The Emergence of the Digitally Connected World

Invited Talk
California Clean Energy Roundtable
Calit2
University of California, San Diego
April 10, 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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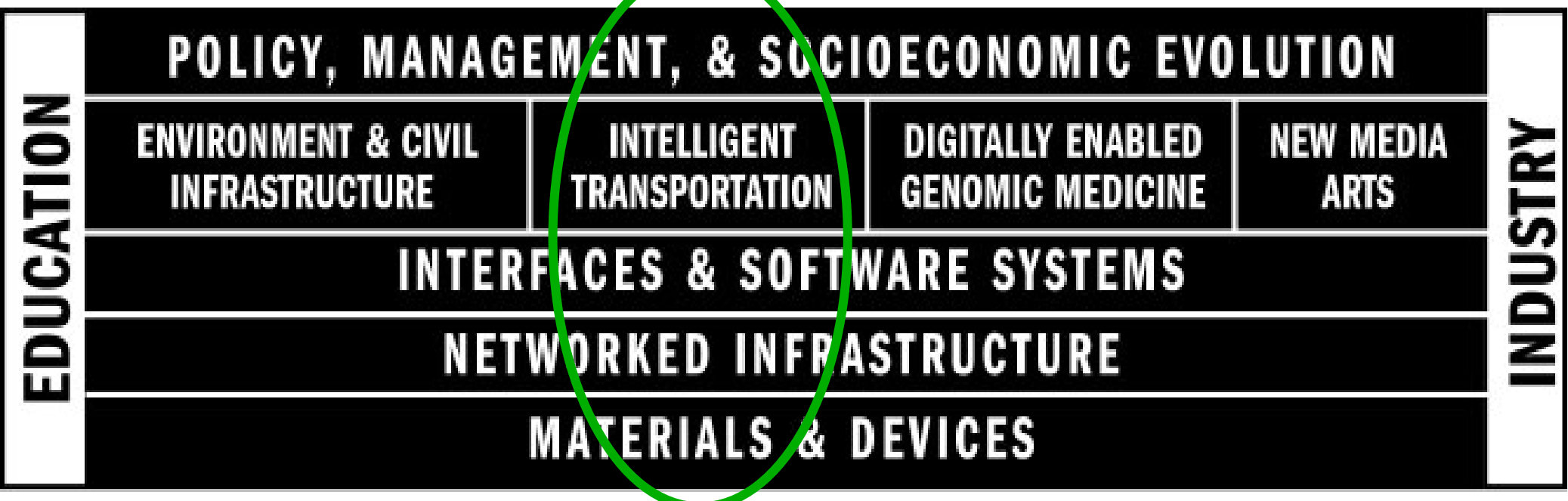
it²

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--A Systems Approach to the Future of the Internet and its Transformation of Our Society

Calit2 Has Assembled a Complex Social Network
of Over 350 UC San Diego & UC Irvine Faculty
From Two Dozen Departments
Working in Multidisciplinary Teams
With Staff, Students, Industry, and the Community



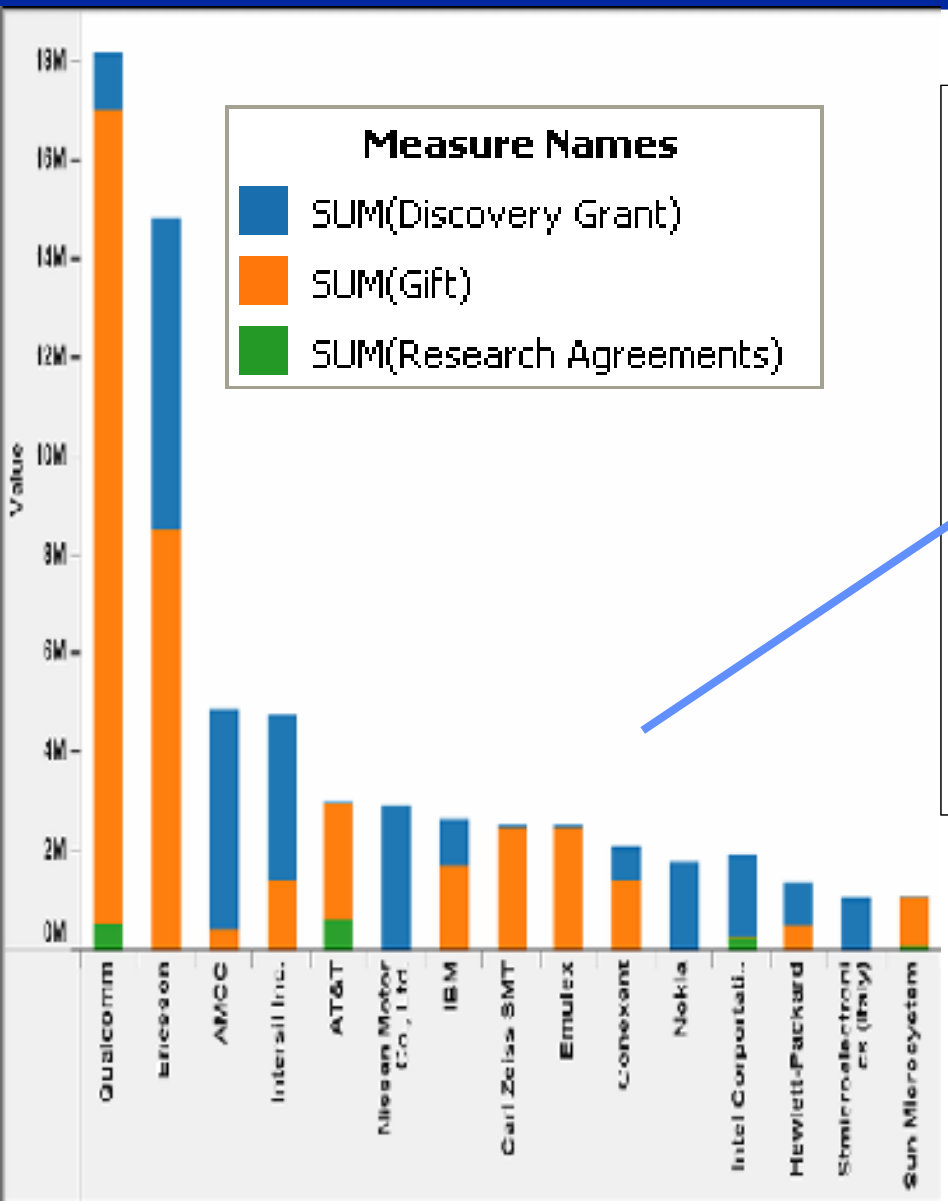
Integrating Technology Consumers and Producers
Into "Living Laboratories"

