"Using OptIPuter Innovations to Enable LambdaGrid Applications"

Keynote

JGN II Symposium

HDTV Over Fiber From Seattle to Osaka

January 18, 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

OptIPuter

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Calit2 -- Research and Living Laboratories on the Future of the Internet

University of California San Diego & Irvine Campuses
Faculty & Staff
Working in Multidisciplinary Teams
With Students, Industry, and the Community



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www.calit2.net

Two New Calit2 Buildings Will Become Collaboration Laboratories



- Will Create New Laboratory Facilities
- International Conferences and Testbeds
- 800 Researchers in Two Buildings

Calit2@UCSD Building Is Connected To Outside With 140 Optical Fibers



State of California Provided $100M Capital

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Calit2 CineGrid Auditorium
Networked Digital Cinema and Global Collaboratorium

- We will Open in 2005 with a 2K Projector
- Plan to Add SHD (4K) Projector for Digital Cinema and Quad HDTV
- Mono and Stereo Viewing





- 250-Seat Auditorium
- Digital Cinema or Scientific Visualization
- Bi-directional Tele-presence Conferencing
- Robotic Camera System for Live Events
- 24-Channel Sound
- Multi-Modal Projection Capabilities
- Multi-Fiber Hi-Speed Network Connectivity

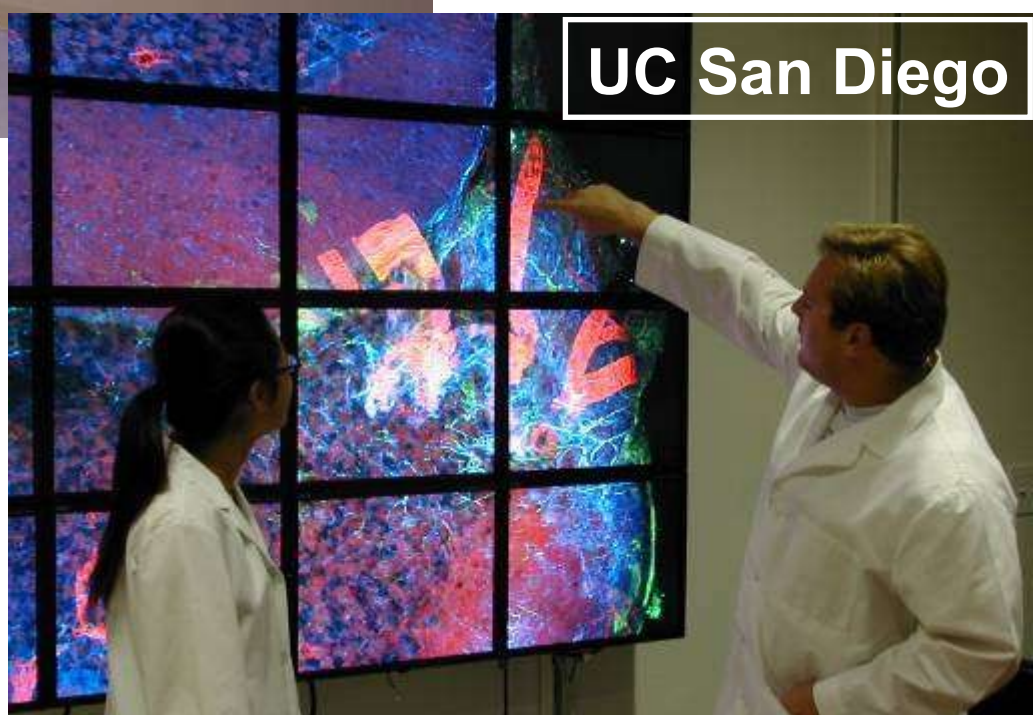
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Source: Sheldon Brown, CRCA, UCSD

Enhanced Collaboration Using DV, HD and SHD over IP



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In 2005 Calit2 will Link Its Two Buildings via Dedicated Fiber over 75 Miles Using OptIPuter Architecture to Create a Distributed Collaboration Laboratory

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An OptIPuter LambdaVision Collaboration Room as Imagined By 2006



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Source: Jason Leigh, EVL, UIC

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15 Year Ago – Our Vision of Using Dedicated Fiber Optic Infrastructure for Collaborative Interactive Visualization

"What we really have to do is eliminate distance between individuals who want to interact with other people and with other computers."
— Larry Smarr, Director, NCSA

SIGGRAPH 1989

We Used Analog TV to Emulate Today's HD over IP Talk



ATT & Sun





"We're using satellite technology…to demo what It might be like to have high-speed fiber-optic links between advanced computers in two different geographic locations."

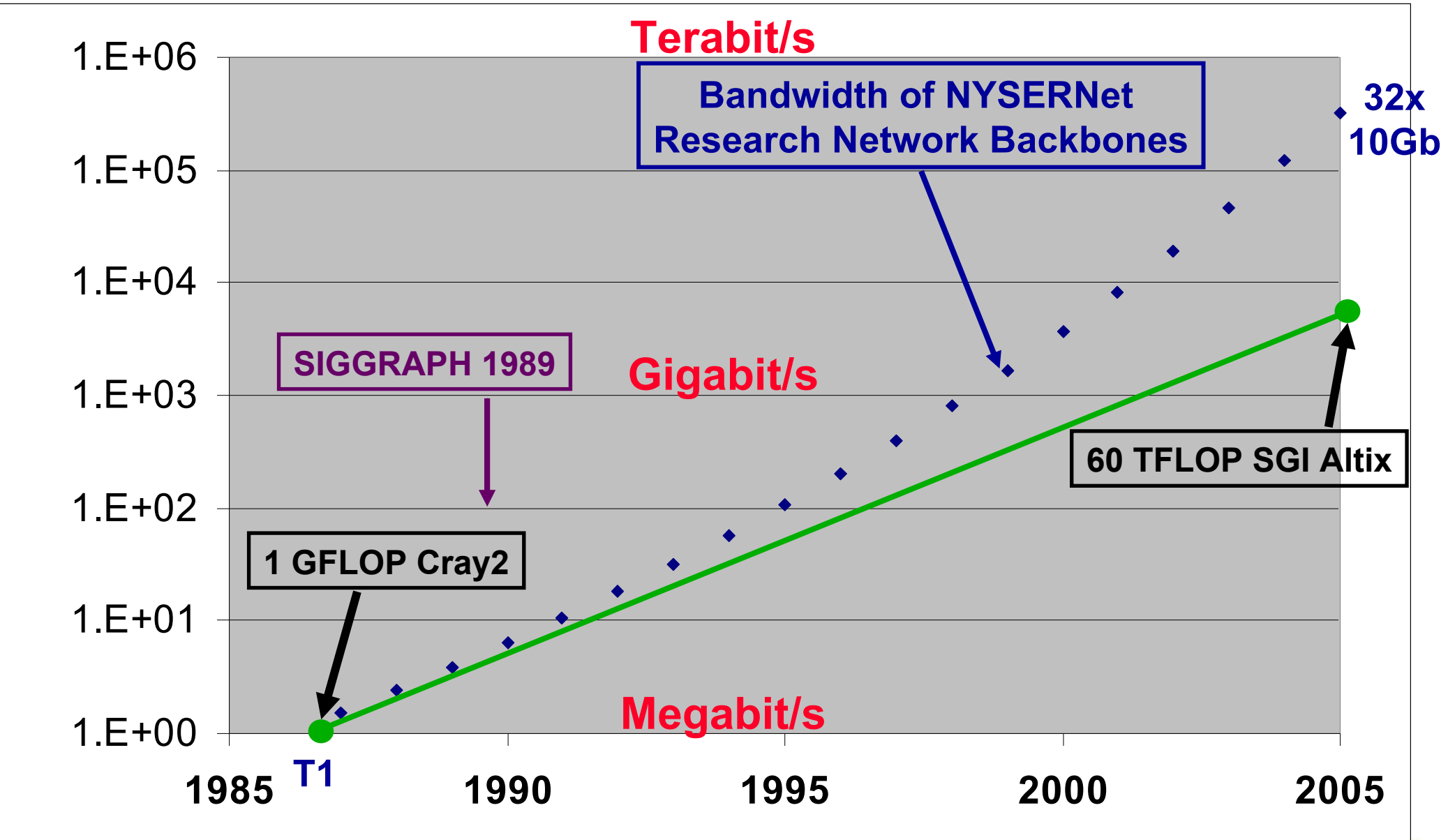
— Al Gore, Senator
Chair, US Senate Subcommittee on Science, Technology and Space

