 Million to Over 300 Calit2 Affiliated Grants



Creating a Rich Ecology of Basic Research



Federal Agency Source of Funds

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Calit2 Review Report p.4,21

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



- **Home Broadband**
  - **1-5 Mbps**



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



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

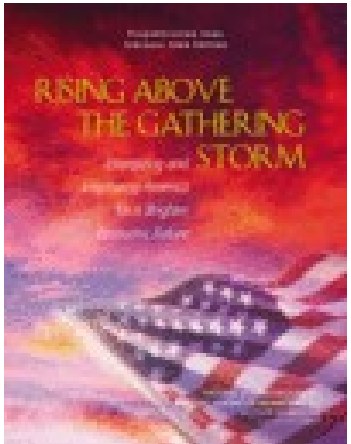
What Actions Should America Take in Economic and Technology Policy to Remain Prosperous in The 21st Century:

Incentives For Innovation

Action D-4: Ensure Ubiquitous Broadband Internet Access.

Several nations are well ahead of the United States in providing broadband access for home, school, and business. That capability can be expected to do as much to drive innovation, the economy, and job creation in the 21st century as did access to the telephone, interstate highways, and air travel in the 20th century. Congress and the administration should take action—mainly in the regulatory arena and in spectrum management—to ensure widespread affordable broadband access in the very near future.

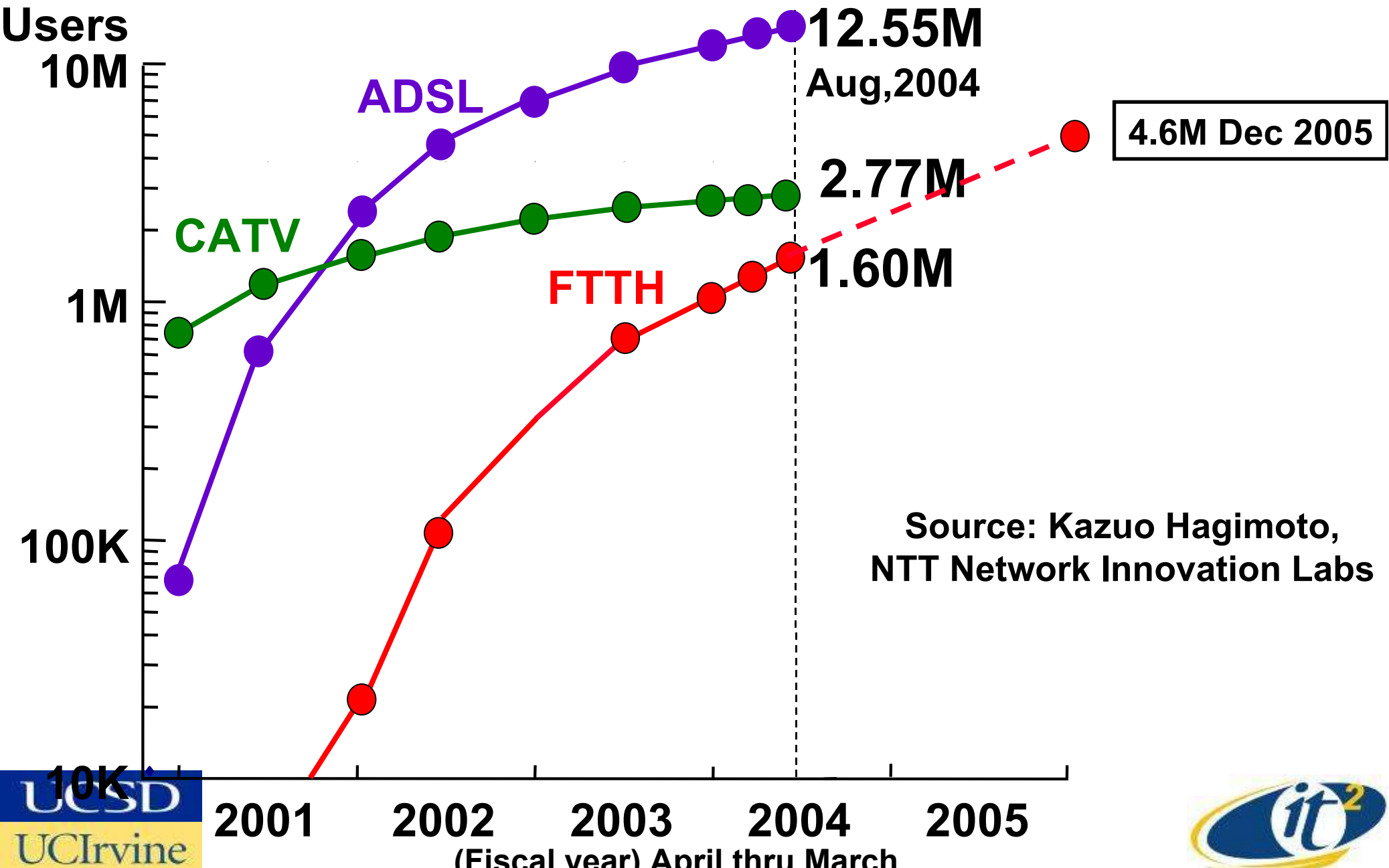
Rising Above The Gathering Storm:
Energizing and Employing America for a Brighter Economic Future
Committee on Prospering in the Global Economy of the 21st Century:
An Agenda for American Science and Technology—NAS, NAE, IOM



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Broadband Service Users in Japan: Moving Quickly to Fiber to the Home