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www.calit2.net

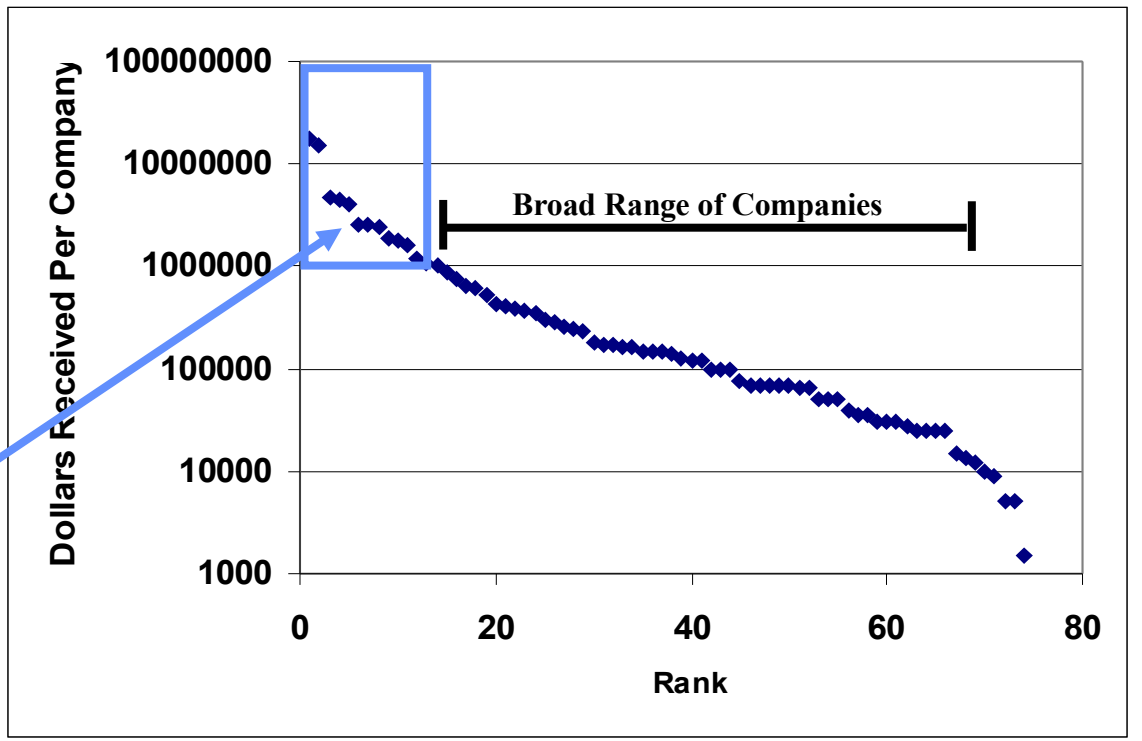
it²

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



Industrial Partners > $1 Million

More Than 80 Have Provided Funds or In-kind



Over $80 Million From Industry So Far

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Calit2 Industrial Partners
Team with Academic Research and Education

- Funding Joint Research Projects
- Endowing Chaired Professorships
- Sending Staff to Live at Calit2
- Supporting Graduate/Undergraduate Fellows
- Providing Equipment to Calit2 Projects
- Joining on Federal Grants
- Granting Access to Industry Facilities
- Using Calit2 Facilities
- Commercialization of Faculty/Staff/Student Research
- Co-Sponsoring Workshops/Conferences
- Hosting Seminars or Lectures

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Calit2 Industry Partners: Driving Public-Private Innovation Throughout The U.S.



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http://ri.calit2.net/industry/

Jerry Sheehan, Calit2 Lead

Calit2 Works Closely with San Diego and Orange County Industrial Groups

SDSIC NETWORK San Diego Software Industry Council

CommNexus™ San Diego A Network of Communications Companies

OCTANe Fueling Innovation Development in Orange County

BIOCOM Accelerating Life Science Success

CleanTECH San Diego

SAN DIEGO DEFCOMM A Defense and Space Technology Consortium

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Calit2 Has Sought to Increase the Entrepreneurial Culture on Both Campuses

VON LIEBIG CENTER

IGNITING TECHNOLOGY

Knobbe Martens Olson & Bear LLP

Intellectual Property Law

Calit2

Accelerating Innovation Advisory services and seed funding to advance commercialization of Jacobs School discoveries



Presenters (from left) Perry, Johnsson, Scacchi and Tomlinson are joined by Calit2's Korean partners via high speed video teleconferencing.

VentureForth @ UCSD

5th Annual Entrepreneurship Conference

Nov 17, 2007 @ CALIT2 UCSD

Entrepreneurs Forum

OCTANe@UCI

TECH COAST ANGELS

TechTIPS UCSD

So You Want to Form a Startup?

Guest Speaker: Alvin Viray
senior licensing officer, UCI Office of Technology Alliances

OCVG

UCSD STARTUP BOOTCAMP:

A 'How'd They Do That?' on Forming Companies

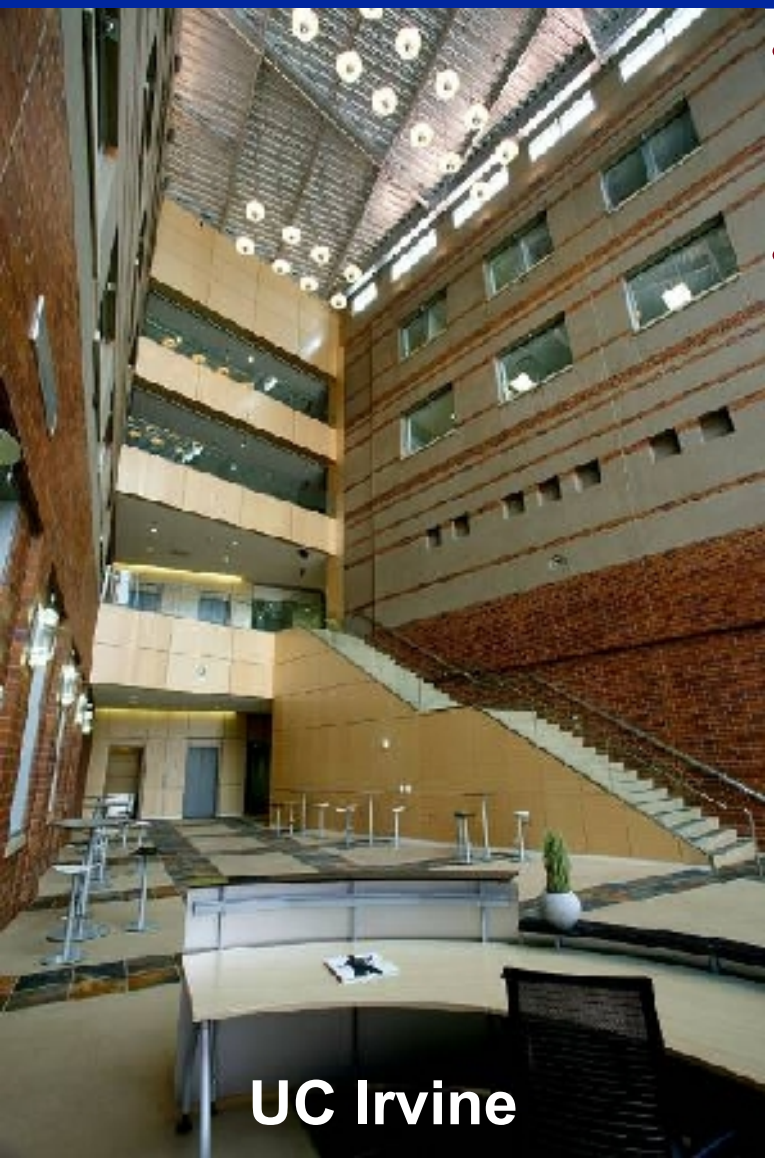
Tuesday, May 9th, 2006
9 am - 5 pm
UCSD Atkinson Auditorium