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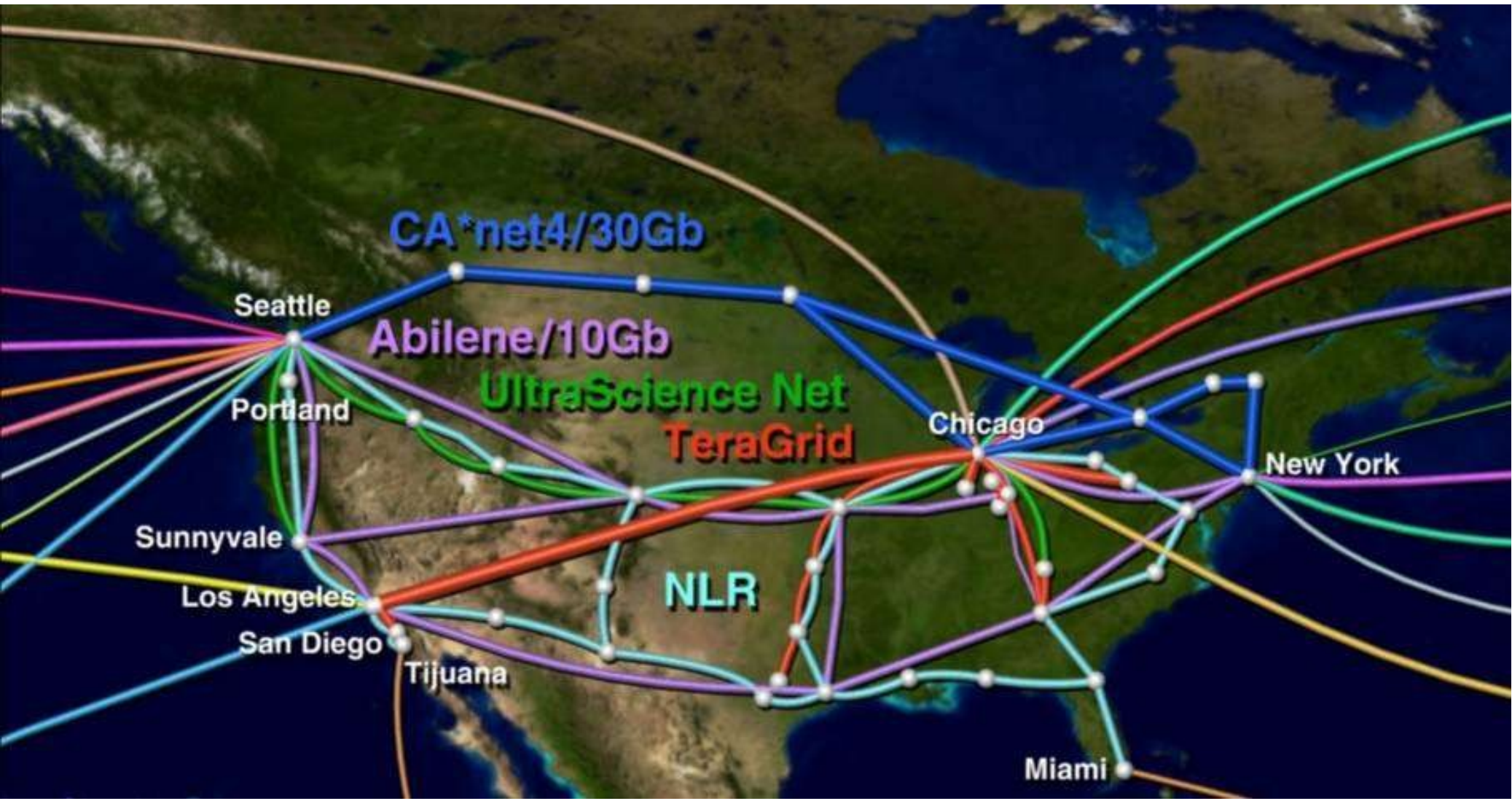
Why Now? - Optical WAN Research Bandwidth Has Grown Much Faster than Research Supercomputer Speed!