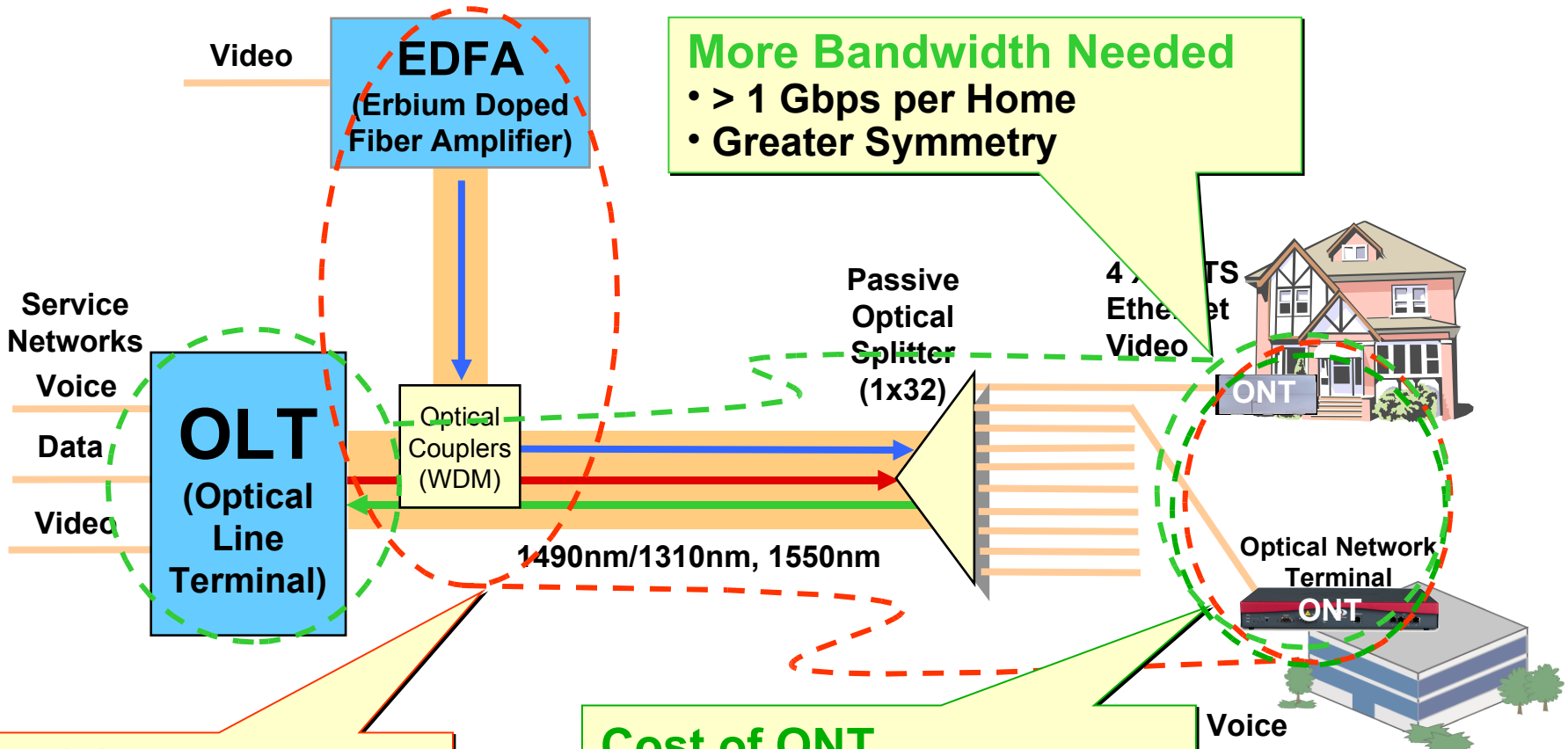


Source: Kazuo Hagimoto, NTT Network Innovation Labs

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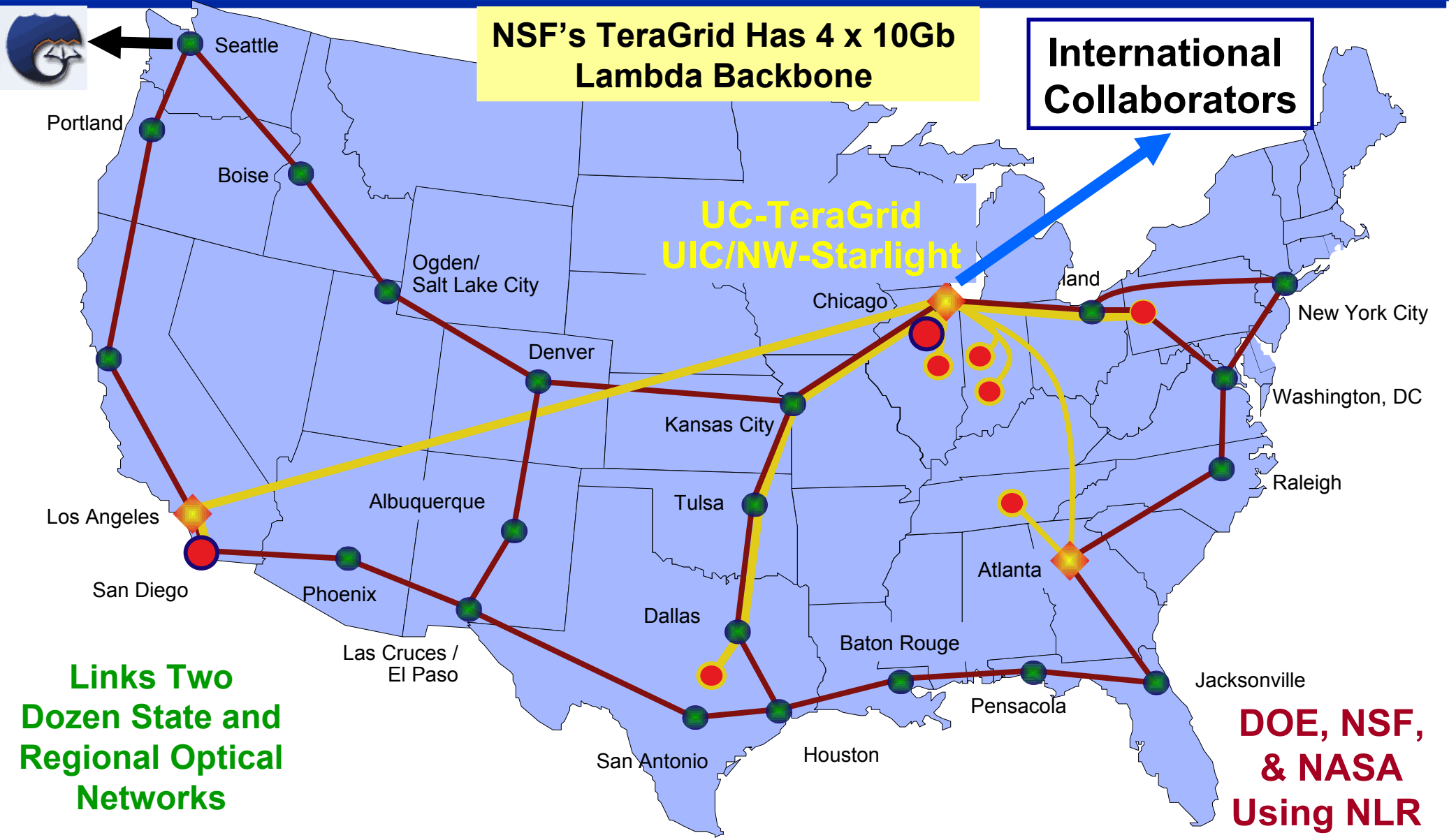
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Verizon Fiber to the Premise: Bringing Gigabit/s to the Home



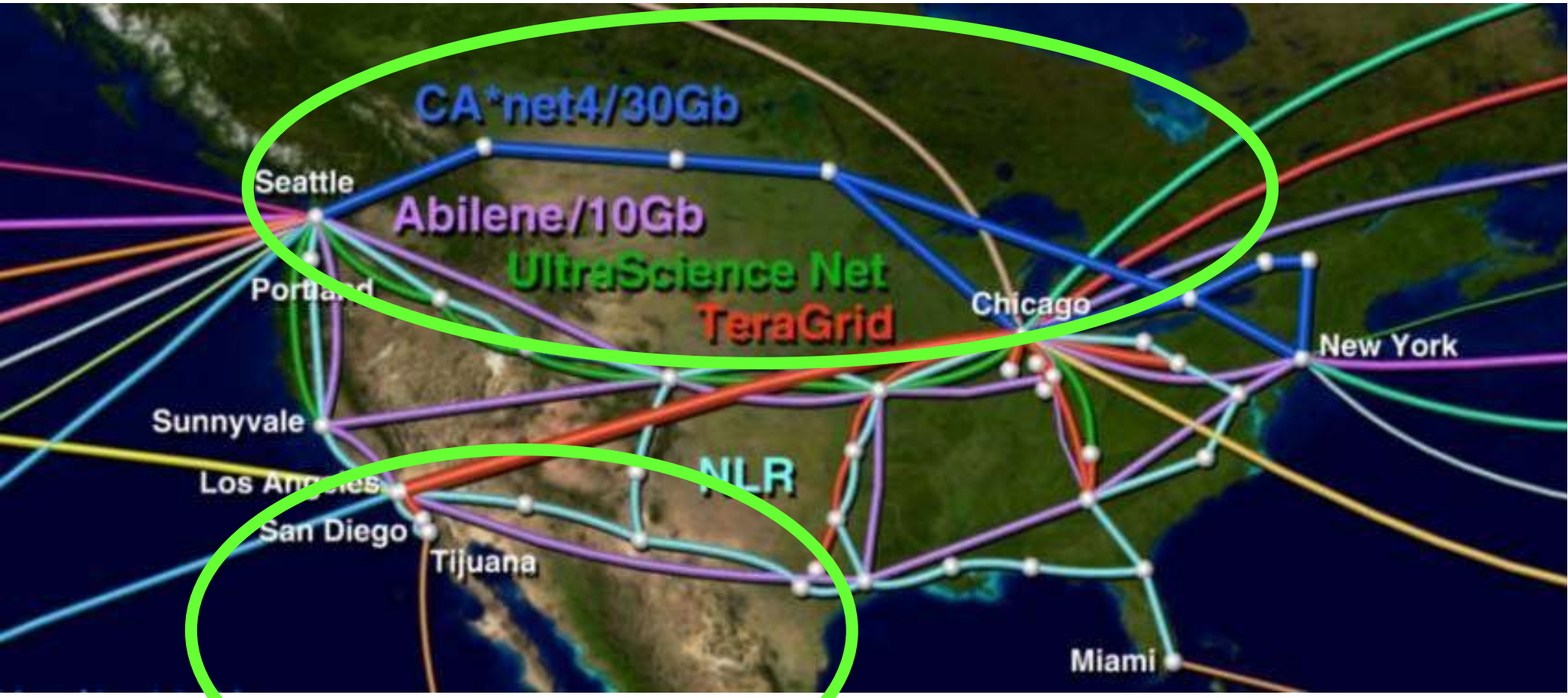
Source: Stuart Elby
VP – Network Architecture, Verizon Technology Org
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Information contained herein is subject to change without notice.