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CONNECT®
Accelerating Innovation in San Diego

it²

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

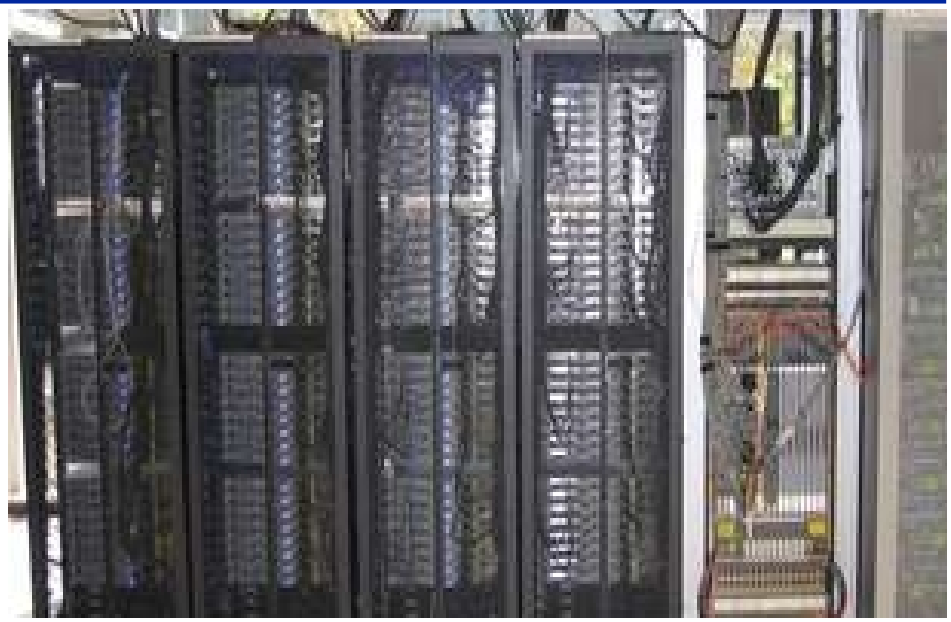
Partnered with Over 100 Companies
Faculty Have Won Over 300 Grants

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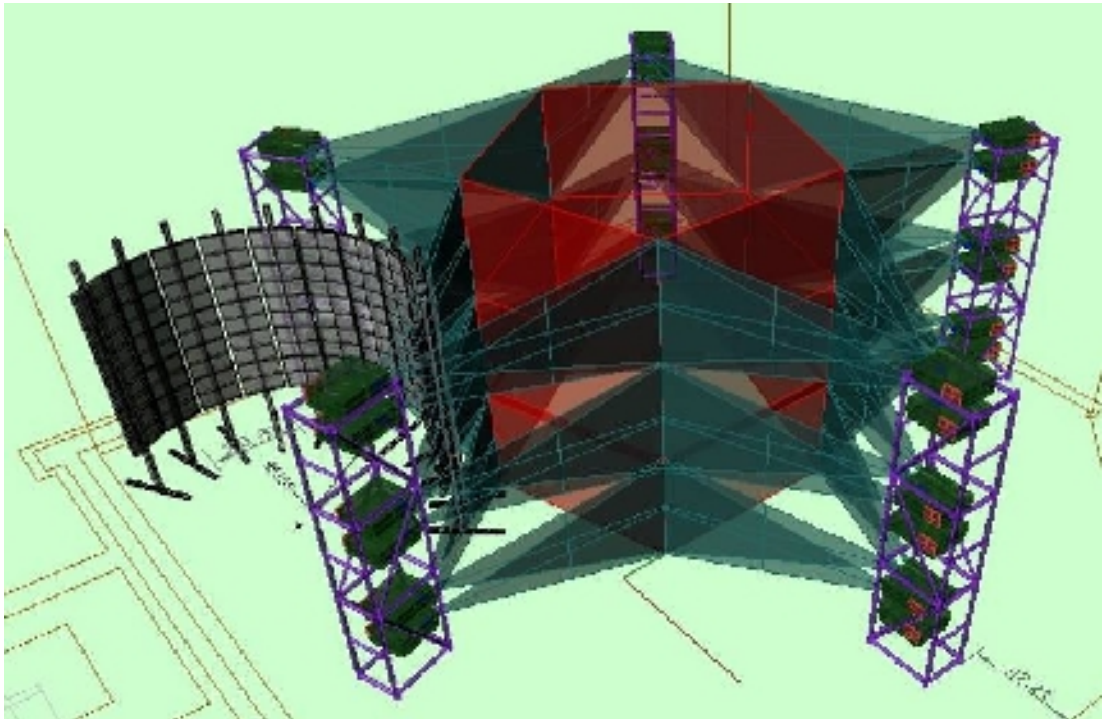
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Calit2's Ultra-Resolution Visualization and Data Server Solutions to Problems of Enormous Complexity





2nd Floor
220Mpixel Wall



Marine Microbial Metagenomics Global DataServer

Virtual Reality CAVE and Varrier

Today's Tours Stops

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Here is the Plan

- **First Split Audience into Two Groups**
  - Group 1--Last Name Starts with A-L Leave for Tours Now
  - Group 2--Last Name Starts with M-Z Stay in Your Seat Now
- **8:35-9:15am**
  - I Will Give Calit2 Overview to Second Group
  - First Group will be Split into Three Subgroups
  - Each Subgroup Has a "Shepard" Who Will Lead You Thru the 3 Stops
  - Each Stop is 10 Minutes, with 2.5 Minutes to Switch to New Demo
  - Please Stay on Time!
- **9:15-9:55am**
  - First Group Arrives Back to Auditorium to Hear Calit2 Overview
  - Second Group Leaves Auditorium, is Split into 3 Groups, and Has Tours
- **10am**
  - All be Back in Auditorium for Tony Haymet Talk

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Calit2 Supports a Variety of Research Programs in Clean Energy

- **Intelligent Transportation**
- **Telepresence**
- **Microbial Bioengineering**
- **Green Cyberinfrastructure**

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Making Cars Cleaner Requires Software Engineering-- Calit2 Established the Automotive Software Workshop

AUTOMOTIVE SOFTWARE WORKSHOP SAN DIEGO 2004



90 % of all Auto Innovations are Now Software-Driven

- Over 10 Million Lines of Code in Your Car!
- Sponsors: Calit2, NSF, EU, DFG
- 50:50 Participation Industry/Academia
- Next Instance Planned For 2009
- Industry Participants Include:

Ford
TOYOTA InfoTechnology Center, U.S.A., Inc.
DAIMLER
VALIDAS validated quality
BMW
TOYOTA
GM
BOSCH
AbsInt Angewandte Informatik
vector
UCSD UCIrvine
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Source: Ingolf Krueger, Calit2

Launch of ZEVnet Fleet of Wireless Cars-- First Calit2 Testbed for Intelligent Transportation

TOY



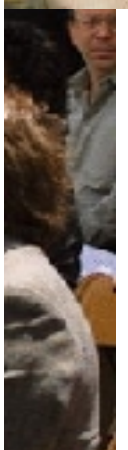
April 18,
Irvine,
www.zevi

Toyota Delivers Plug-in Prius to UC Irvine and UC Berkeley as Part of Clean Mobility Partnership









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Natio
Universit

TORRANCE, Calif., Nov. 9, 2007 -- Toyota Motor Sales, U.S.A.,

TUDIES

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Calit2 California
Peer-to -Peer Wireless Traffic Report

- Citizen to Citizen Accident Reports
- Real-Time Freeway Speeds
- "Leave Now" Paging Services

20,000+ Users
> 1000 Calls Per Day

San Diego
(866) 500 0977



LA & OC
(888) 9 CALIT2



Bay Area
(888) 4 CALIT2



http://traffic.calit2.net

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Source: Ganz Chockalingam, Calit2

