"Cyberinfrastructure for Environmental Observations"

Invited Talk to Symposium on
Science and Technology in GEOSS: The Role of Universities
Hosted by Calit2@UCSD
for the SIO Center for Earth Observations and Applications
La Jolla, CA
November 21, 2005

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

Vision for Creating an Integrated Interactive Information System for Earth Exploration

Vantage Points

Far-Space

Near-Space

Airborne

Terrestrial

Permanent

Deployable

Capabilities

L1/L2/HEO/GEO
Sentinel satellites for continuous monitoring

LEO/MEO
Active & passive sensors for trends & process studies

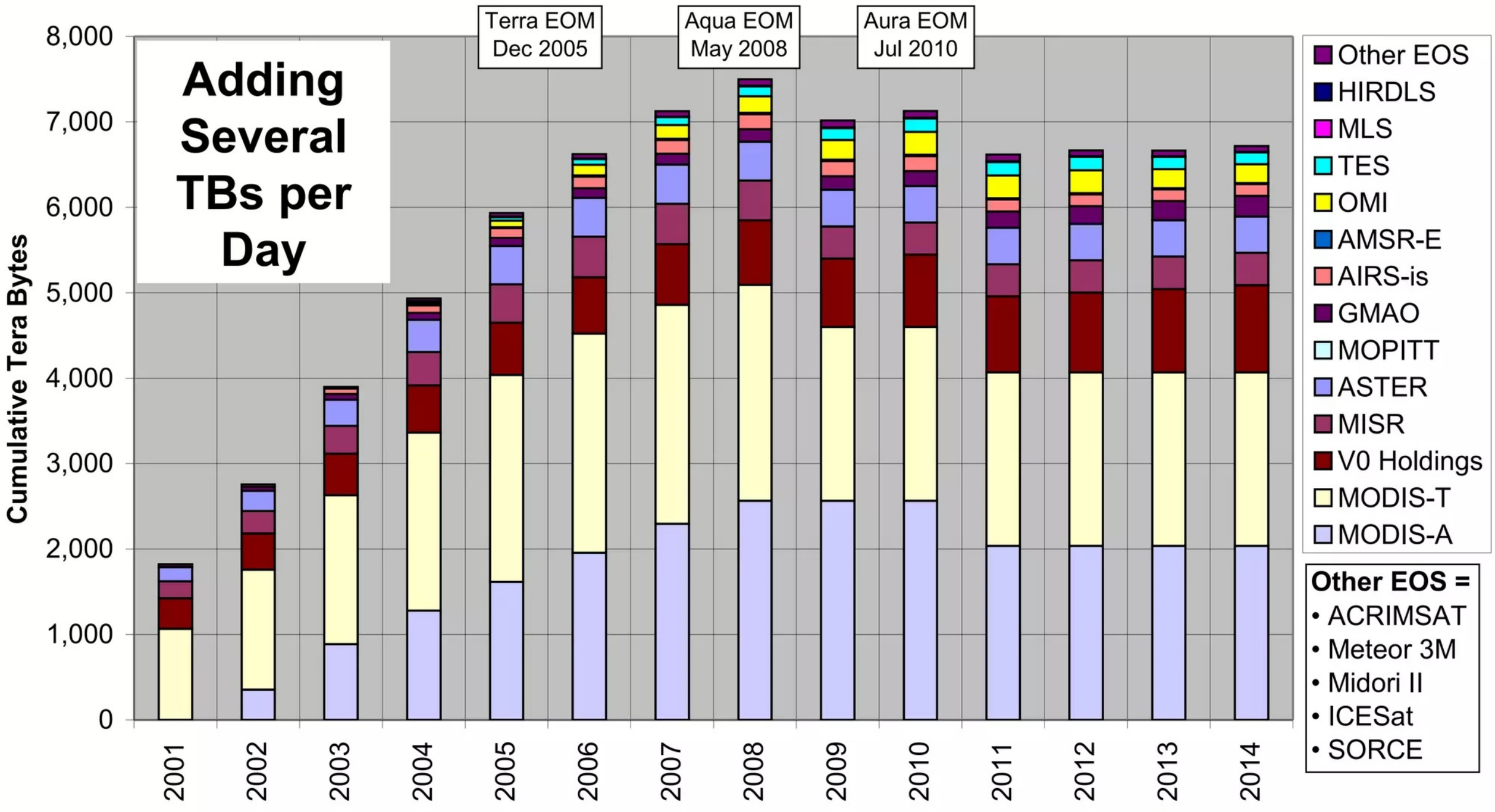
Suborbital
In situ measurement in research campaigns & validation of new remote sensors

Surface-Based Networks
Ocean buoys, air samplers, strain detectors, ground validation sites



Information Systems
Data management, data assimilation, modeling & synthesis

Major Obstacle: Trying to Do Global Earth Sciences On a Shared Internet Designed for Email and FTP



file name: archive holdings_122204.xls
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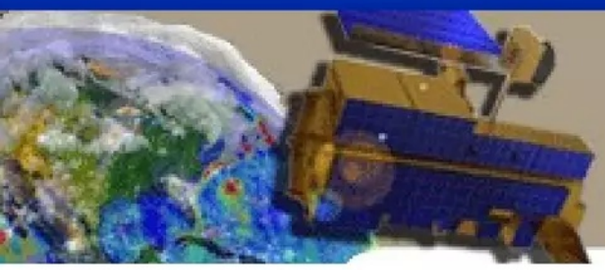
NOTE: Data remains in the archive pending transition to LTA

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Source: Glenn Iona, EOSDIS Element Evolution Technical Working Group January 6-7, 2005

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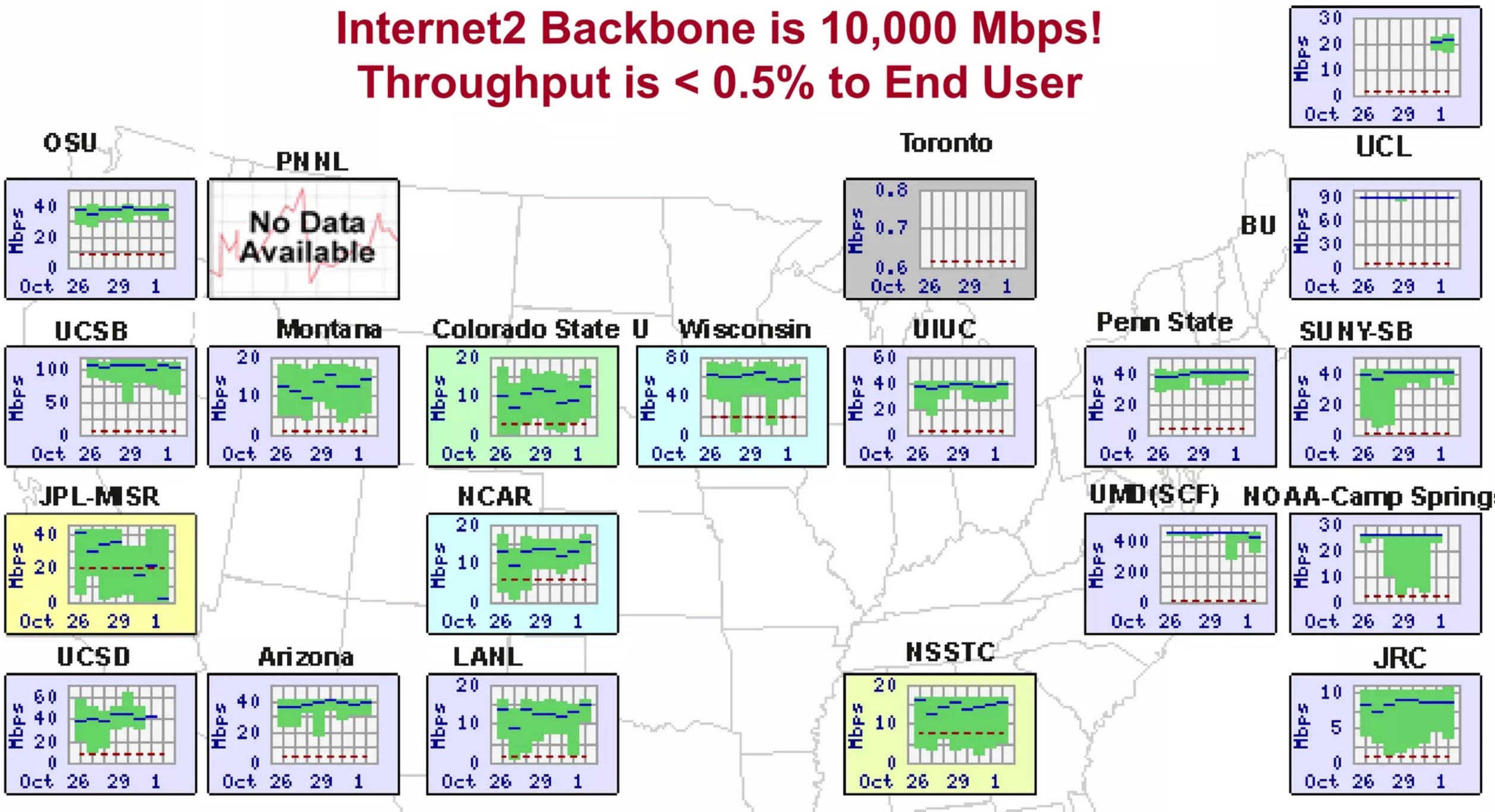
Challenge: Average Throughput of NASA Data Products to End User is < 50 Mbps