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



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Creating a North American Superhighway for High Performance Collaboration



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Next Step: Adding Mexico to Canada's CANARIE and the U.S. National Lambda Rail

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Calit2 Has Become a Global Hub for Optical Connections

Between 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

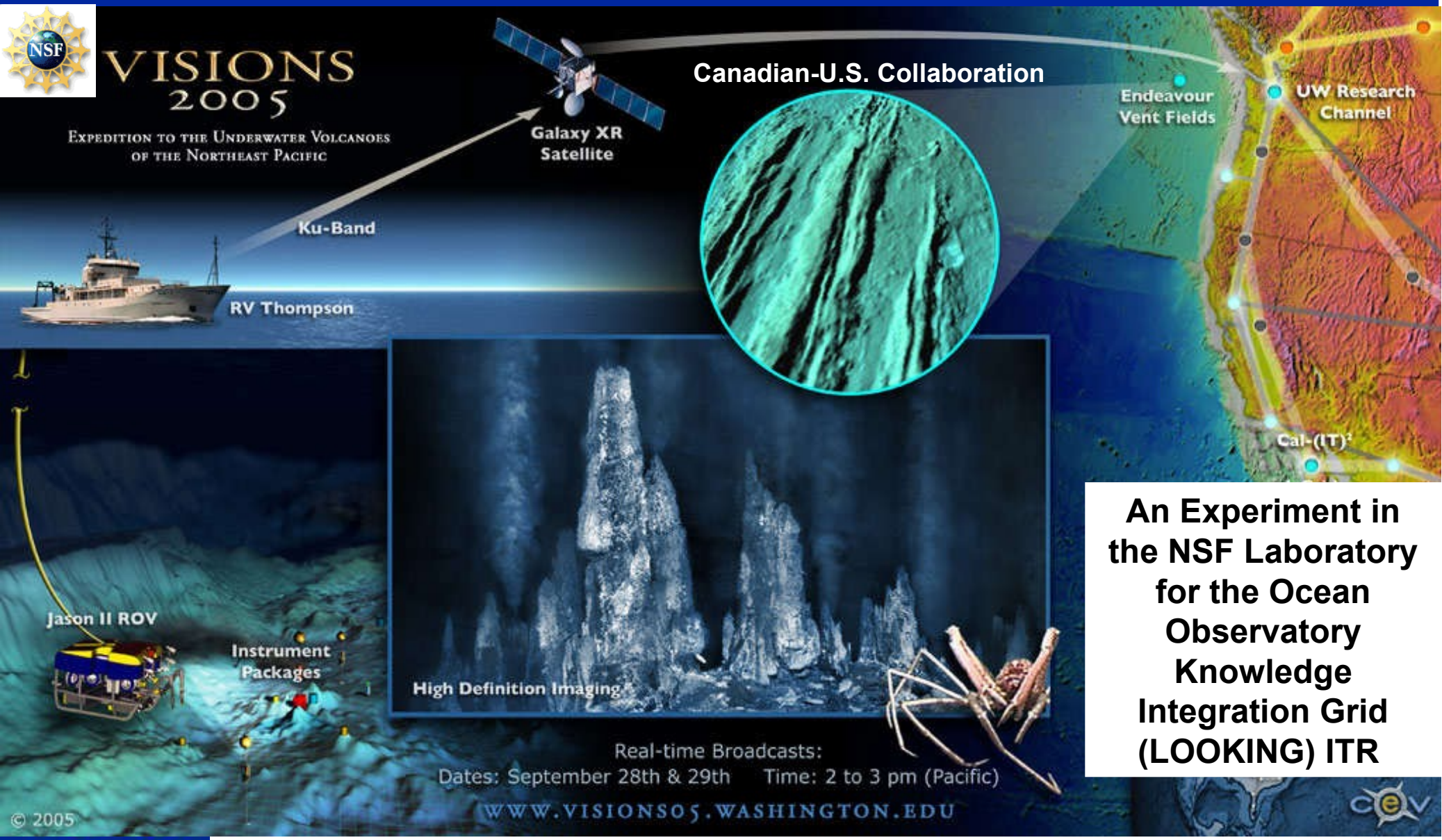
Calit2 @ University of California, San Diego

California Institute for Telecommunications and Information Technology



21 Countries Driving 50 Demonstrations
1 or 10Gbps to Calit2@UCSD Building
Sept 2005

iGrid Scientific Instrument Services: Enable Remote Interactive HD Imaging of Deep Sea Vent



An Experiment in the NSF Laboratory for the Ocean Observatory Knowledge Integration Grid (LOOKING) ITR

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Prototype of CI for NSF's ORION

Source John Delaney & Deborah Kelley, UWash

High Definition Still Frame of Hydrothermal Vent Ecology 2.3 Km Deep



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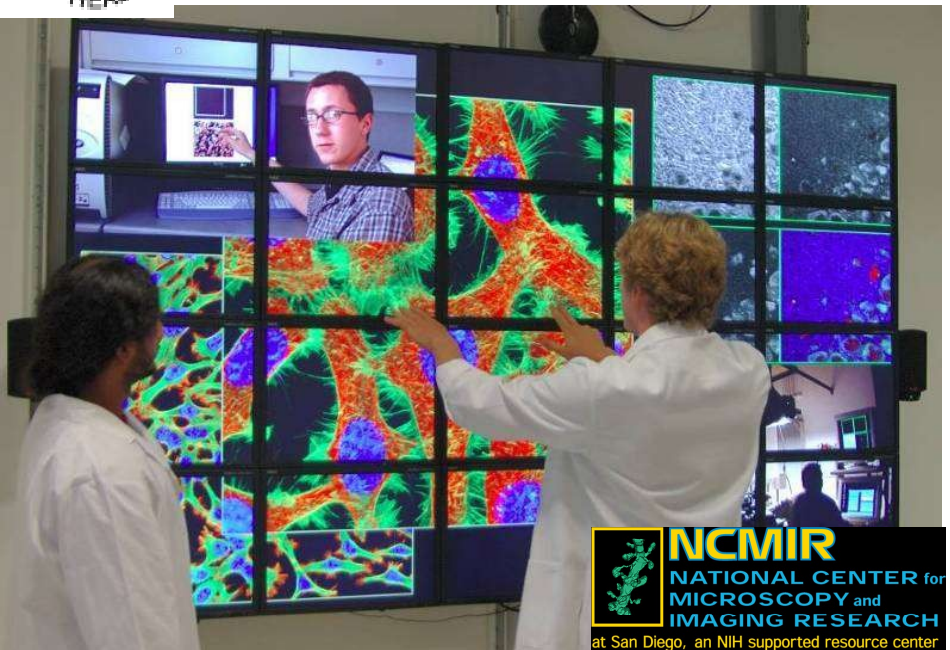
White Filamentous Bacteria on 'Pill Bug' Outer Carapace