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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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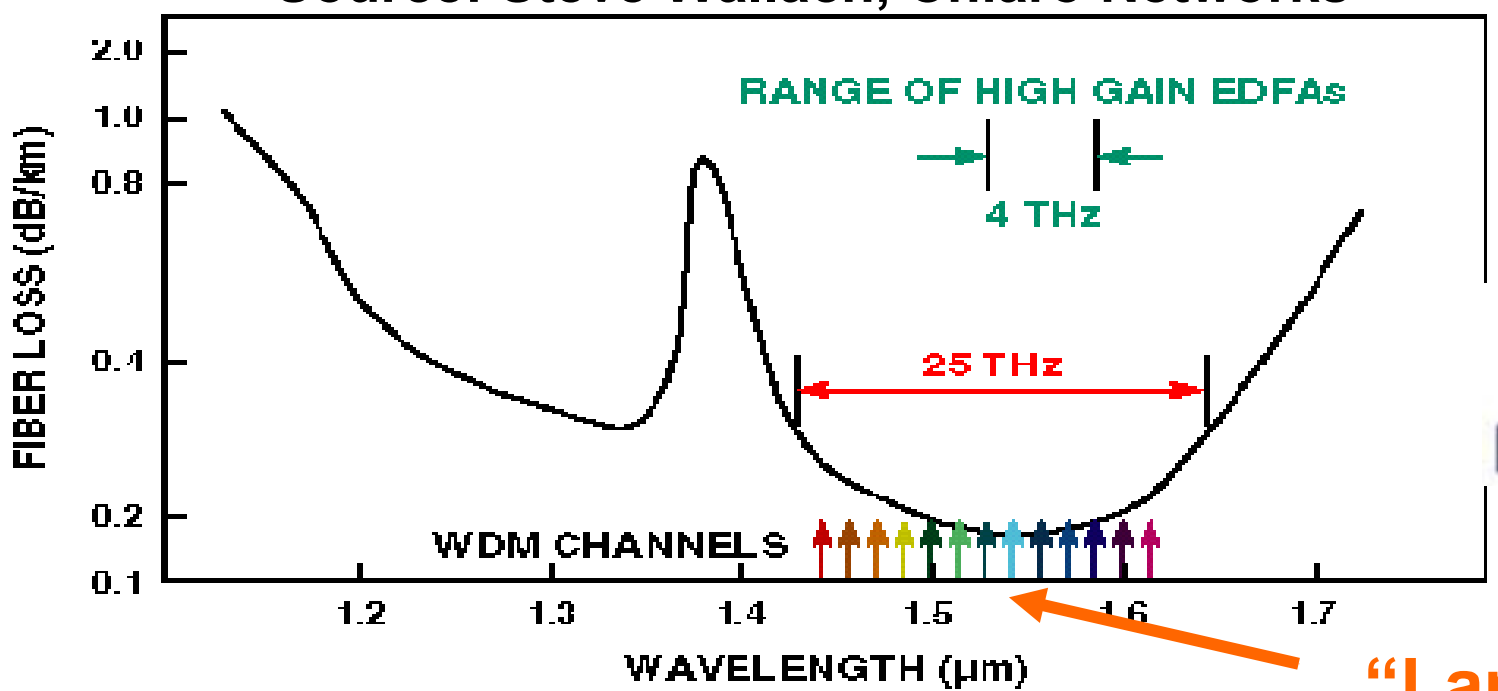
Dedicated Optical Channels Makes High Performance Cyberinfrastructure Possible

WAVELENGTH DIVISION MULTIPLEXING (WDM)

10 Gbps per User ~ 500x Shared Internet Throughput

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

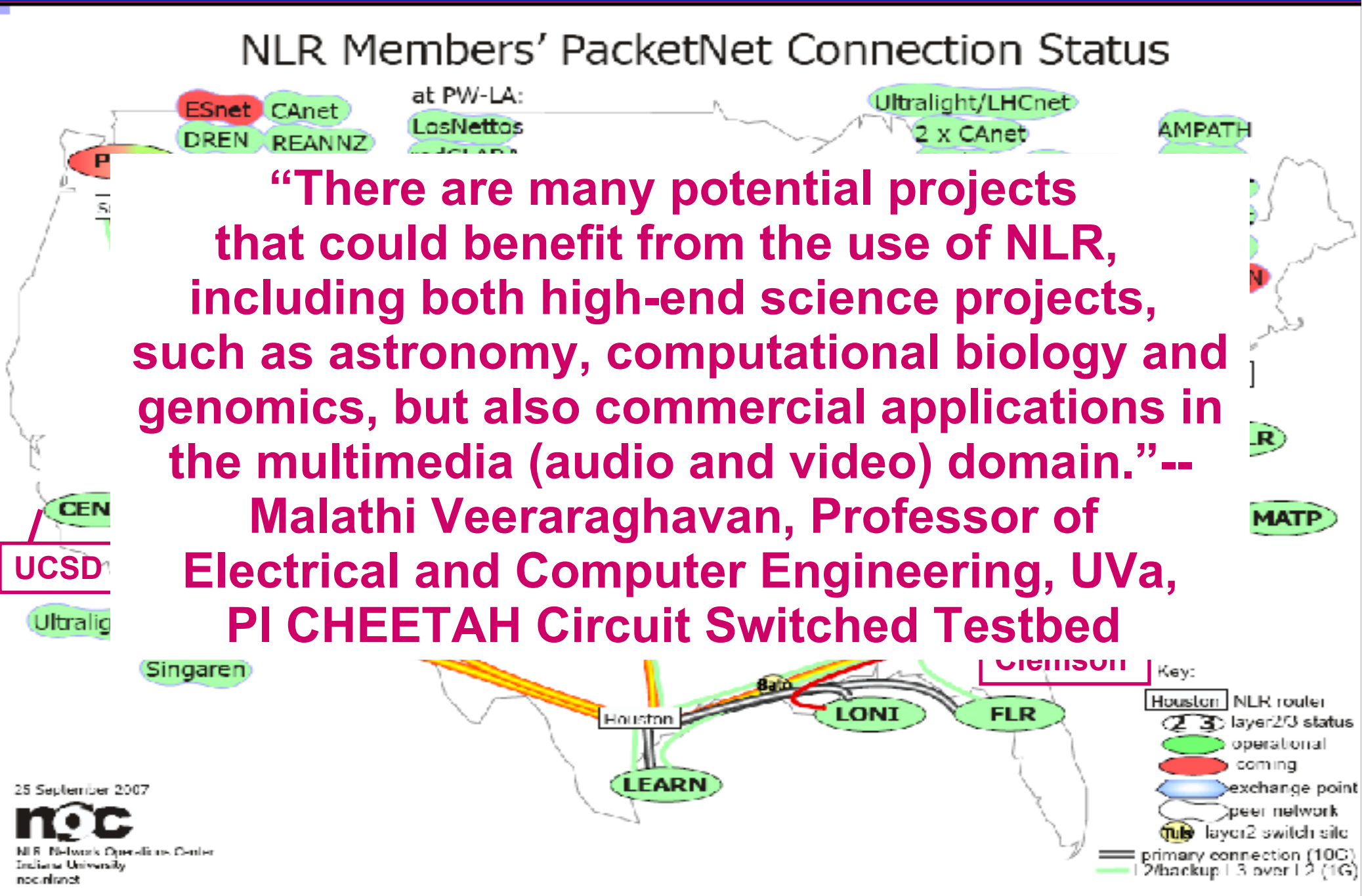
Source: Steve Wallach, Chiaro Networks



"Lambdas"