ENSIGHT Active Testing TERRA Destinations

Tested October 2005

Internet2 Backbone is 10,000 Mbps!
Throughput is < 0.5% to End User



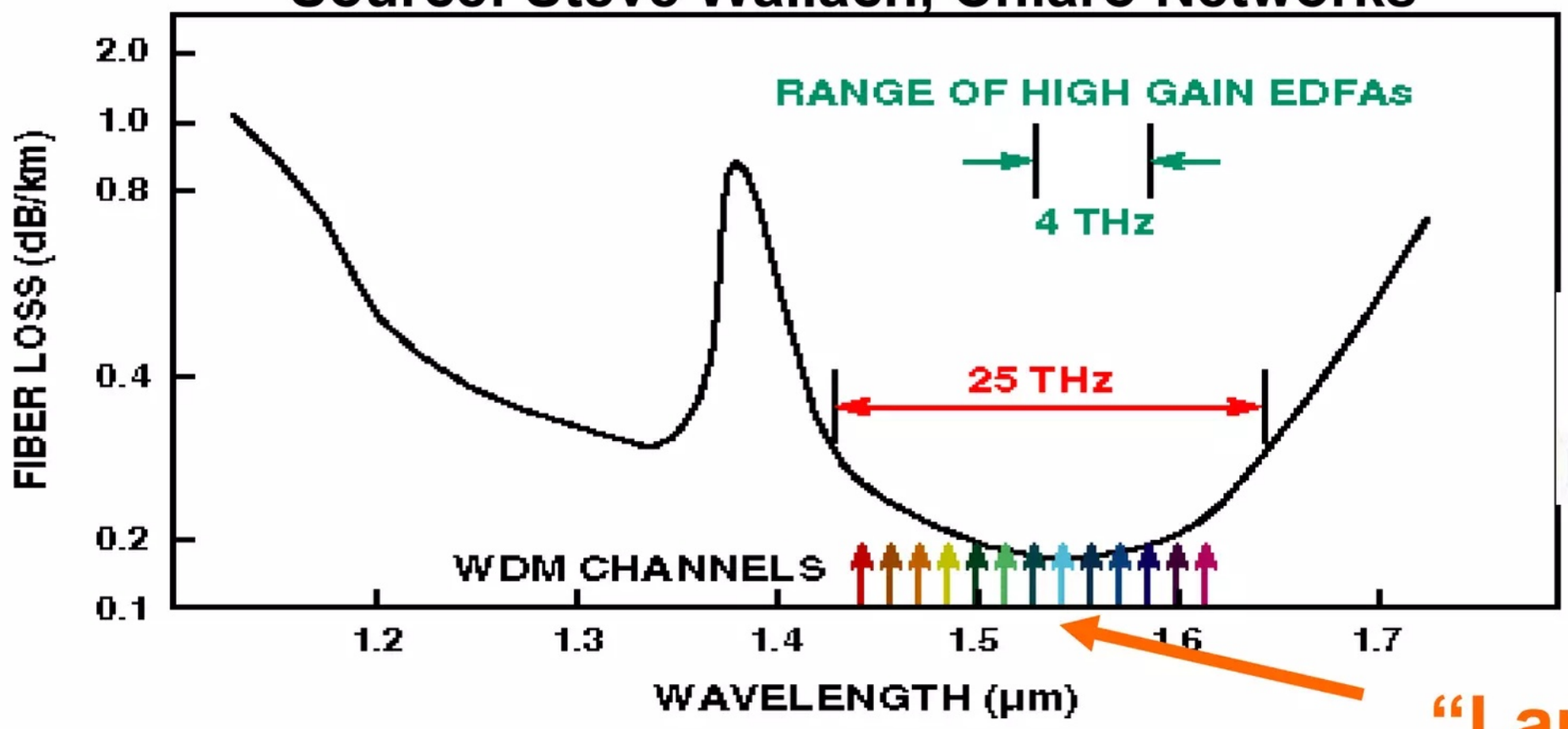
Dedicated Optical Channels Makes High Performance Cyberinfrastructure Possible

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



"Lambdas"