NYSERnet is the New York State University Network

Source: Timothy Lance, President, NYSERNet

15 Years Later-- USA Has Dedicated 10Gb Research and Education Connectivity



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Global Lambda Integrated Facility (GLIF)
Integrated Research Lambda Network

Many Countries are Interconnecting Optical Research Networks

to form a Global SuperNetwork



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Visualization courtesy of
Bob Patterson, NCSA

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Announcing…

Call for Applications Using the GLIF SuperNetwork

iGrid 2005

THE GLOBAL LAMBDA INTEGRATED FACILITY

www.startap.net/igrid2005/

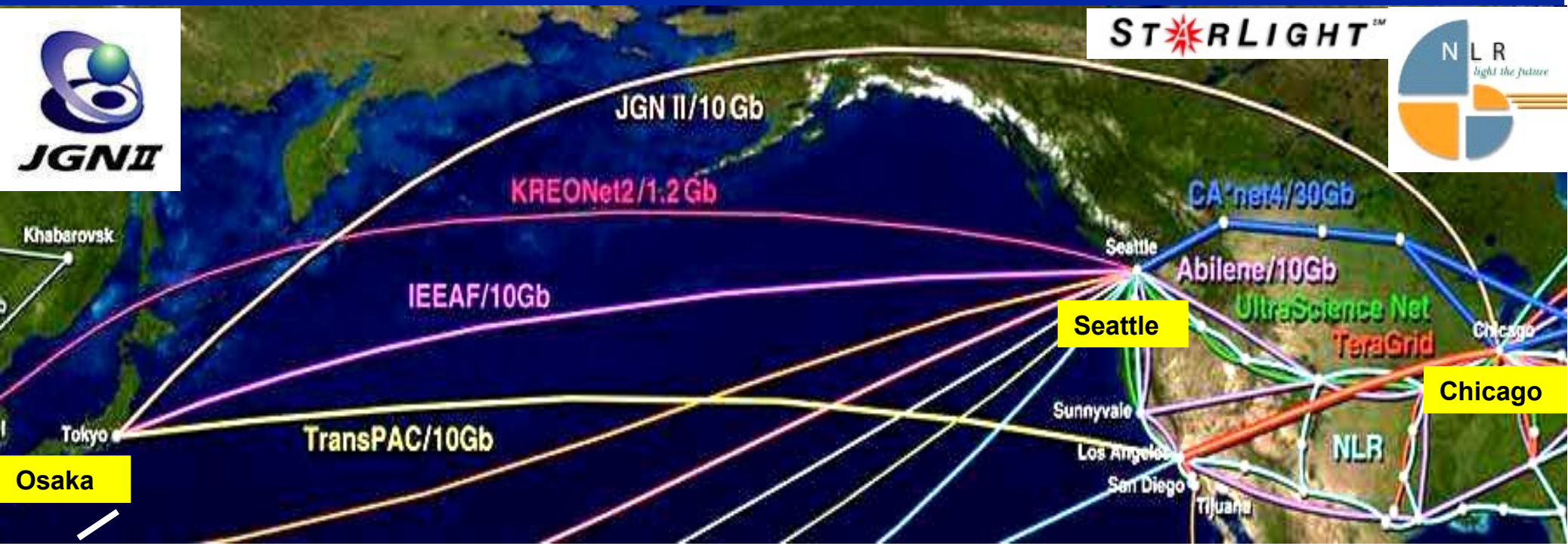
September 26-30, 2005
University of California, San Diego
California Institute for Telecommunications and Information Technology

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Maxine Brown, Tom DeFanti, Co-Organizers

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Today's Lecture--Uncompressed HDTV at 1.5 Gpbs Live From Seattle to Osaka



Japan: NiCT/ JGN II, NiCT/APAN, NTT Group, KDDI, WIDE Project

USA: University of California San Diego/Calit2, University of Washington/Pacific Northwest Gigapop, PacificWave, ResearchChannel, Pacific Interface, Inc., StarLight (Argonne National Laboratory, Northwestern University, University of Illinois at Chicago), Indiana University, Intel

Circuits: JGN II, WIDE, KDDI, NTT Group, IEEAF, NLR (National Lambda Rail)

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Enabled by International Human Networks

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We Build on Pioneering Research in Japan and USA Using HD, DV, and SHD over IP

- **U Washington Research Channel Uncompressed HD-over-IP**
  - Experiments With Compressed HD over Internet2 since 1999
  - Today's Uncompressed Live Transmission from Seattle to Osaka
- **KDDI Compressed HD-over-IP**
  - NCMIR/UCSD to Univ. of Osaka Using its HDTV MPEG2 Codec
  - Recently Upgraded to HDTV JPEG 2000 (Lower Latency)
- **WIDE Compressed DV-over-IP**
  - Keio University, Japan Using their DVTS software running on PC
- **NTT Uncompressed HD-over-IP**
  - First demonstration 2001 over 2.4 Gb Optic-Fiber
  - Nov 2004 iVISTO Multi-HD Streams Tokyo to Osaka Over 10 GigE
- **NTT Labs Compressed SHD-over-IP**
  - Demonstrations in Japan and the USA Since 2002
  - Using JPEG 2000, 7 Gbps is Compressed to ~ 300 Mbps

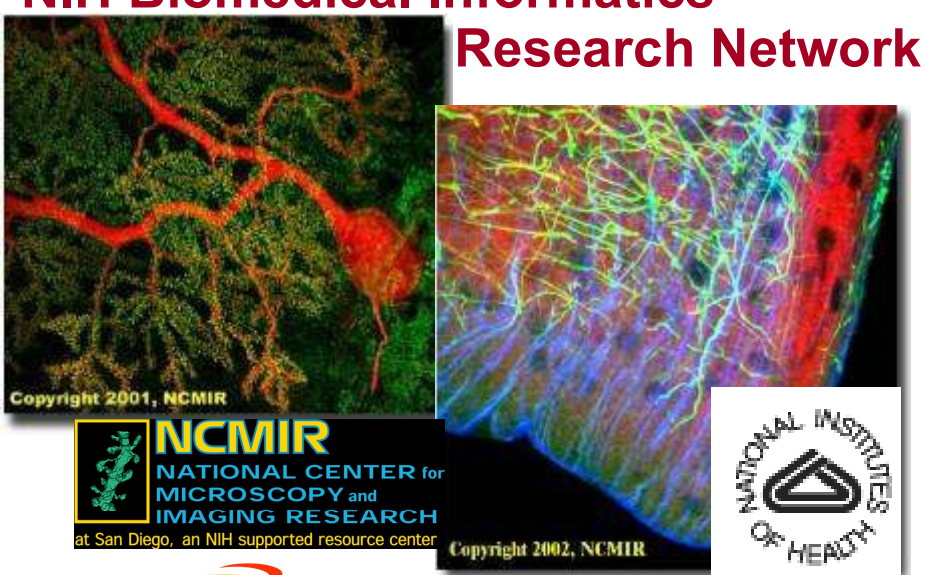
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The OptIPuter Project
Collaborative Visualization of Large Remote Data Objects