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

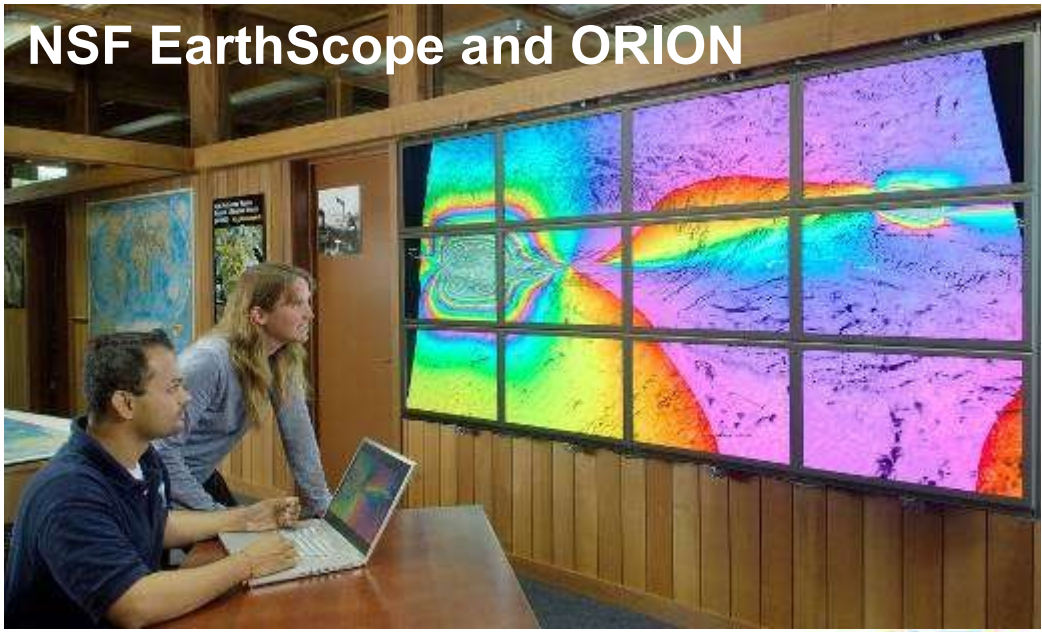
- **NSF Large Information Technology Research Proposal**
  - Calit2 (UCSD, UCI) and UIC Lead Campuses—Larry Smarr PI
  - Partnering Campuses: SDSC, USC, SDSU, NCSA, NW, TA&M, UvA, SARA, NASA Goddard, KISTI, AIST, CRC(Canada), CICESE (Mexico)
- **Engaged Industrial Partners:**
  - IBM, Sun, Telcordia,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

NIH Biomedical Informatics Research Network



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

NSF EarthScope and ORION



SCRIPPS INSTITUTION OF OCEANOGRAPHY

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High Resolution Aerial Photography Generates Images With 10,000 Times More Data than Landsat7

Landsat7 Imagery
100 Foot Resolution
Draped on elevation data





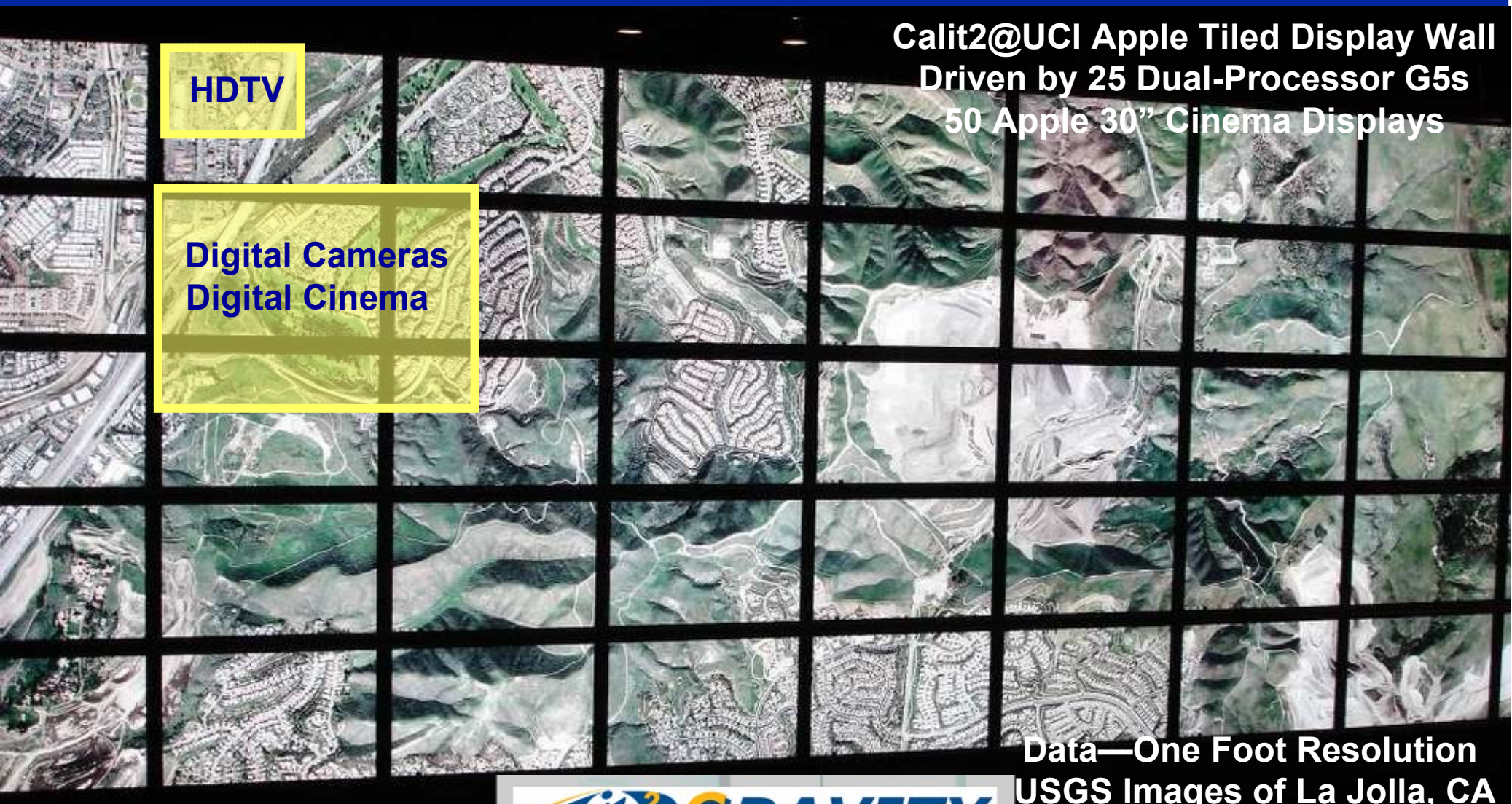
New USGS Aerial Imagery
At 1-Foot Resolution

~10x10 square miles of 350 US Cities
2.5 Billion Pixel Images Per City!

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Prototyping the User Interface of 2015
One Hundred Million Pixels Connected at 10Gbps



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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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!

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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:

Calit2 is Now Attracting Private Foundation Grants
Announced January 17, 2006--$24.5M Over Seven Years

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

Sargasso Sea Data

Sorcerer II Expedition (GOS)