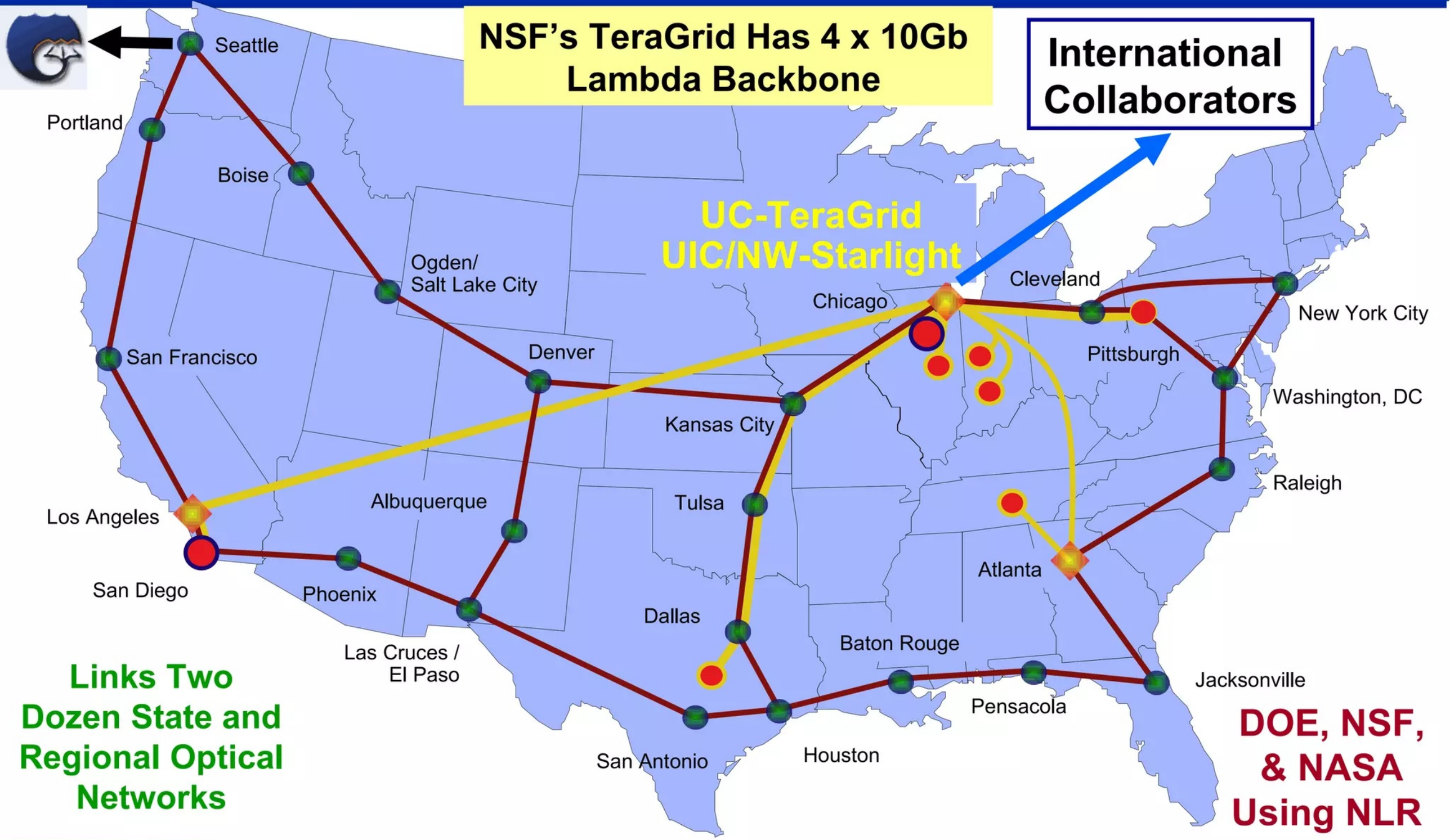
CHIARO

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

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



Links Two Dozen State and Regional Optical Networks

DOE, NSF, & NASA Using NLR

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

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Global Connections
Between University Research Centers at 10Gbps

Maxine Brown, Tom DeFanti, Co-Chairs

iGrid 2005

THE GLOBAL LAMBDA INTEGRATED FACILITY

www.igrid2005.org



September 26-30, 2005

Calit2 @ University of California, San Diego

California Institute for Telecommunications and Information Technology

the UC Discovery Grant



21 Countries Driving 50 Demonstrations
1 or 10Gbps to Calit2@UCSD Building
Sept 2005--
A Number of Projects are SensorNets

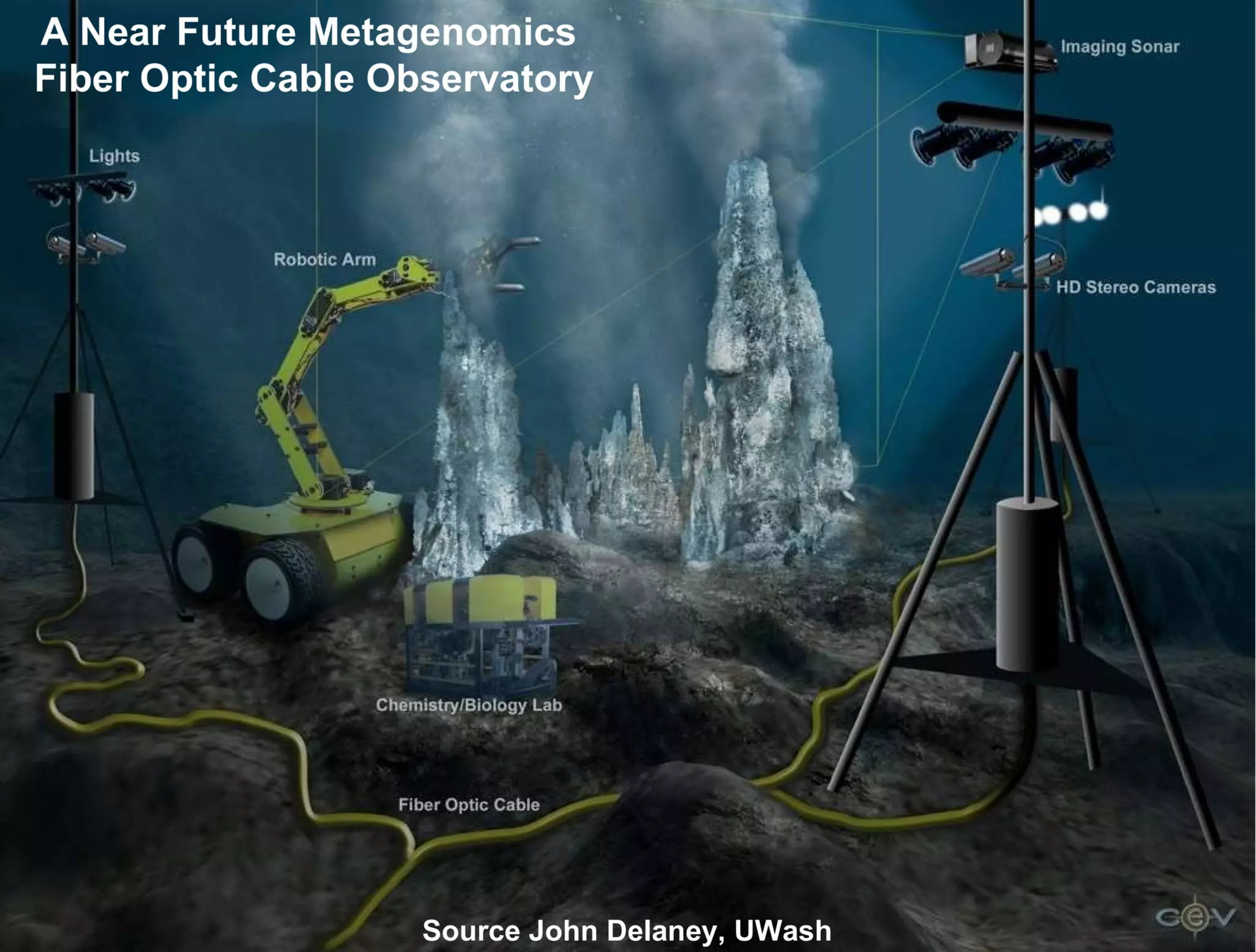
Prototyping Cabled Ocean Observatories Enabling High Definition Video Exploration of Deep Sea Vents



iGrid 2005

Source John Delaney & Deborah Kelley, UWash

A Near Future Metagenomics Fiber Optic Cable Observatory



Source John Delaney, UWash

Calit2 is Partnering with the new SIO Center for Earth Observations and Applications

- Viewing and Analyzing Earth Satellite Data Sets
- Earth Topography
- Project Atmospheric Brown Clouds
- Climate Modeling
- Ocean Observatories
- Coastal Zone Data Assimilation
- Marine Microbial Ecology Metagenomics
- Earth Sciences Collaboratory

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ROADnet and HiSeasNet are Prototypes of the Future of *In Situ* Earth Observing Systems

BRINGING THE INFORMATION SUPERHIGHWAY TO THE DIRT ROAD AND THE HIGH SEAS

http://roadnet.ucsd.edu

Real-time Observatories, Applications, and Data management Network **ROADNet**



Office of Naval Research

NSF

SDSU

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IGPP

SDSC
SAN DIEGO SUPERCOMPUTER CENTER









HiSeasNet

The Real-time Observatories, Applications and Data management Network is an interdisciplinary collaboration funded by the National Science Foundation and the Office of Naval Research. Participating institutions include Scripps Institution of Oceanography and the San Diego Supercomputer Center at the University of California, San Diego.