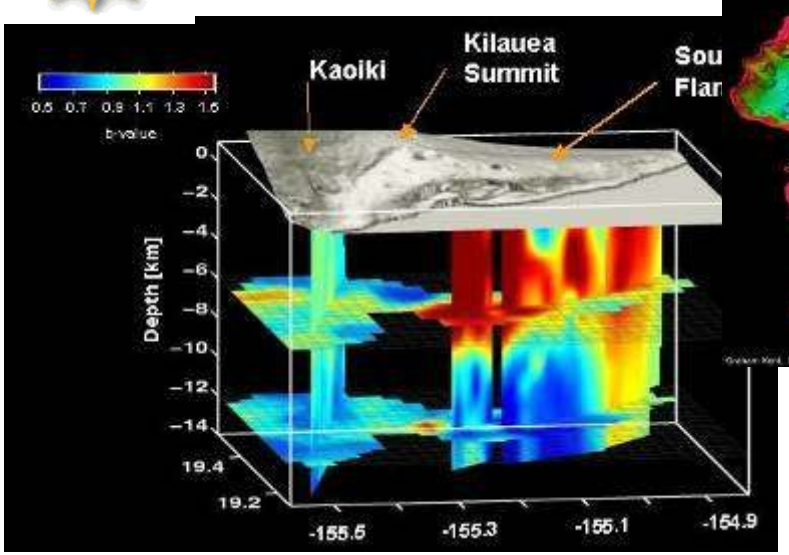
- **NSF Large Information Technology Research Grant**
  - Calit2 /UCSD and EVL/UIC Lead Campuses—Larry Smarr, PI
  - Partners: USC, SDSU, NWU, Texas A&M, Univ. Amsterdam
  - $13.5 Million Over Five Years 2003 – 2008
- **Driven by Long Term National Scientific Projects**
- **Industrial Partners**
  - IBM, Sun, Telcordia, Chiaro, Calient, Glimmerglass, Lucent

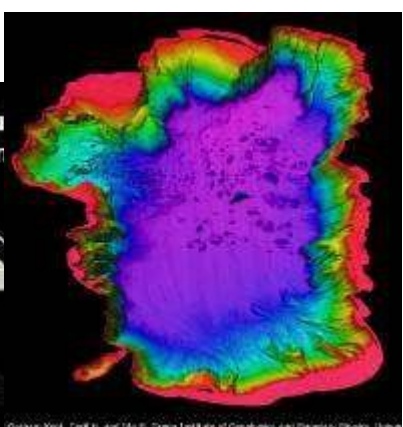
NIH Biomedical Informatics Research Network



http://ncmir.ucsd.edu/gallery.html

NSF EarthScope and ORION





siovizcenter.ucsd.edu/library/gallery/shoot1/index.shtml

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Optical Networking, Internet Protocol, Computer
Bringing the Power of Lambdas to Users

- **Extending Grid Middleware to Control:**
  - Jitter-Free, Fixed Latency, Predictable Optical Circuits
    - One or Parallel Dedicated Light-Pipes (1 or 10 Gbps WAN Lambdas)
    - Uses Internet Protocol, But Does NOT Require TCP
    - Exploring Both Intelligent Routers and Passive Switches
  - Clusters Optimized for Storage, Visualization, and Computing
    - Linux Clusters With 1 or 10 Gbps I/O per Node
    - Scalable Visualization Displays Driven By OptIPuter Clusters
- **Applications Drivers:**
  - Earth and Ocean Sciences
  - Biomedical Imaging
  - Digital Media at SHD resolutions (Comparable to 4K Digital Cinema)

The OptIPuter Envisions a Future When the Central Architectural Element Becomes Optical Networks-NOT Computers - Creating "SuperNetworks"

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OptIPuter User Interface
Scaling to 100 MegaPixels!

55-Panel Display
100 Megapixels

30 x 10GE interfaces
1/3 Tera bit/sec

Driven by 30 Node Cluster of 64 bit Dual Opterons

60 TB Disk

Linked to OptIPuter

Working with NASA Teams to Unify Software



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Source: Jason Leigh, Tom DeFanti, EVL@UIC
OptIPuter Co-PIs

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OptIPuter National Testbed
10GE CAVEwave Rides the National LambdaRail