JGI Community Sequencing Project

Moore Marine Microbial Project

NASA and NOAA Satellite Data

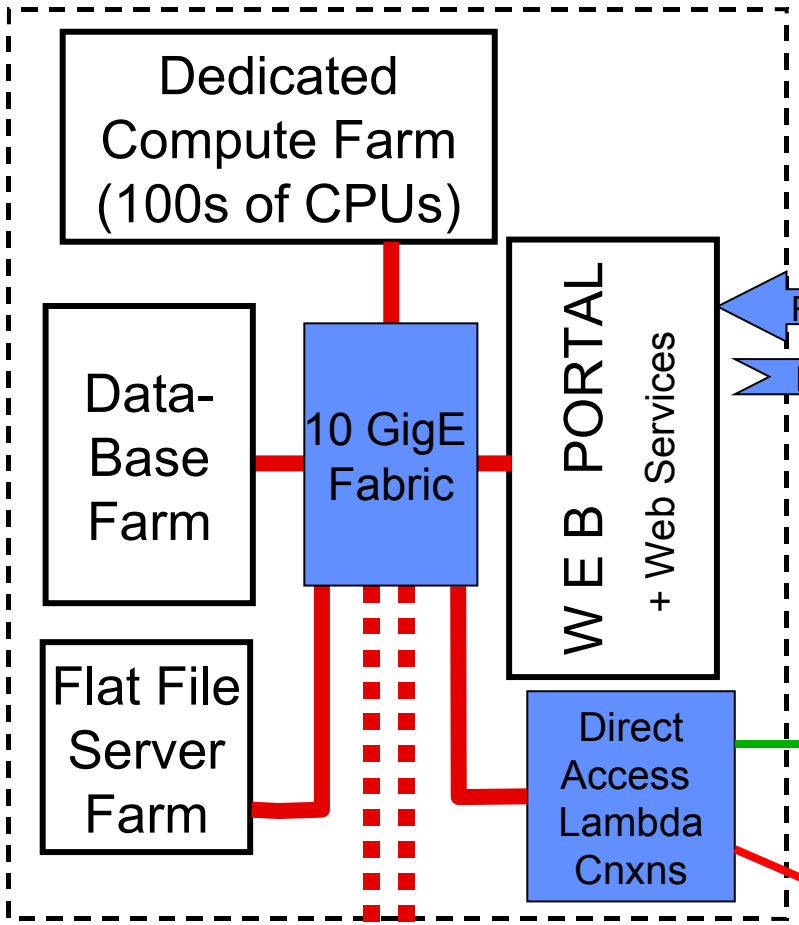
Community Microbial Metagenomics Data



J. Craig Venter INSTITUTE

SDSC SAN DIEGO SUPERCOMPUTER CENTER

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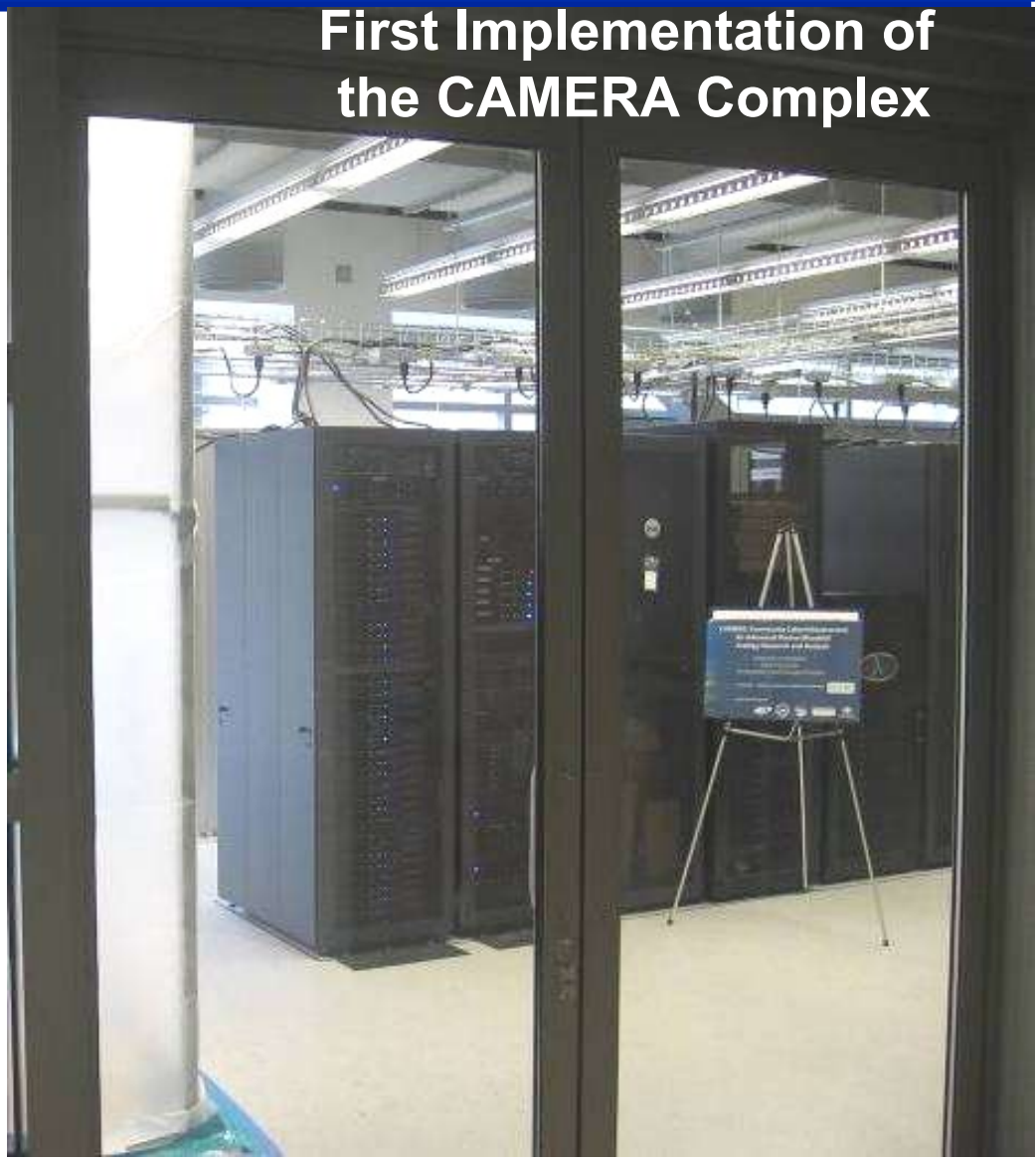
Source: Phil Papadopoulos, SDSC, Calit2



The Future Home of the Moore Foundation Funded Marine Microbial Ecology Metagenomics Complex

Public GOS Data Release:
January 16, 2007





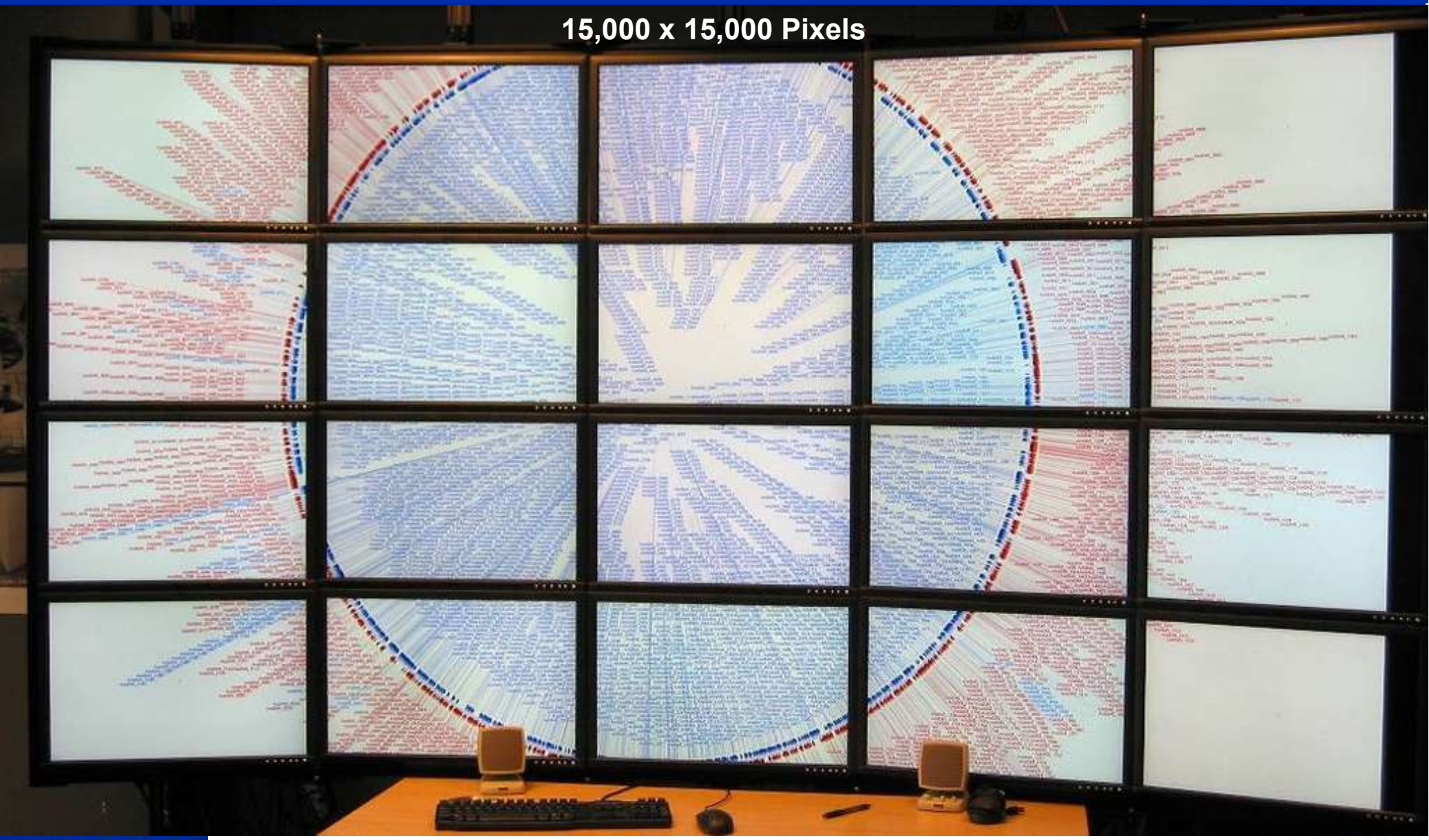
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Photos Courtesy Joe Keefe, Calit2