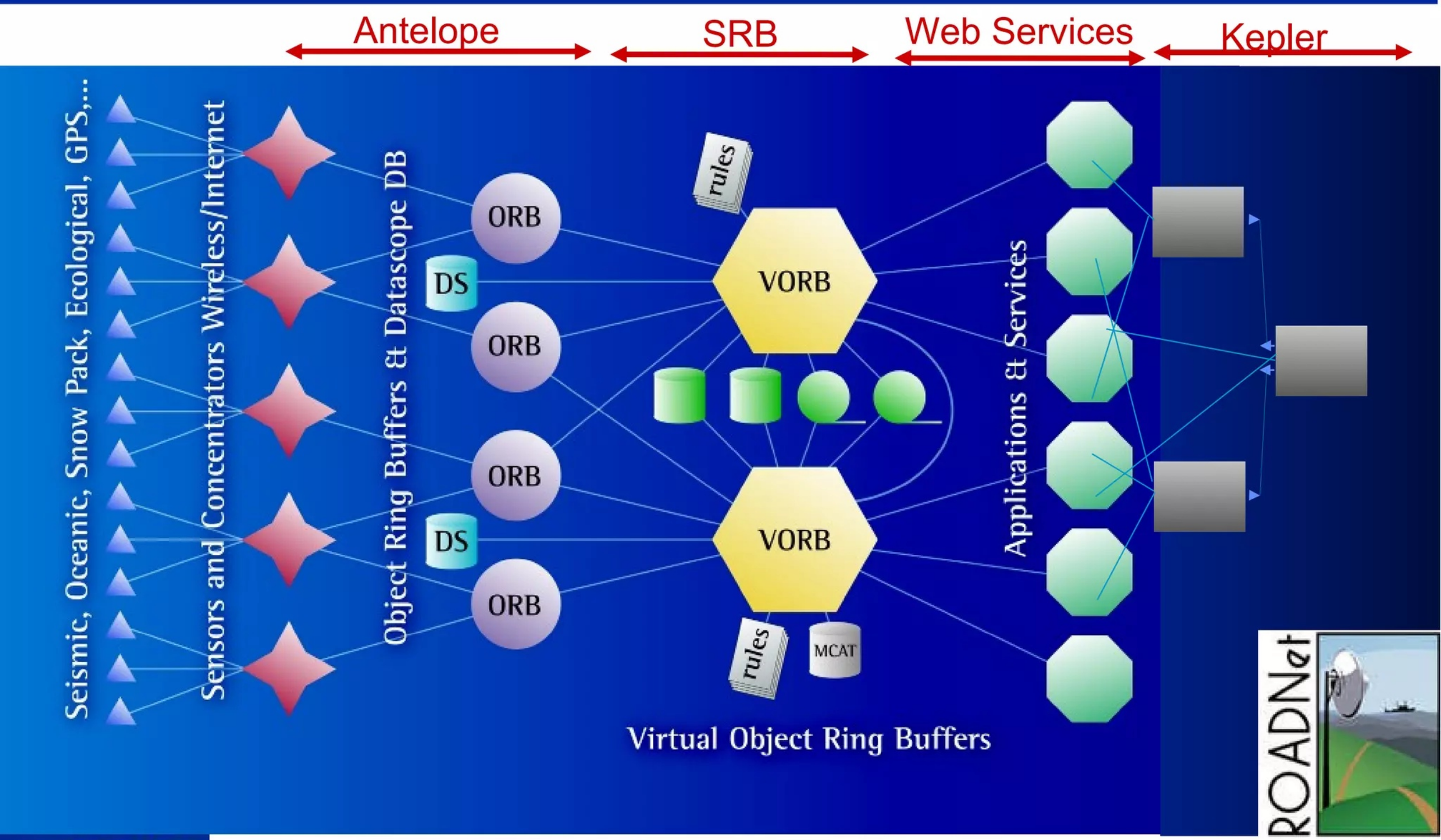
jonathan berger, tom orrett, frank vernon, scripps institution of oceanography, university of california san diego

ROADNet

PROVIDING COMMUNICATIONS AND NETWORKING FOR THE ORION FLEET OF MOORED OCEAN OBSERVATORIES

ROADNet Architecture:

SensorNets, Storage Research Broker, Web Services, Work Flow



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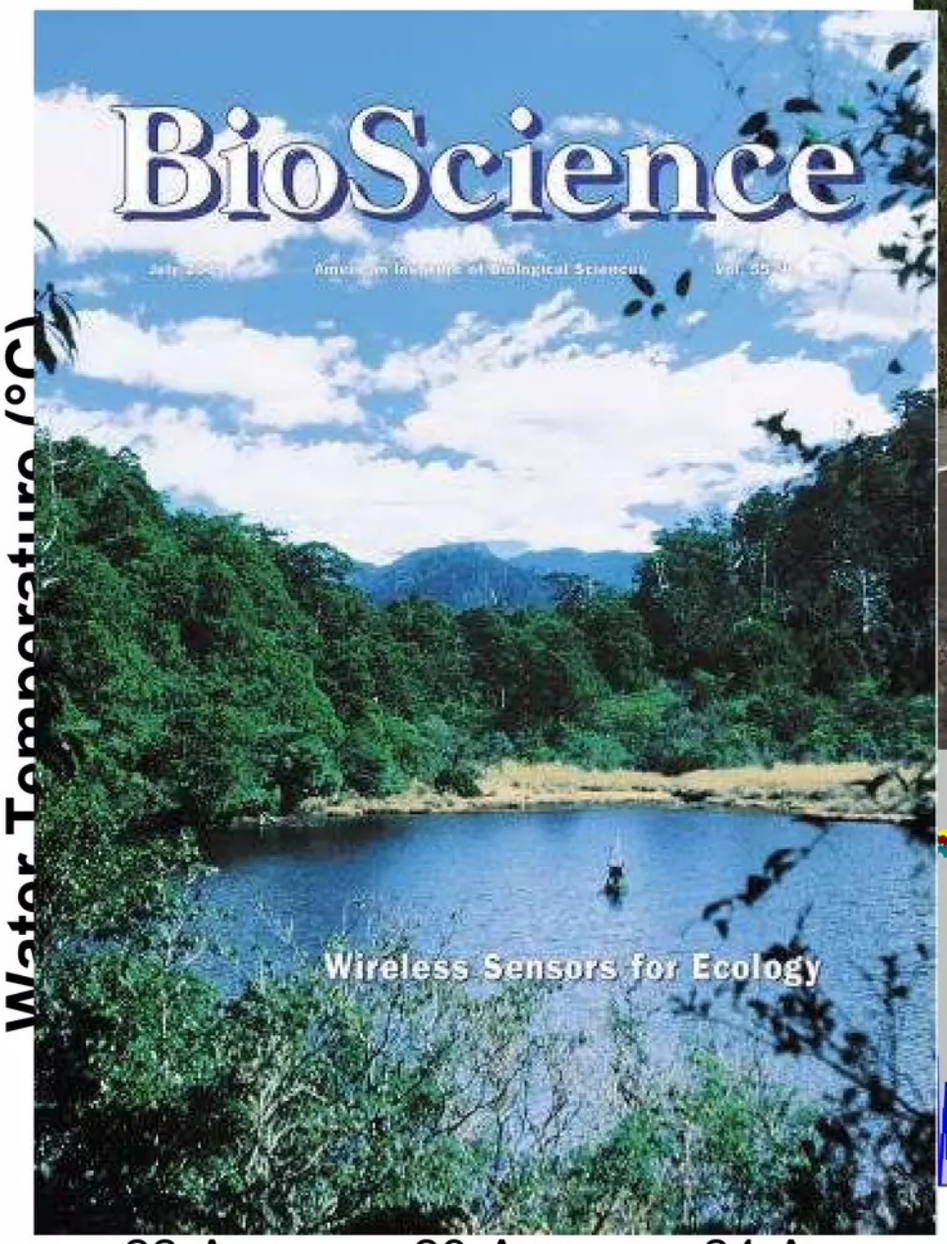
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Frank Vernon, SIO; Tony Fountain, Ilkay Altintas, SDSC