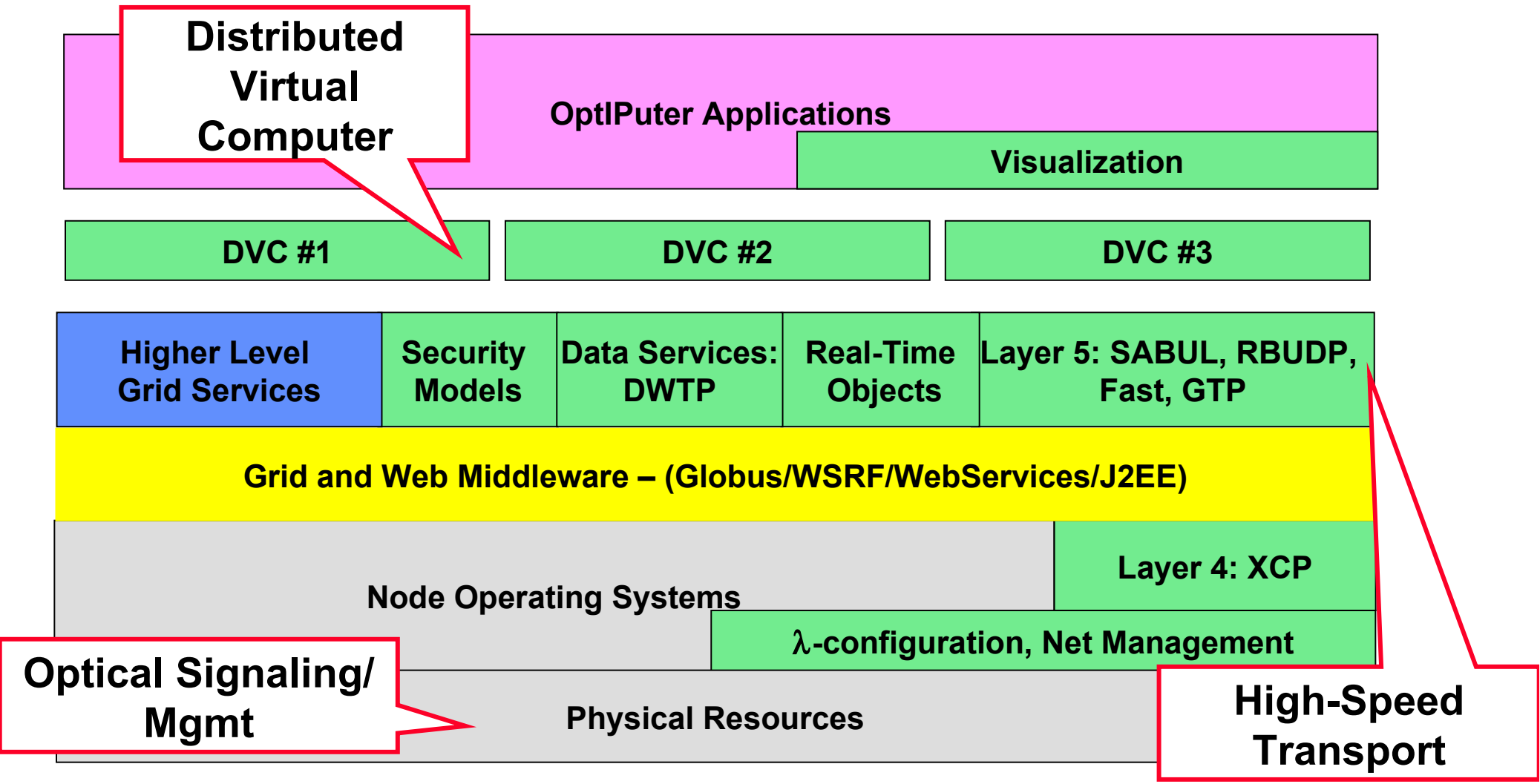


Next Step: Coupling NASA Centers to NSF OptIPuter Testbed

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Source: Tom DeFanti, OptIPuter co-PI

OptIPuter Middleware Architecture
The Challenge of Transforming Grids into LambdaGrids



Green are OptIPuter Additions to Standard Grid Stack

Source: Andrew Chien, UCSD
OptIPuter Software Systems Architect

Four Examples of LambdaGrid Applications

- Biomedical Brain Imaging and Microscopy
- Earth Climate Modeling
- Ocean Floor Observatories
- Digital Cinema