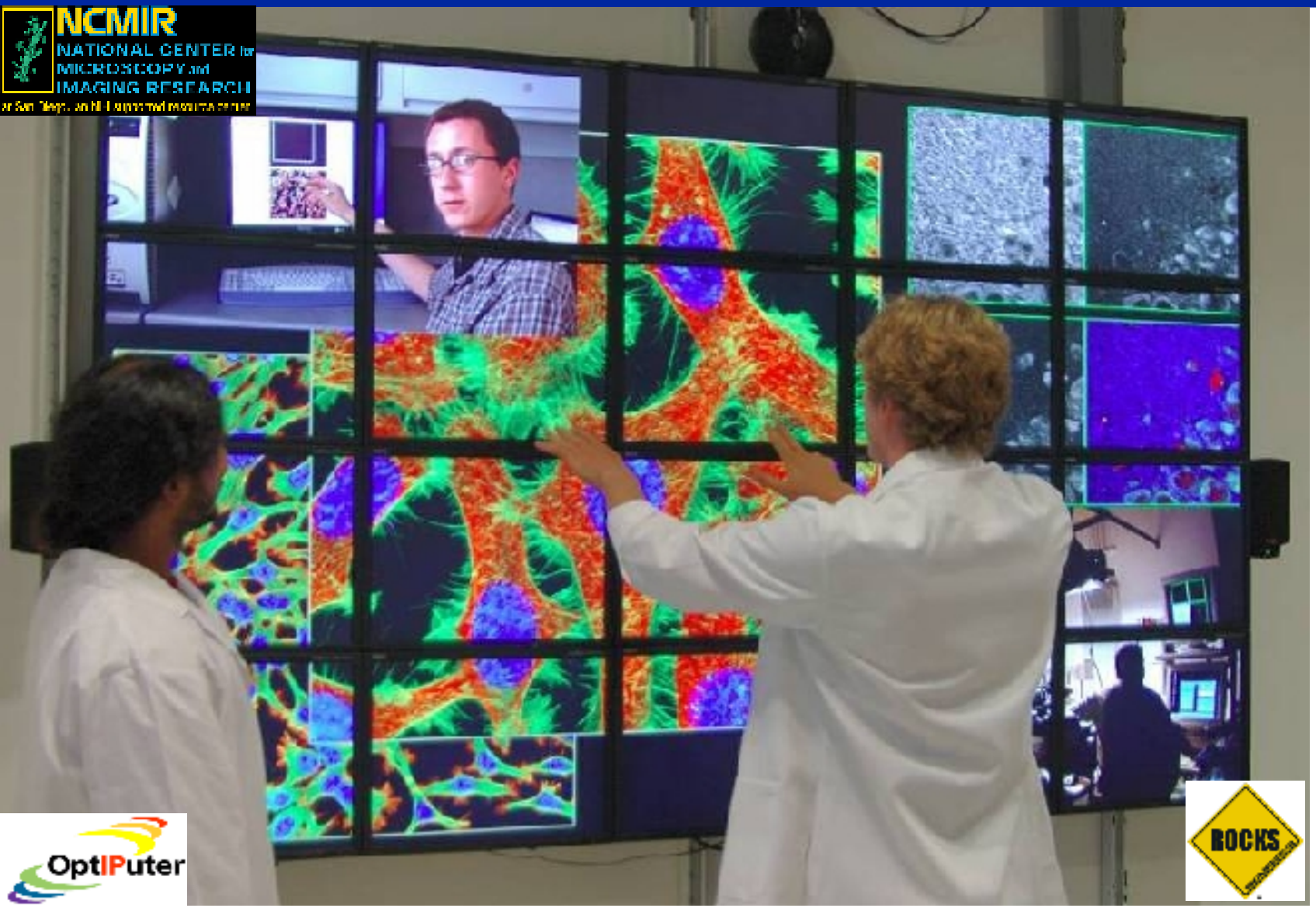
Parallel Lambdas are Driving Optical Networking The Way Parallel Processors Drove 1990s Computing

National LambdaRail
Provides Clear Channel 10Gpbs Service Across US



"There are many potential projects that could benefit from the use of NLR, including both high-end science projects, such as astronomy, computational biology and genomics, but also commercial applications in the multimedia (audio and video) domain."--
Malathi Veeraraghavan, Professor of Electrical and Computer Engineering, UVa, PI CHEETAH Circuit Switched Testbed

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



Scalable Adaptive Graphics Environment (SAGE)

Now in Sixth and Final Year

Picture Source: Mark Ellisman, David Lee, Jason Leigh

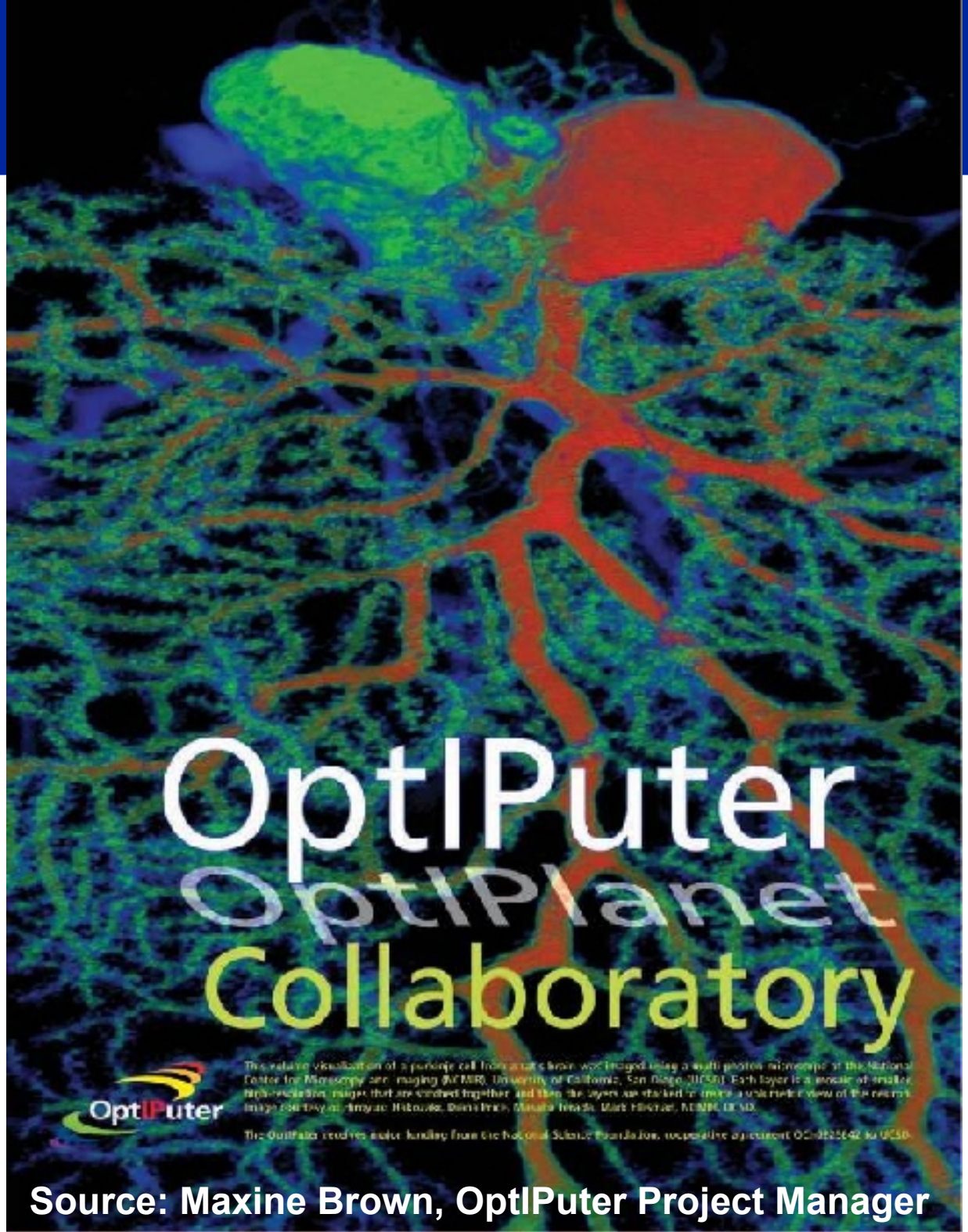
Calit2 (UCSD, UCI) and UIC Lead Campuses—Larry Smarr PI
Univ. Partners: SDSC, USC, SDSU, NW, TA&M, UvA, SARA, KISTI, AIST
Industry: IBM, Sun, Telcordia, Chiaro, Calient, Glimmerglass, Lucent