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INSTITUTE

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Use of OptIPortal to Interactively View Microbial Genome



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Source: Raj Singh, UCSD

Acidobacteria bacterium Ellin345 (NCBI)
Soil Bacterium 5.6 Mb

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Use of OptIPortal to Interactively View Microbial Genome



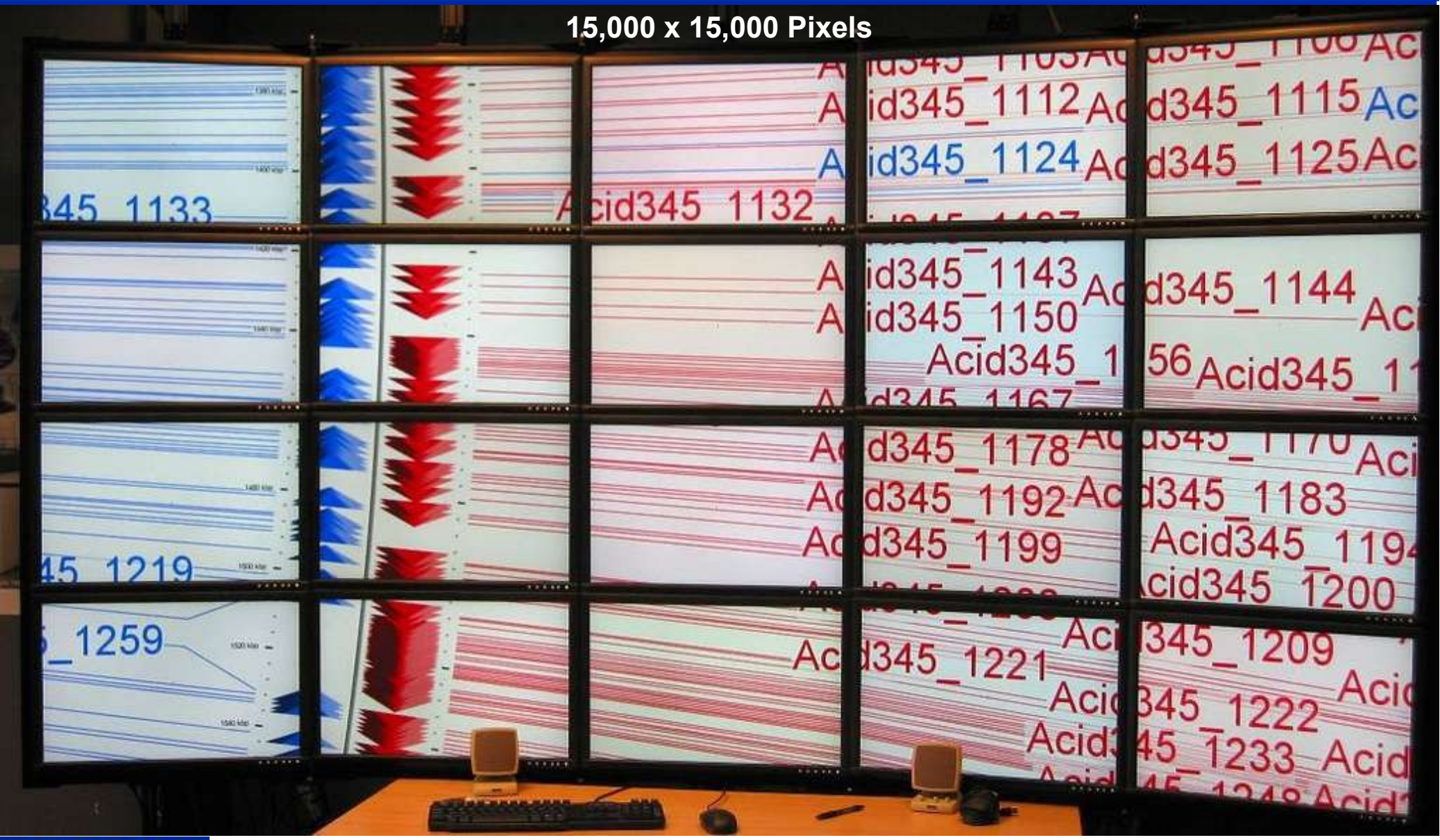
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Source: Raj Singh, UCSD

Acidobacteria bacterium Ellin345 (NCBI)
Soil Bacterium 5.6 Mb

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Use of OptIPortal to Interactively View Microbial Genome



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Source: Raj Singh, UCSD

Acidobacteria bacterium Ellin345 (NCBI)
Soil Bacterium 5.6 Mb

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OptIPortal–
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





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Powered by Rocks ROCKS

Source: Phil Papadopoulos SDSC, Calit2

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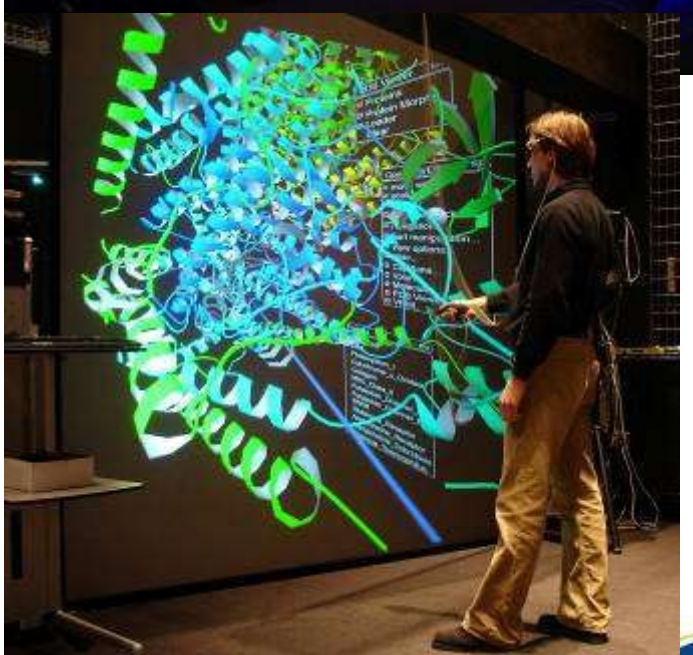
Calit2 is Now OptIPuter Connecting Remote Moore-Funded Microbial Researchers