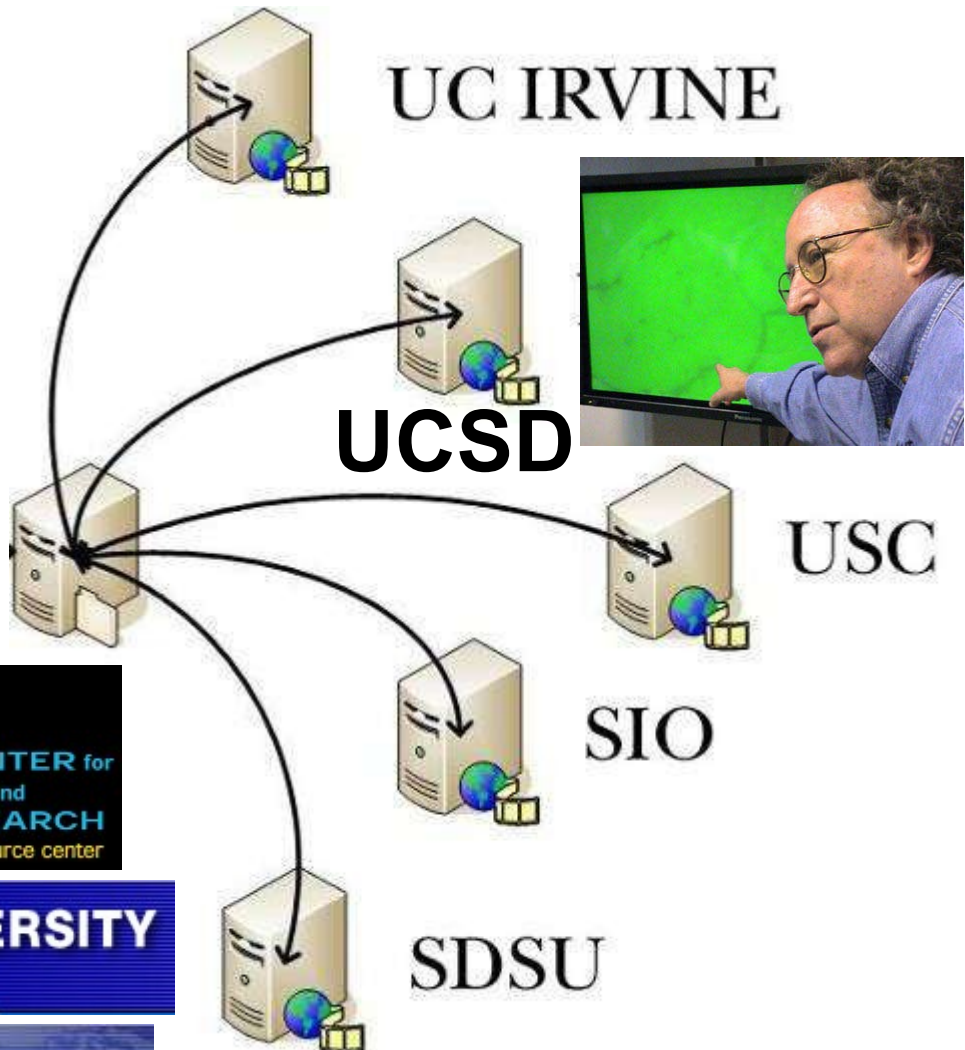
OptIPuter Application Drivers

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

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



Southern California OptIPuter



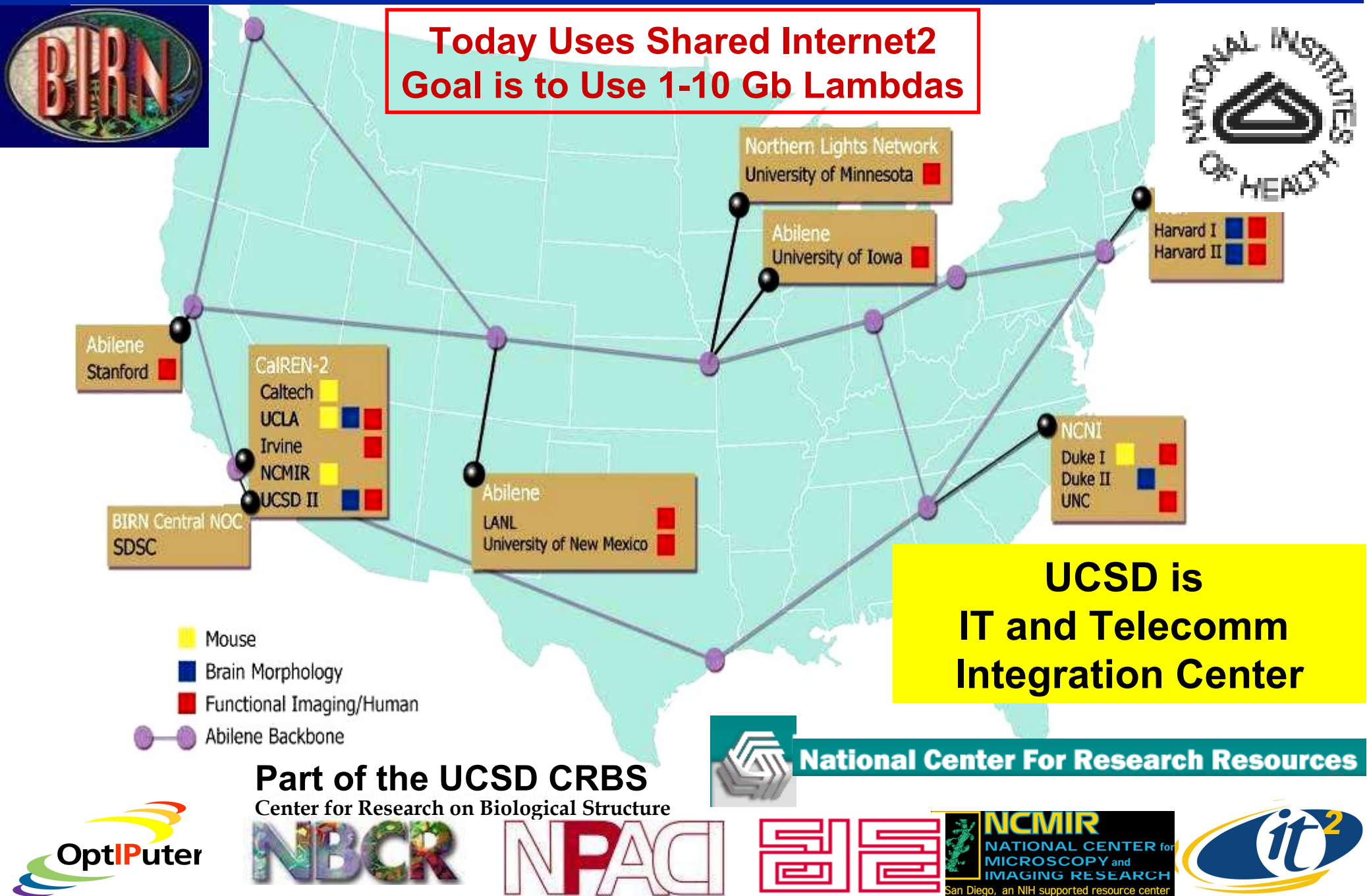
NCMIR NATIONAL CENTER for MICROSCOPY and IMAGING RESEARCH at San Diego, an NIH supported resource center

OSAKA UNIVERSITY

KDDI GROUP KDDI Labs USA

Source: Mark Ellisman, UCSD

OptIPuter Driver: The NIH BIRN Biomedical Informatics Research Network



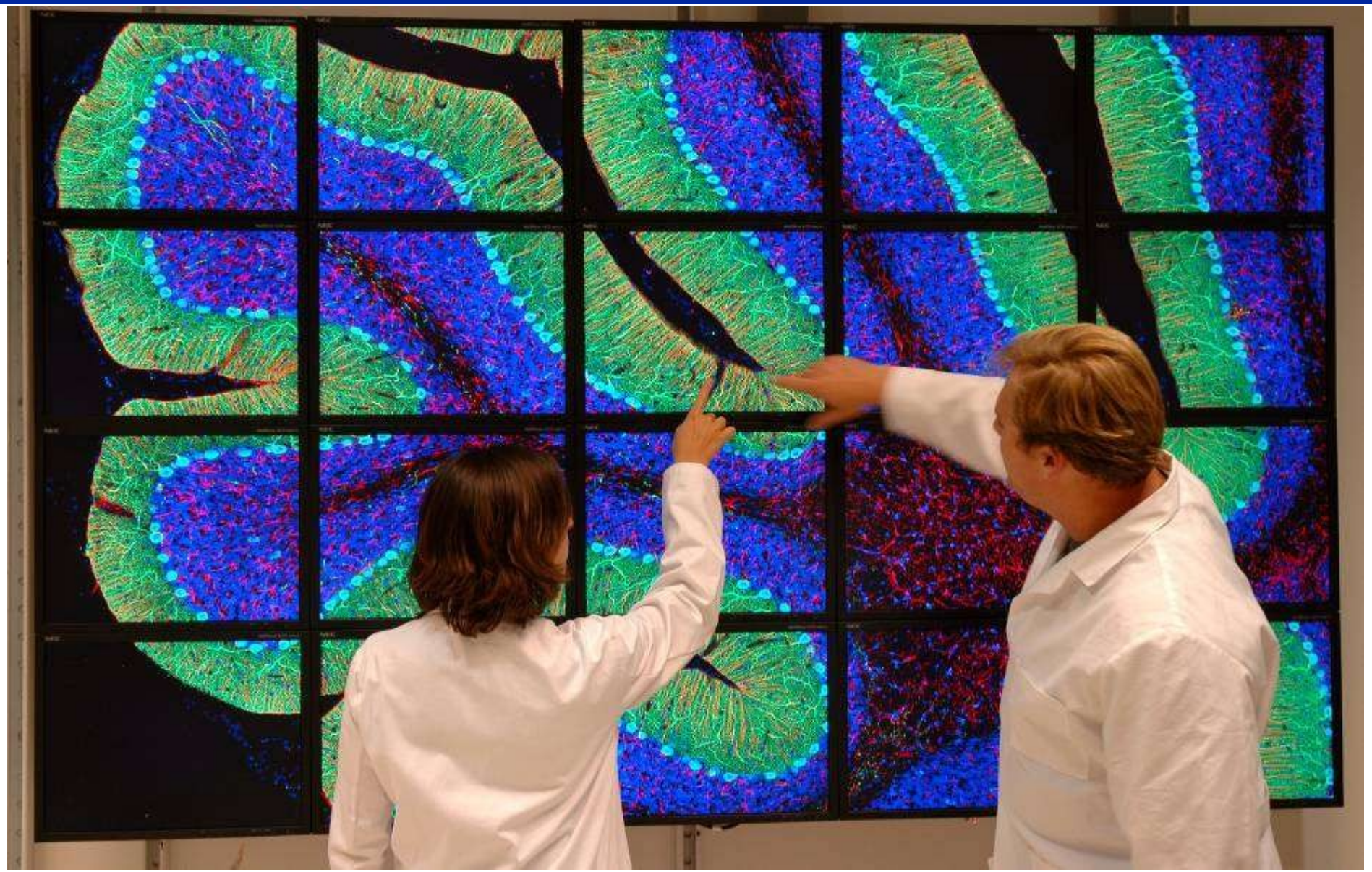
UCSD is IT and Telecomm Integration Center