The Calit2 Large OptIPortals Tie Calit2 at UCSD and UCI Into an HD Collaboratory



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OptIPortals Used to Visually Study Very Large Collages from NASA Space Observatories



Source: Maxine Brown, OptIPuter Project Manager

Green Initiative:

Can Optical Fiber Replace Airline Travel for Continuing Collaborations ?

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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

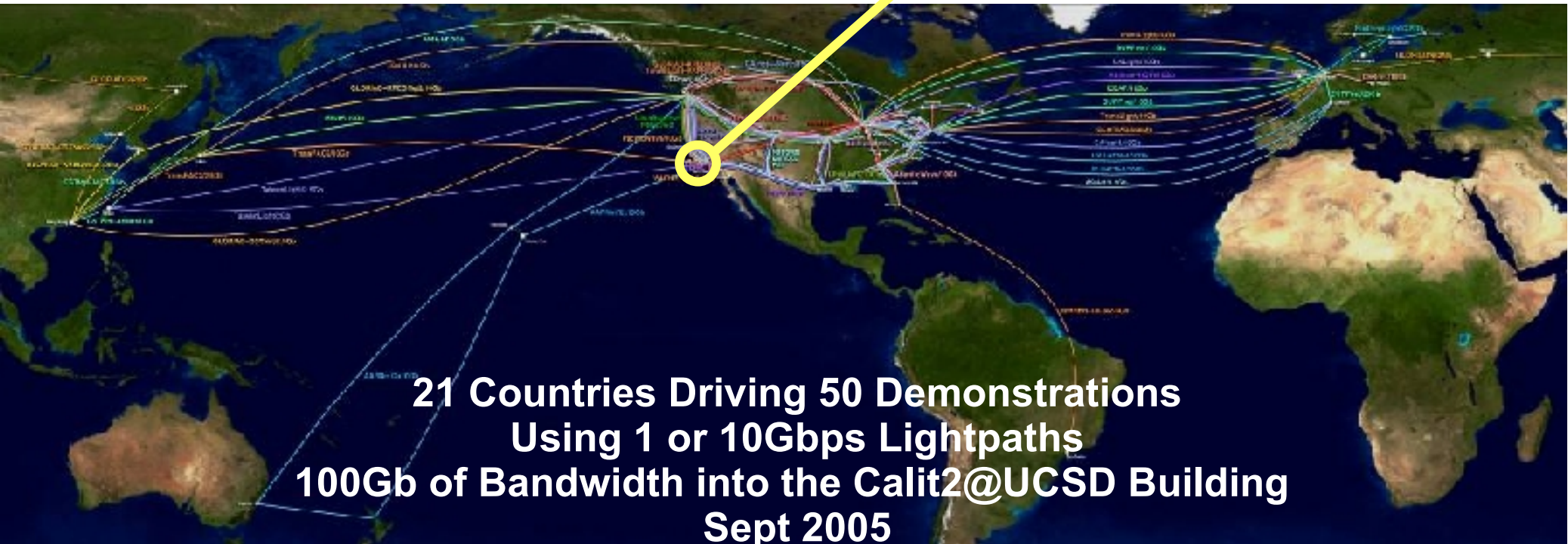
THE GLOBAL LAMBDA INTEGRATED FACILITY

www.igrid2005.org



the UC Discovery Grant

September 26-30, 2005
Calit2 @ University of California, San Diego
California Institute for Telecommunications and Information Technology

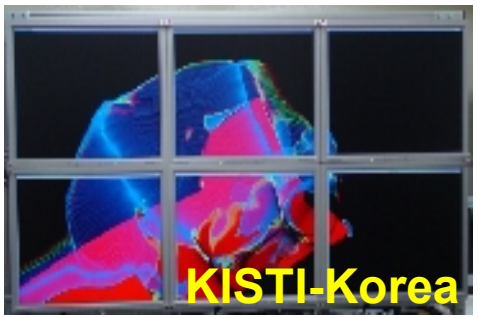


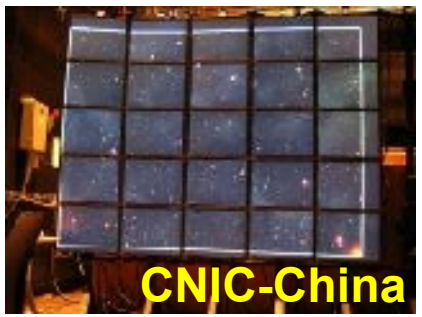
21 Countries Driving 50 Demonstrations
Using 1 or 10Gbps Lightpaths
100Gb of Bandwidth into the Calit2@UCSD Building
Sept 2005