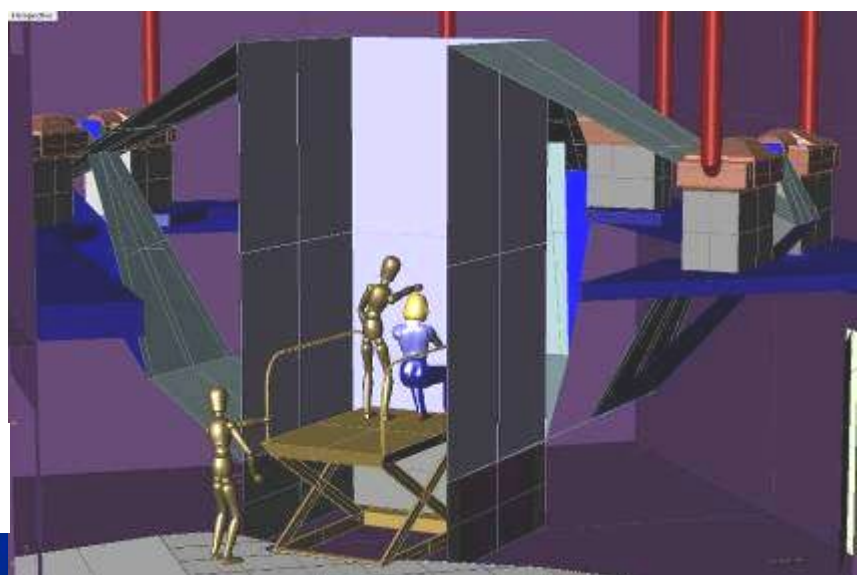


Partnering with UIC Electronic Visualization Lab to Create Next Generation Virtual Reality Lab

- Varrier Autostereo Virtual Reality
  - Head-Tracked No Need for Glasses
  - 65 High Resolution LCD Tiles
  - 45 Mpixels/eye of Visual Stereo
- 4KAVE—Digital Cinema Quality VR
  - Working Prototype 4 Mpixel Wall
  - Full Scale 4KAVE Being Designed
    - Two Sony 4K Projectors Per Wall
    - 32 Mpixel/eye of Stereo w/4-Walls







evl electronic visualization laboratory

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Dan Sandin, Greg Dawe, Tom Peterka, Tom DeFanti, Jason Leigh, Jinghua Ge, Javier Girado, Bob Kooima, Todd Margolis, Lance Long, Alan Verlo, Maxine Brown, Jurgen Schulze, Qian Liu, Ian Kaufman, Bryan Glogowski

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Calit2 is Globally Connecting with California's Major Trading Partners

- **International Commerce Drives 25% Of California's Economy**
- **Largest Export Market is Computers and Electronic Products**
- **Top Five Export Markets for California:**
  - Mexico
  - Japan
  - Canada
  - China
  - South Ko
- **India is a Critical Growth Market for California**
  - California is the Top State Exporting to India
  - Exports Between California and India Increased ~30% from 2004 and 2005
- **India and US Have an Action Plan to Double Bilateral Trade in 3 Years**

CICESE



Canada - California Strategic Innovation Partnership Summit



PACIFIC RIM APPLICATIONS AND GRID MIDDLEWARE ASSEMBLY
PRAGMA

U.S.-INDIA SUMMIT

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San Diego Interactive Imaging of High Resolution Brain Slices Generated at McGill University



There are 7407 Slices at 20 µm
Each Image has 8513 x 12,472 pixels

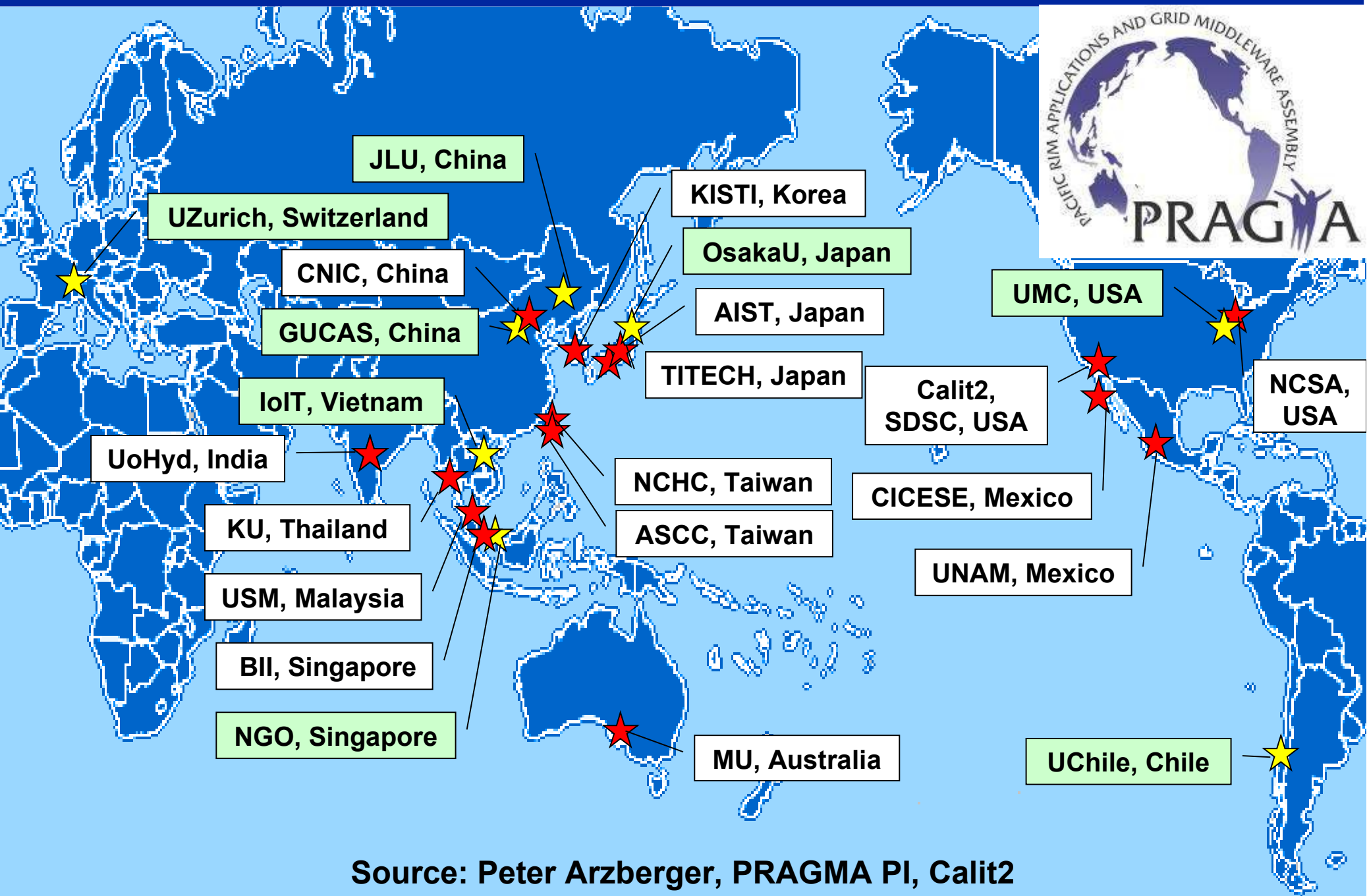
NCMIR
NATIONAL CENTER for MICROSCOPY and IMAGING RESEARCH
at San Diego, an NIH supported resource center

Source: Mark Ellisman, UCSD, Calit2

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International Grid Testbed
Pacific Rim Applications and Grid Middleware Assembly



Source: Peter Arzberger, PRAGMA PI, Calit2

Brain Imaging Collaboration -- UCSD & Osaka Univ. Using Real-Time Instrument Steering and HDTV