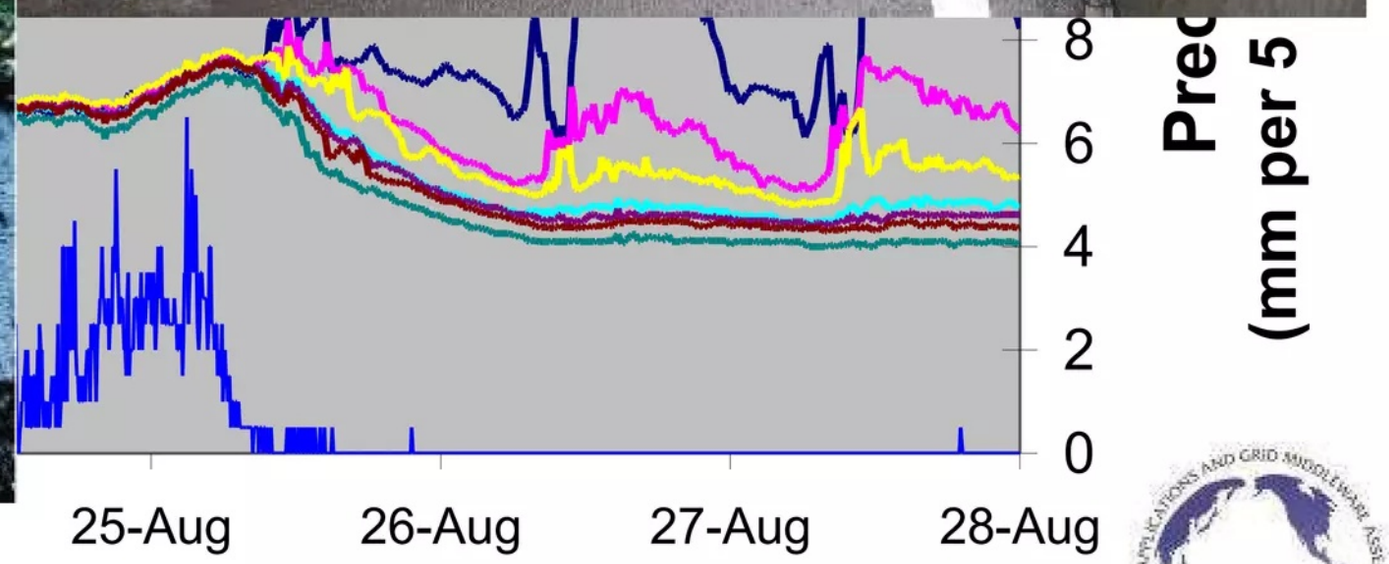
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Remote Observation of Episodic Events in Water-Based Ecological Systems

Used by NSF Director Feb 2005







Part of a growing global lake observatory network - http://lakemetabolism.org

Source: Tim Kratz

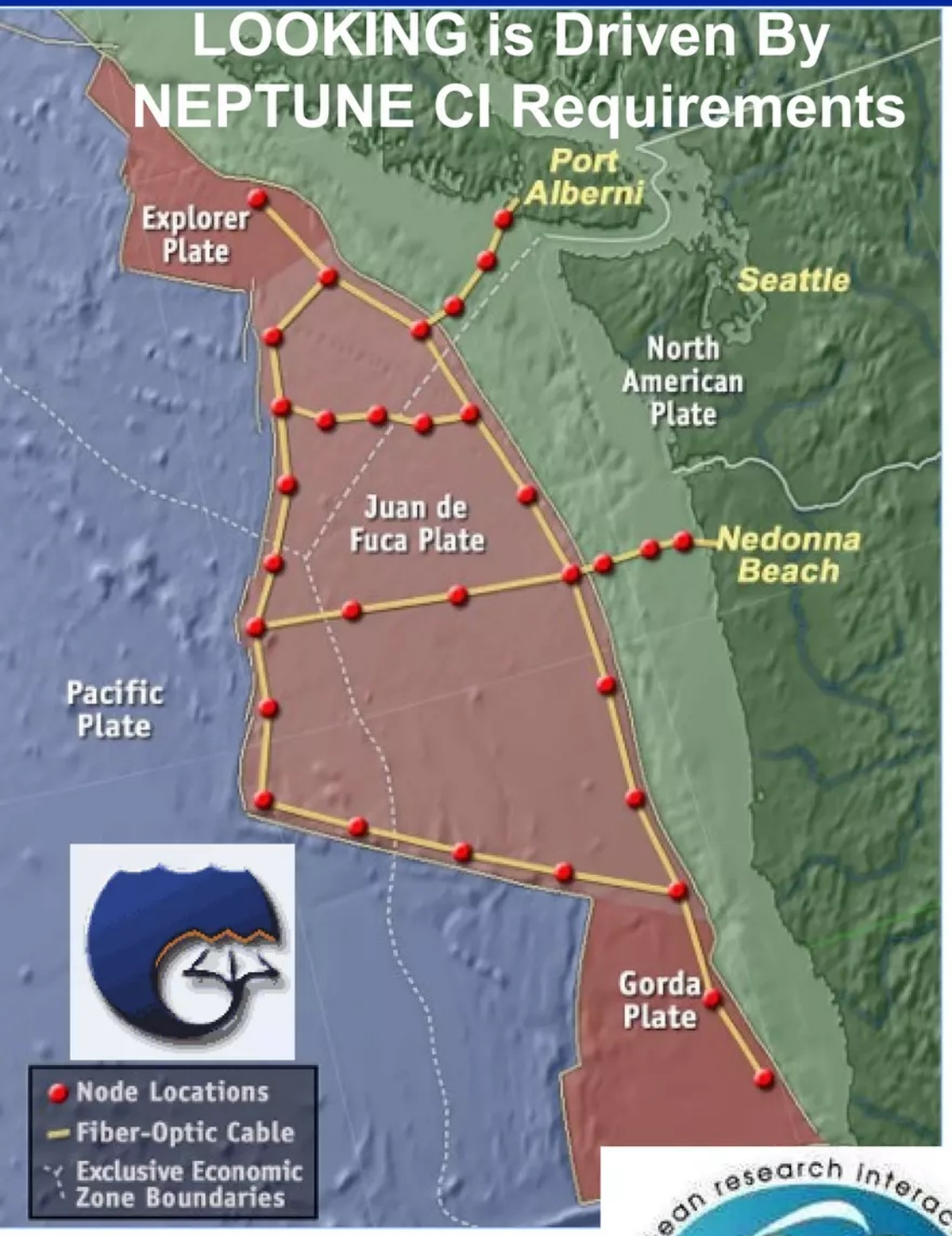
Supported by Moore Foundation

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PRAGMA

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Adding Web & Grid Services to Optical Channels to Provide Real Time Control of Ocean Observatories