National Center For Research Resources

Part of the UCSD CRBS
Center for Research on Biological Structure

OptIPuter NBCR NPACI SDSC NCMIR NATIONAL CENTER for MICROSCOPY and IMAGING RESEARCH San Diego, an NIH supported resource center it2

OptIPuter JuxtaView Software for Viewing High Resolution Images on Tiled Displays



OptIPuter

30 Million Pixel Display
NCMIR Lab UCSD

Source: David Lee, Jason Leigh

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OptIPuter Interactive Browsing of Remote Earth Sciences Images on Scalable Displays

Enables Scientists To Perform Coordinated Studies Of Multiple Remote-Sensing Or Simulation Datasets

Source: Milt Halem & Randall Jones, NASA GSFC
& Maxine Brown, UIC EVL





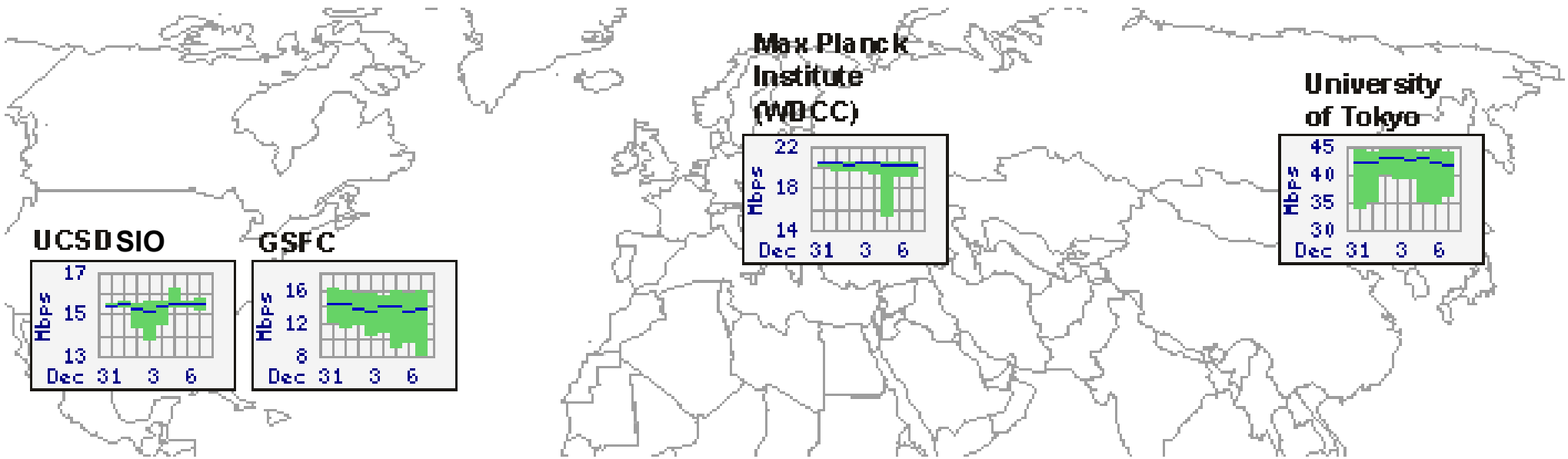
Earth Science Data Sets Created by GSFC's Scientific Visualization Studio were Retrieved Across the NLR in Real Time from OptIPuter Servers in Chicago & San Diego and From GSFC Servers in McLean, VA, then Displayed at SC2004 in Pittsburgh

http://esdcd.gsfc.nasa.gov/LNetphoto3.html

Next Step: OptIPuter, NLR, and Starlight Enabling Coordinated Earth Observing Program (CEOP)

Source: Milt Halem, NASA GSFC

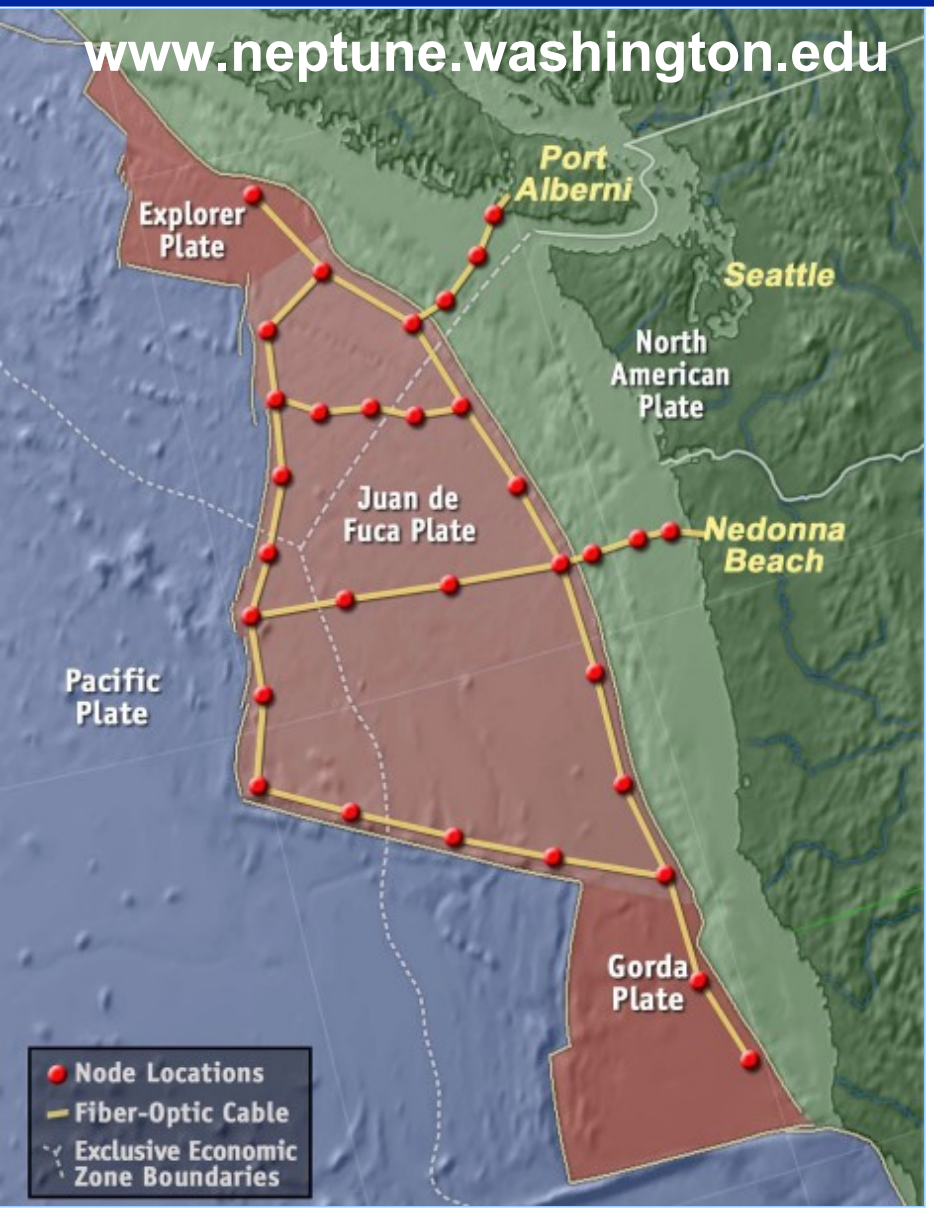
Coupling 300TB's of Observational Data at Univ. of Tokyo to 100TB's of Model Assimilation Data at Max Plank Institute Using OptIPuter Technology Over the NLR and Starlight