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


NCMIR@UCSD

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Powered by Rocks ROCKS

evl electronic visualization laboratory

it2

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



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ROCKS

January 15, 2008

OptIPuter

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

calit2

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



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

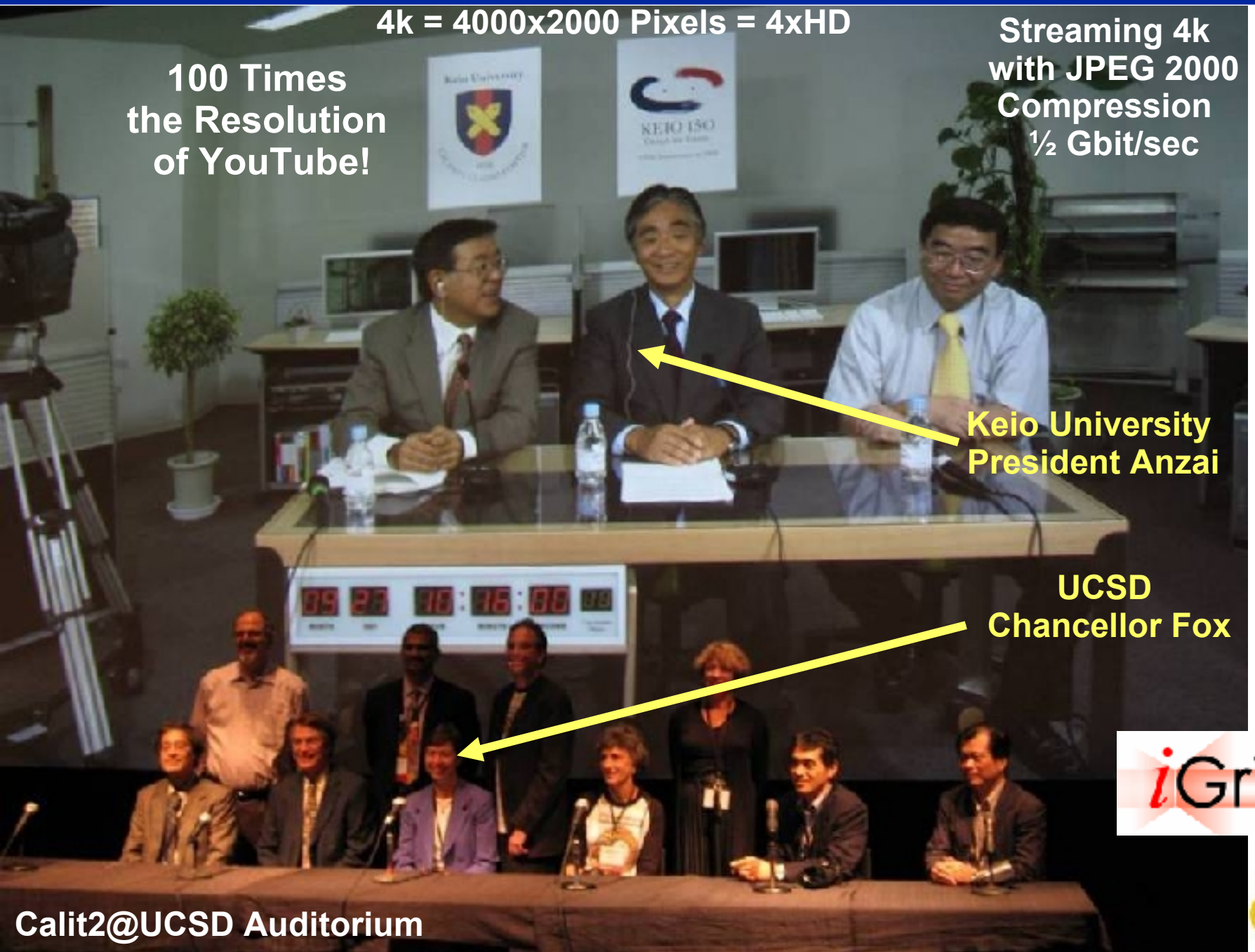


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Source John Delaney & Deborah Kelley, UWash

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iGrid Lambda Streaming Services: Telepresence Meeting Using Digital Cinema 4k Streams



CineGrid

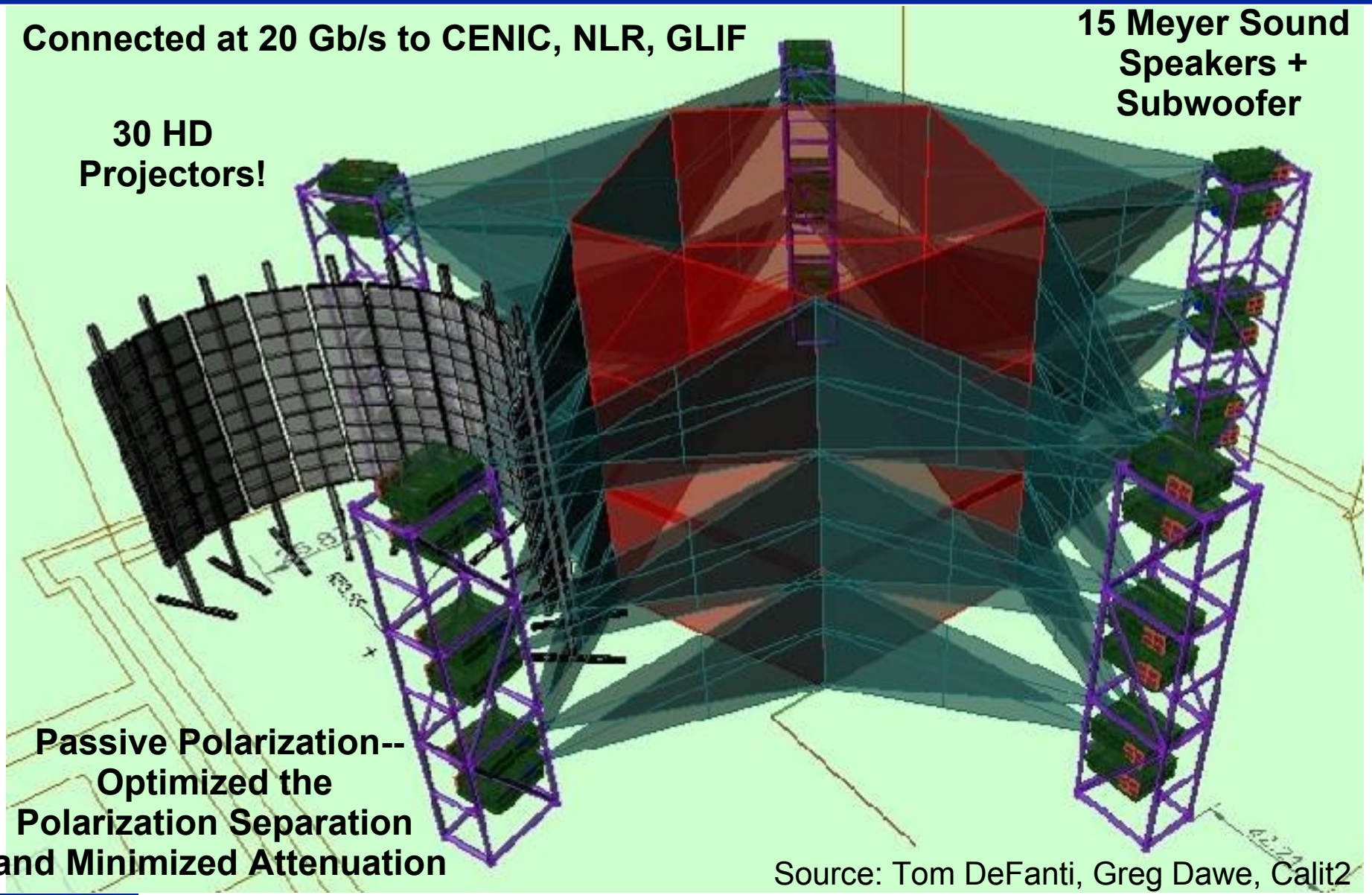
Lays Technical Basis for Global Digital Cinema

Sony
NTT
SGI

iGrid 2005

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3D OptIPortals: Calit2 StarCAVE and Varrier: Enables Exploration of Virtual Worlds



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Cluster with 30 Nvidia 5600 cards-60 GB Texture Memory