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)
- **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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NSF

ocean research interactive ORION observatory networks

Making Management of Gigabit Flows Routine

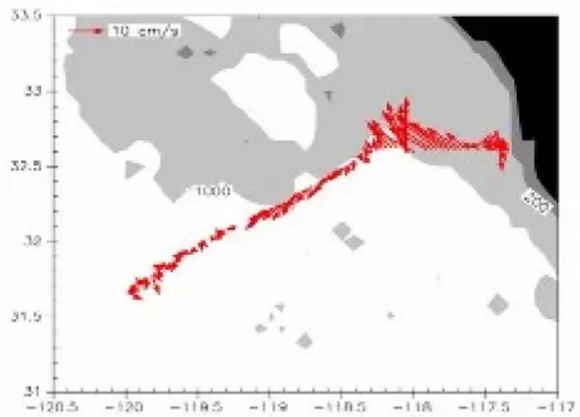
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LOOKING Builds on the Multi-Institutional SCCOOS Program, OptIPuter, and CENIC-XD

- **SCCOOS is Integrating:**
  - Moorings
  - Ships
  - Autonomous Vehicles
  - Satellite Remote Sensing
  - Drifters
  - Long Range HF Radar
  - Near-Shore Waves/Currents (CDIP)
  - COAMPS Wind Model
  - Nested ROMS Models
  - Data Assimilation and Modeling
  - Data Systems



Yellow—Initial LOOKING OptIPuter Backbone Over CENIC-XD





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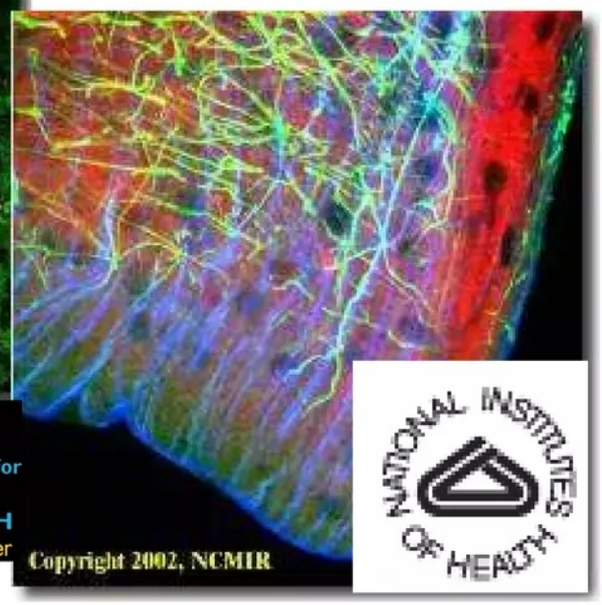
ROADNet

The OptIPuter Project –
Linking Global Scale Science Resources to User's Linux Clusters

- **NSF Large Information Technology Research Proposal**
  - Calit2 (UCSD, UCI) and UIC Lead Campuses—Larry Smarr PI
  - Partnering Campuses: USC, SDSU, NW, TA&M, UvA, SARA, NASA
- **Industrial Partners**
  - IBM, Sun, Telcordia, Chiaro, Calient, Glimmerglass, Lucent
- **$13.5 Million Over Five Years—Entering 4th Year**
- **Creating a LambdaGrid "Web" for Gigabyte Data Objects**

NIH Biomedical Informatics Research Network





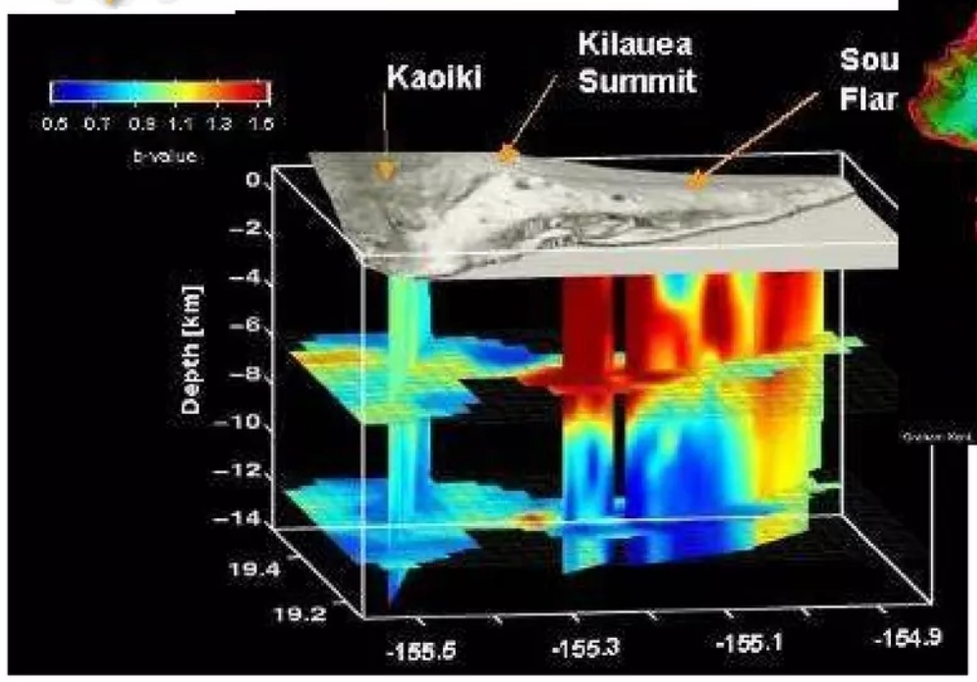
NCMIR
NATIONAL CENTER for MICROSCOPY and IMAGING RESEARCH
at San Diego, an NIH supported resource center

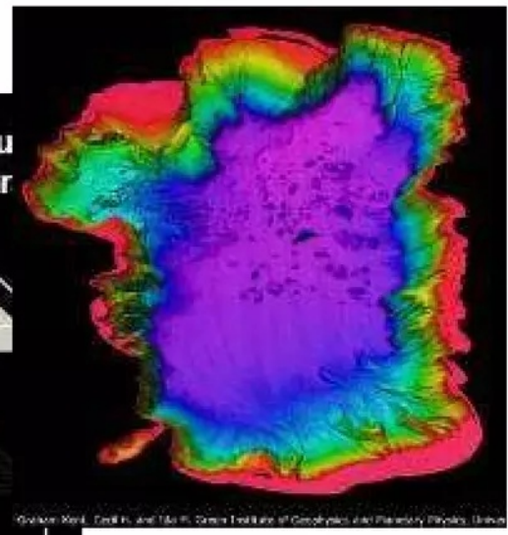
NATIONAL INSTITUTES OF HEALTH

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NSF EarthScope and ORION





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NSF is Launching a New Cyberinfrastructure Initiative