Most Powerful Electron Microscope in the World -- Osaka, Japan







HDTV

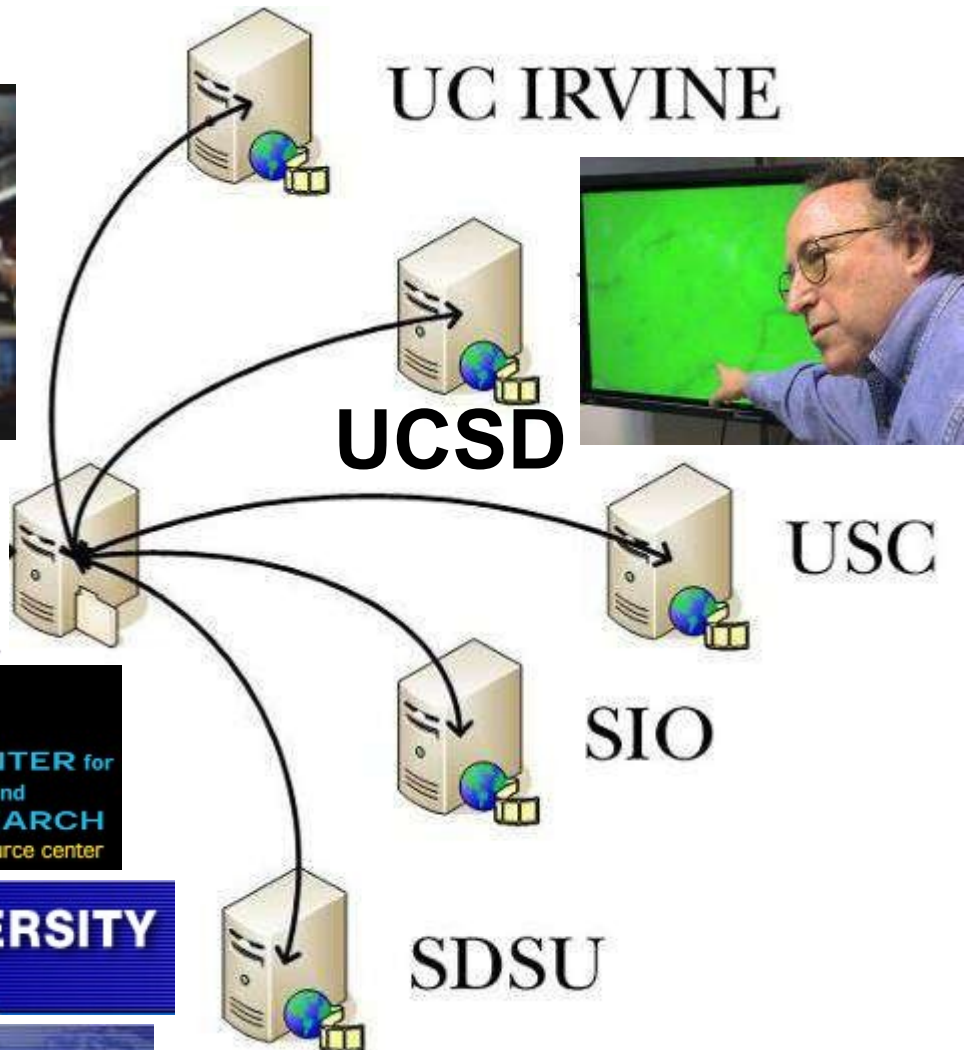
NBCR

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

OSAKA UNIVERSITY

KDDI GROUP KDDI Labs USA

Southern California OptIPuter



Source: Mark Ellisman, UCSD

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CalViz--
HD Streaming Internationally



Photo: Courtesy of Harry Ammons

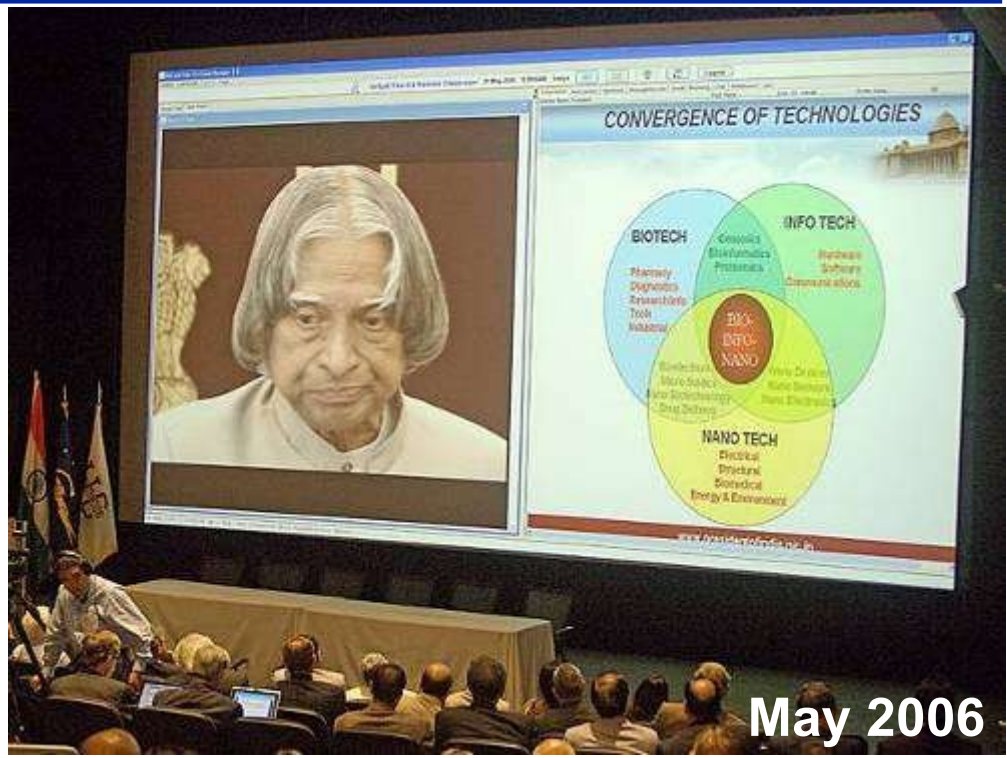
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Studio on 4th Floor of Calit2@UCSD Building
Two Talks to Australia in March 2006

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Qualcomm, Jacobs School of Engineering, & Calit2 International Initiative with India

- **Telecom Sector Trend:**
  - California Companies and Foreign Governments are Establishing R&D Centers Overseas
- **Plan For Engagement:**
  - Develop a Global R&D Alliance Involving Government, Academic Institutions and Industry
- **Status**
  - Raised Resources
  - Developed MOU with Ministry of Science and Technology, Government Of India
  - US-India Summit Meeting
  - Built Up an India-Interest Team
  - Exploring New Programs



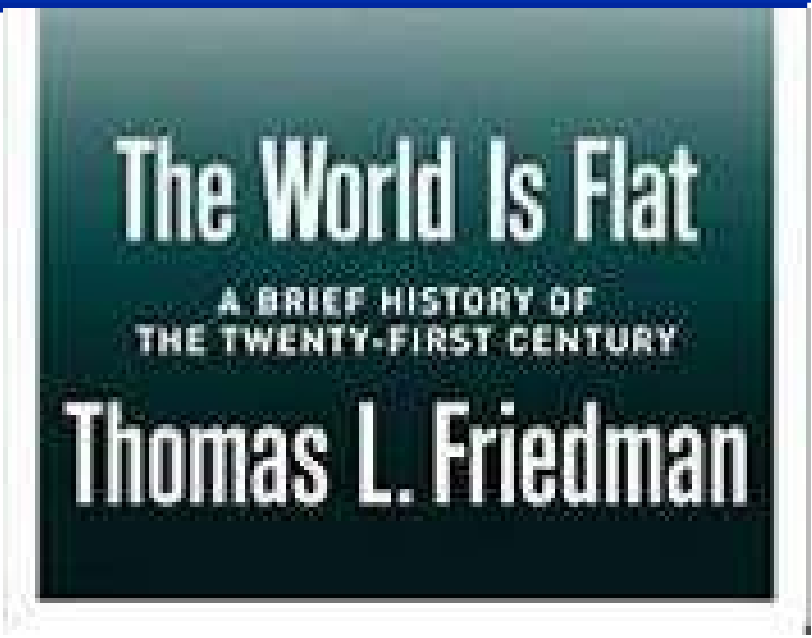
- PURA--Societal Grid for a Billion People
- Convergence of Info- Nano - Bio
- Interactive Knowledge System
- Ubiquitous Unlimited Bandwidth

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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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