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

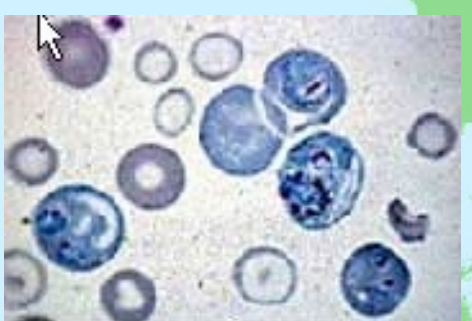
Plus 155 Marine Microbial Genomes



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

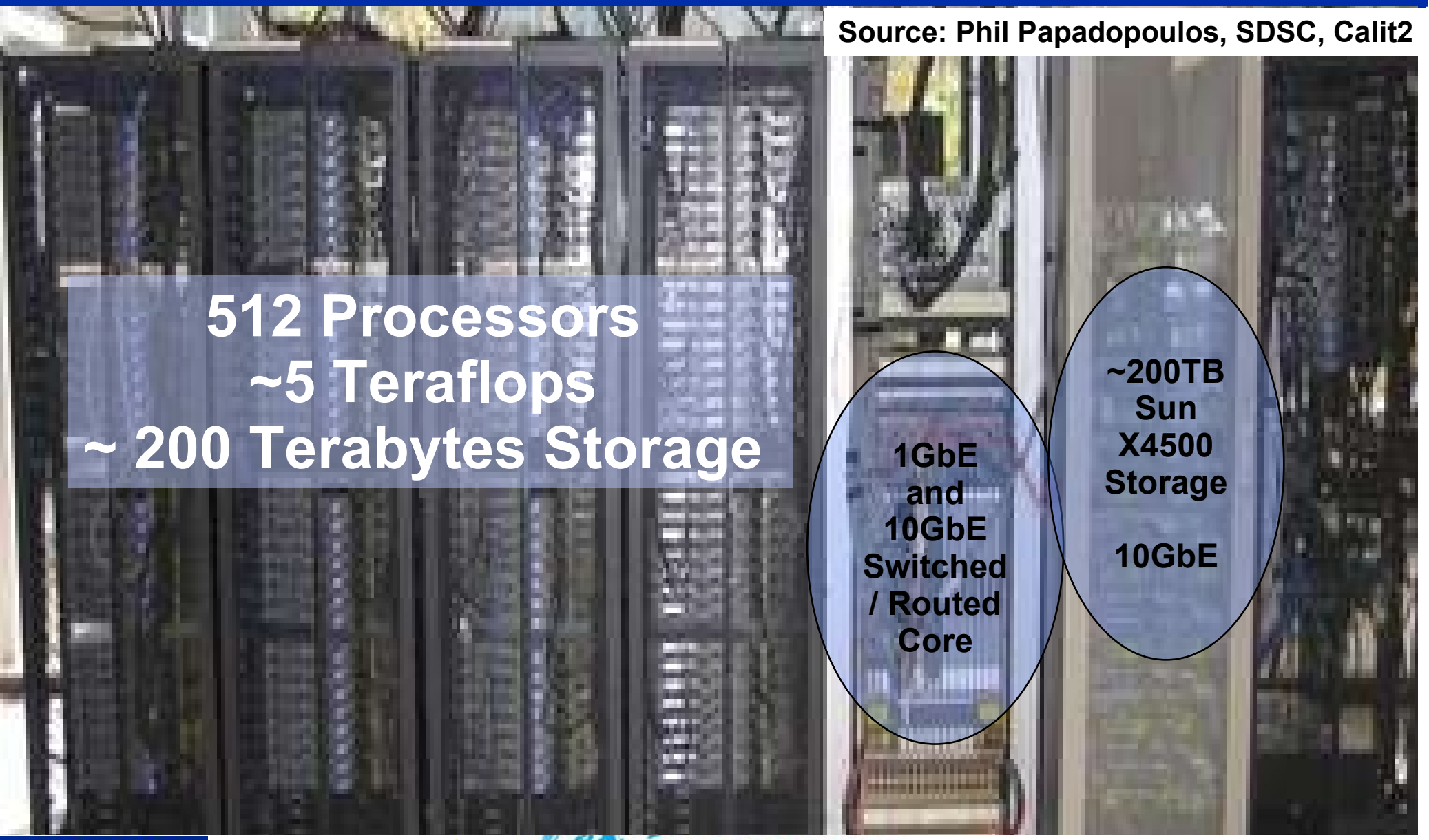
Gordon and Betty MOORE FOUNDATION

J. Craig Venter INSTITUTE

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Calit2 Microbial Metagenomics Cluster- Used by Over 2000 Scientists in 50 Countries

Source: Phil Papadopoulos, SDSC, Calit2



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

OptIPlanet Collaboratory Persistent Infrastructure Supporting Microbial Research



iHDTV: 1500 Mbits/sec Calit2 to UW Research Channel Over NLR

OptIPuter

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

ROCKS







UW's Research Channel Michael Wellings

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Green Cyberinfrastructure
Exponential Time Bomb for Global Warming

- **Gartner Estimates the Manufacture of IT Equipment, its Use and Disposal Accounts for 2% of Global CO_2 Emissions**
  - Equivalent To The Aviation Industry!
  - www.globalactionplan.org.uk/upload/resource/Full-report.pdfEnergy
- **Usage Per Compute Server Rack Is Growning Rapidly**
  - From ~ 2 KW/Rack In 2000 To ~30 KW/Rack (= 6 Houses) In 2010
  - Cooling and Power Issues are a Major Factor in System Design
- **Calit2 is Developing a Full-scale Virtualized Device, the Greenlight Instrument, to Measure, Monitor, and Make Publicly Available, Real-Time Energy Sensors on Distributed IT Systems**
  - Allowing Researchers Anywhere to Study the Energy Cost of At-Scale Computing, Storage, and Transmission of Information

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



Sun Black Box Container



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 Temperature and Humidity, Incoming and Exiting Water Temperature and Power Utilization in Each of the 8 Racks**

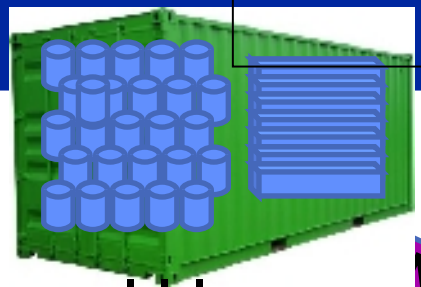
UCSD Structural Engineering Dept. Conducted Tests May 2007

UCSD Jacobs School of Engineering

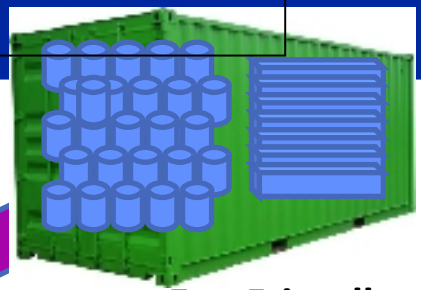
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Planned UCSD Energy Instrumented Cyberinfrastructure



Active Data Replication



Eco-Friendly
Storage and Compute

V x 10 Gbit

N x 10 Gbit



10 Gigabit
L2/L3 Switch

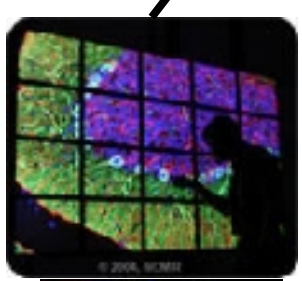
"Network in a box"
- > 200 Connections
- DWDM or Gray Optics

Wide-Area 10G
- Cenic/HPR
- NLR Cavewave
- Cinegrid
- …

On-Demand Physical Connections



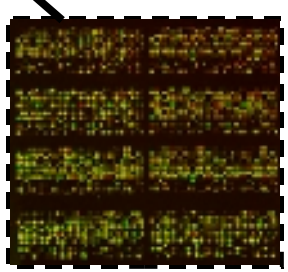
camera



NCMIR



NBCR



Microarray

Your Lab Here

OptIPuter

UCSD
UCIrvine

ROCKS

Source:Phil Papadopoulos, SDSC/Calit2

it²