"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



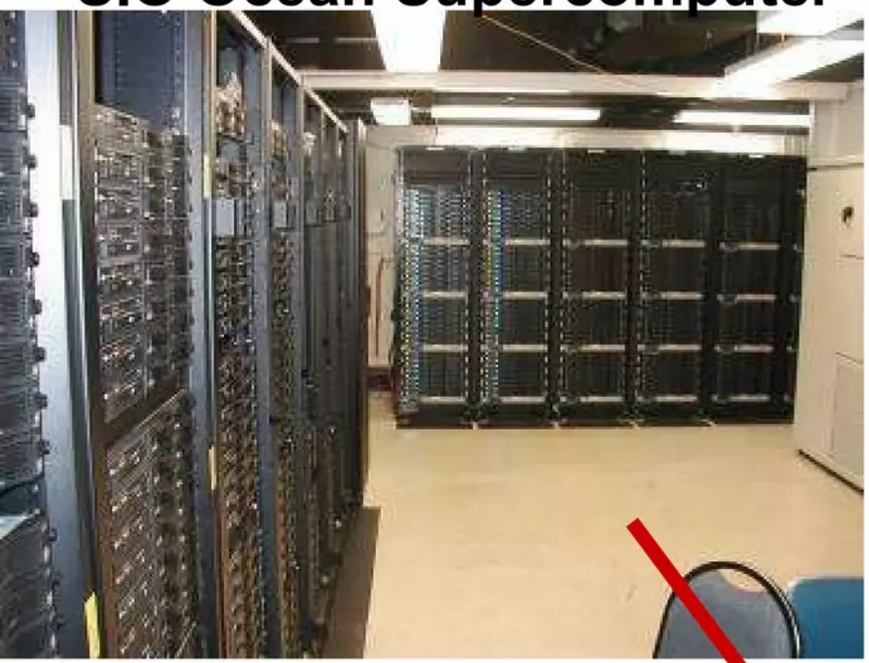
www.ctwatch.org

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UCSD is Prototyping Campus-Scale On-Ramps to the National LambdaRail, TeraGrid, and GLIF

SIO Ocean Supercomputer



UCSD Campus LambdaStore Architecture

IBM Storage Cluster



Streaming Microscope





2 Ten Gbps Campus Lambda Raceway







Global LambdaGrid



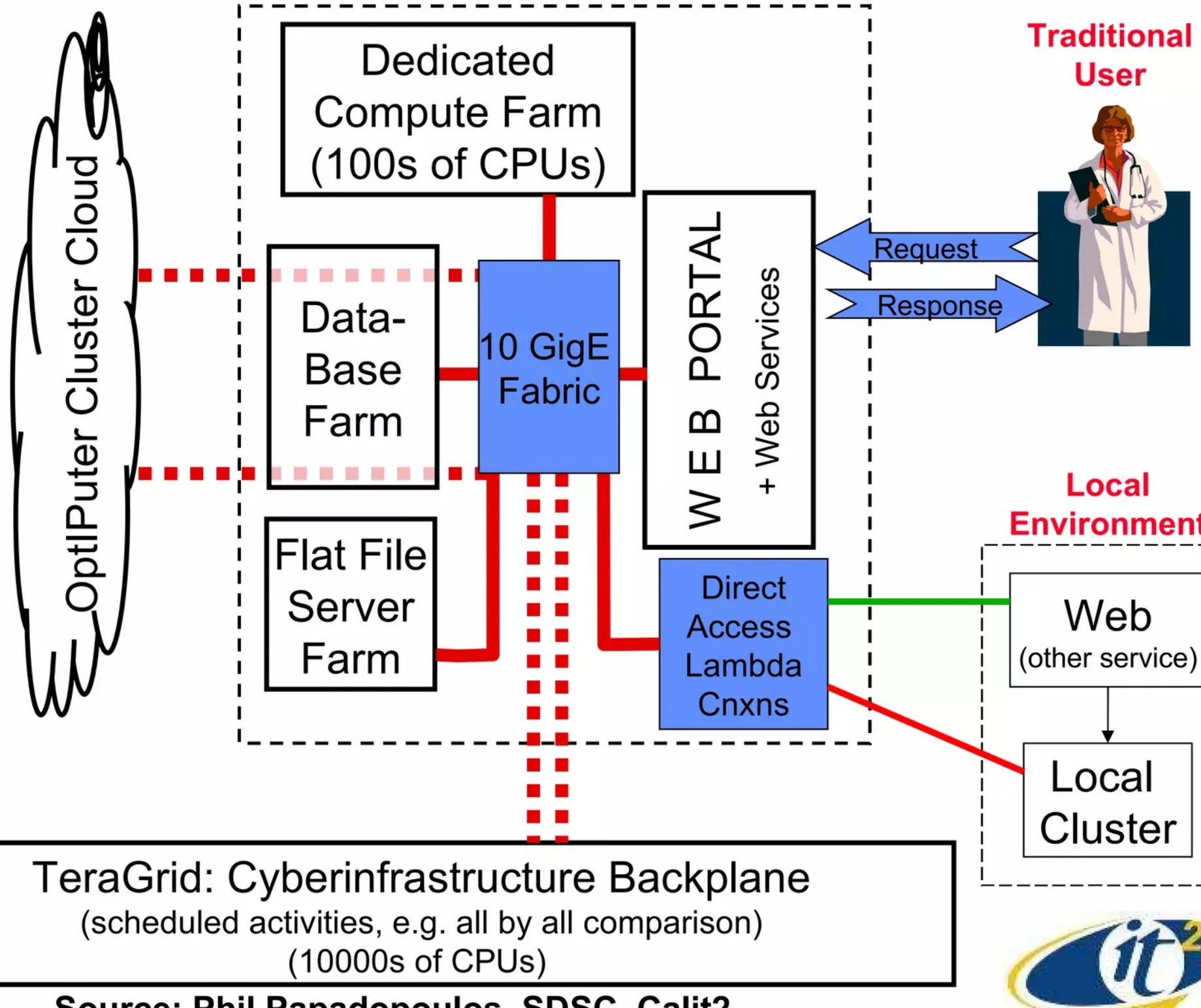
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Source: Phil Papadopoulos, SDSC, Calit2

Calit2/SDSC Direct Access Core Architecture Supporting Massive Instrumental Datasets

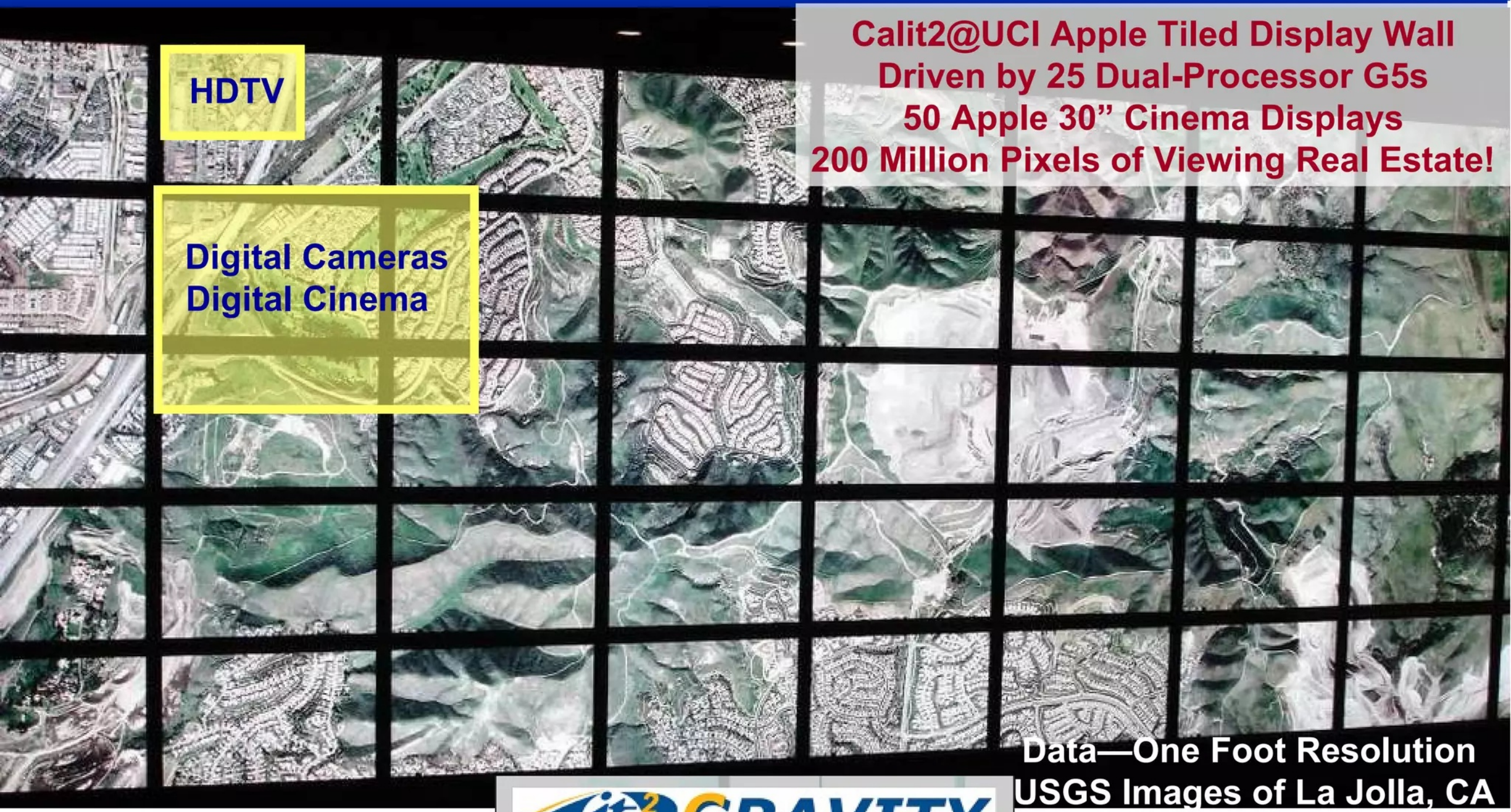
Emerging Services Oriented Architecture Enabling Use of LambdaGrids



Source: Phil Papadopoulos, SDSC, Calit2

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Tiled Walls for Interactive Exploration of Large Earth Sciences Data Sets With Integration of Streaming High Resolution Video



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

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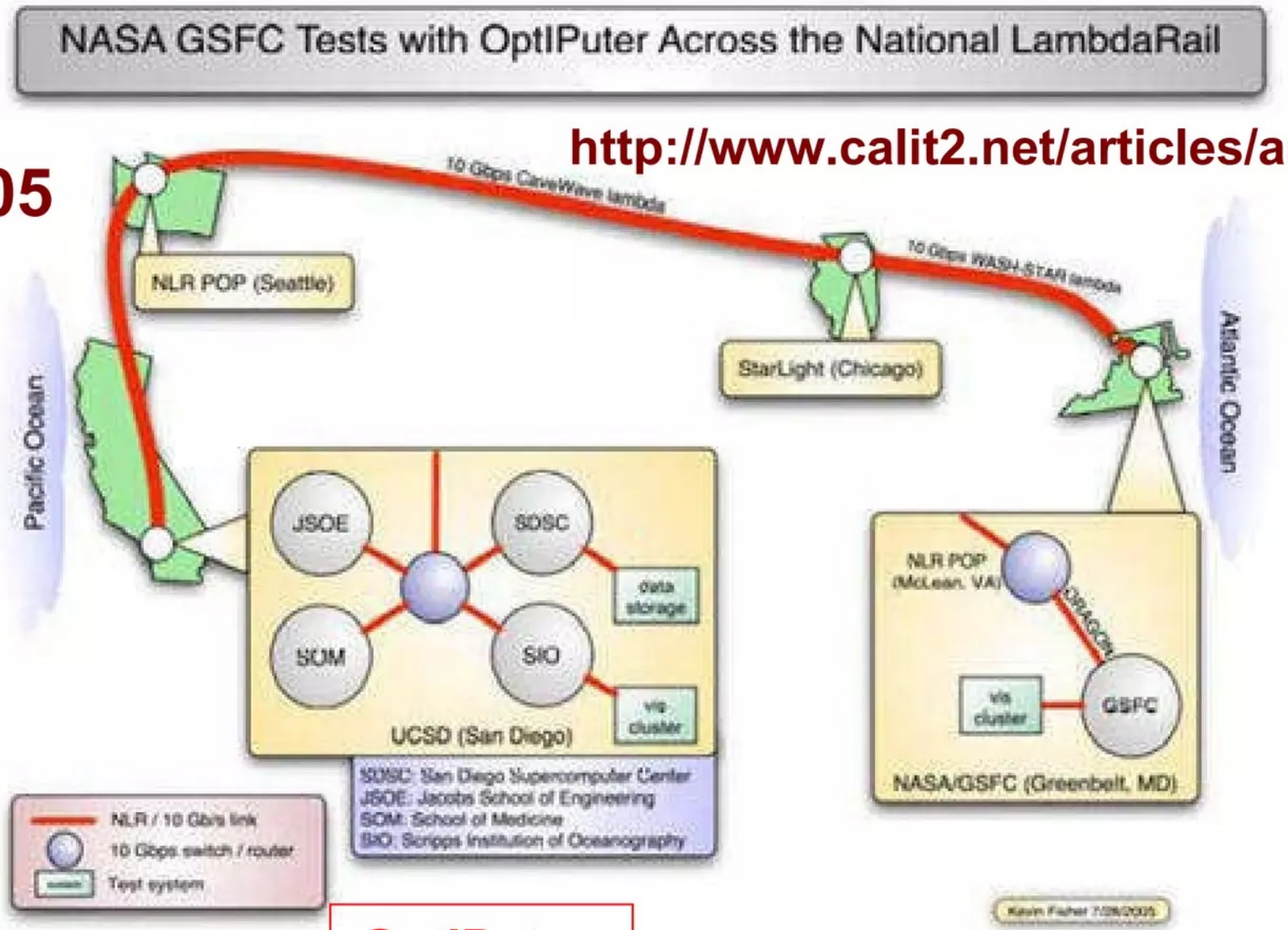
Source: Falko Kuester, Calit2@UCI
NSF Infrastructure Grant

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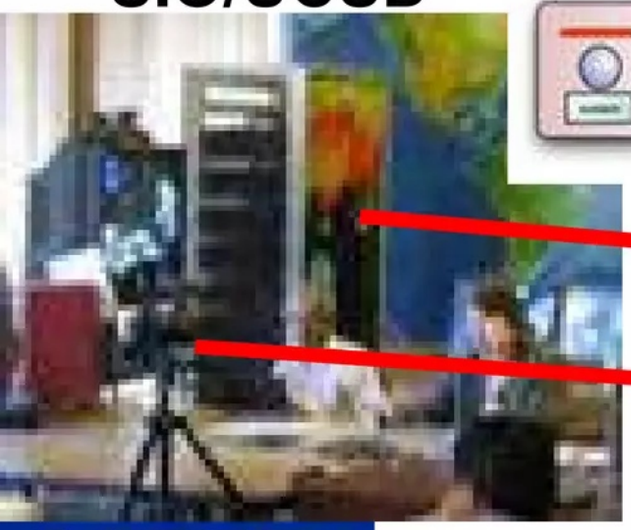
Combining Telepresence with Remote Interactive Analysis of Earth Sciences Data Over NLR

August 8, 2005

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



SIO/UCSD



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OptIPuter Visualized Data

HDTV Over Lambda



NASA Goddard

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