Note Current Throughput 15-45 Mbps:
OptIPuter 2005 Goal is ~1-10 Gbps!

http://ensight.eos.nasa.gov/Organizations/ceop/index.shtml

New OptIPuter Driver: Gigabit Fibers on the Ocean Floor Controlling Sensors and HDTV Cameras Remotely



- **A New Generation of Ocean Observatories**
  - Using Submarine Telecom Cable
- **Linked to Land Fiber Backbone**
- **NSF Funded LambdaGrid Project**
  - Laboratory for the Ocean Observatory Knowledge Integration Grid
  - Building a Prototype Based on OptIPuter Technologies Plus Web/ Grid Services
  - Data and HDTV Streams Over IP

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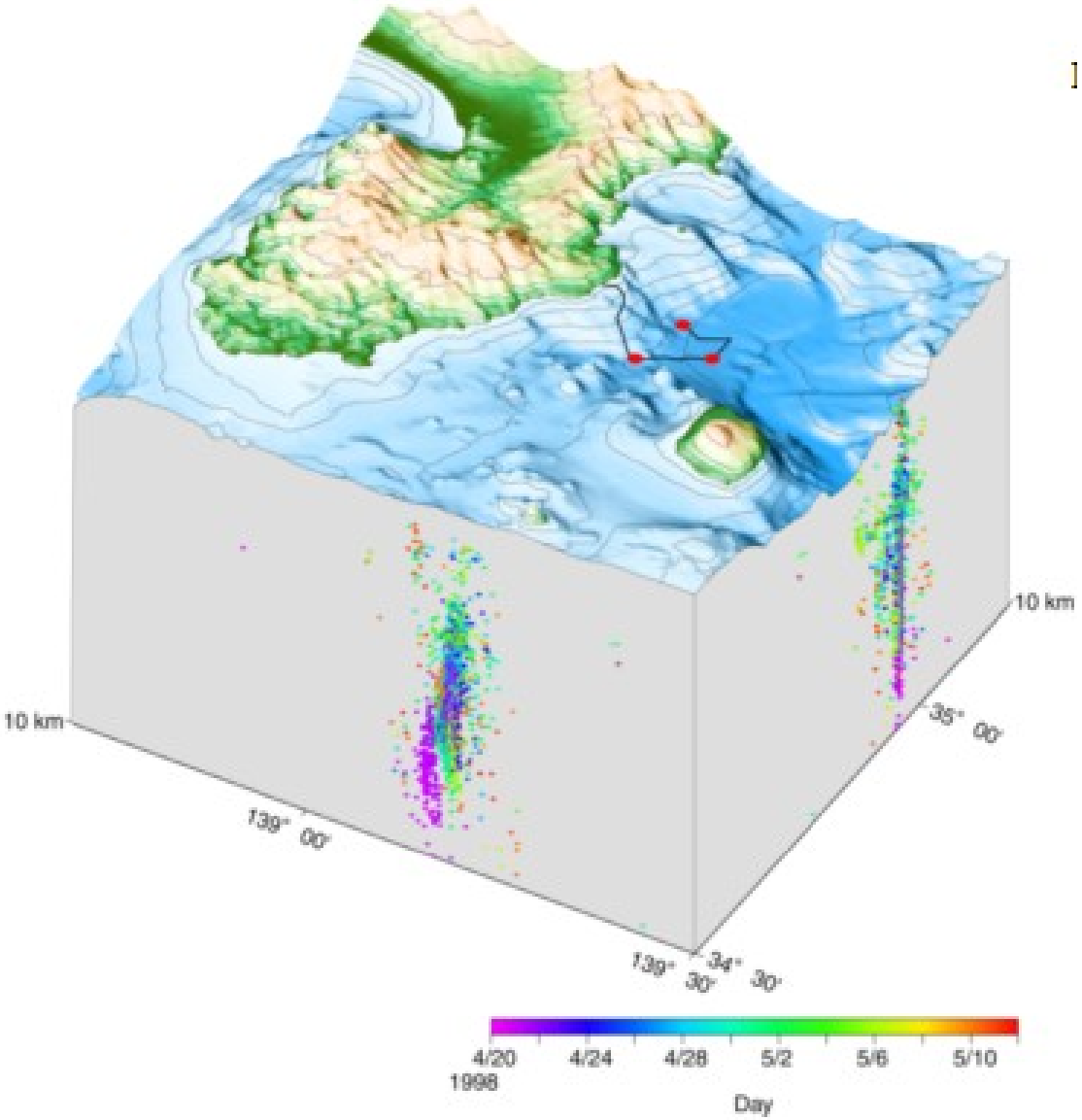
(Funded by NSF ITR- John Delaney, UWash, PI)

NSF

ocean research interactive ORION observatory networks

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Major Collaboration Opportunity Emerging Between U.S. and Japan



- Japan Has Historically Been a Pioneer in Cabled Ocean Observatories
- New Challenge:
  - How to Link to Cyber-infrastructure?
  - Ocean-Side Control
    - Instrument
    - Infrastructure
  - Shore-Side
    - Data Management
    - Simulation
    - Visualization

www.eri.u-tokyo.ac.jp/KOHO/Yoran2003/sec6-6-eng.htm

Applying the OptIPuter to Digital Cinema
The Calit2 CineGrid Project

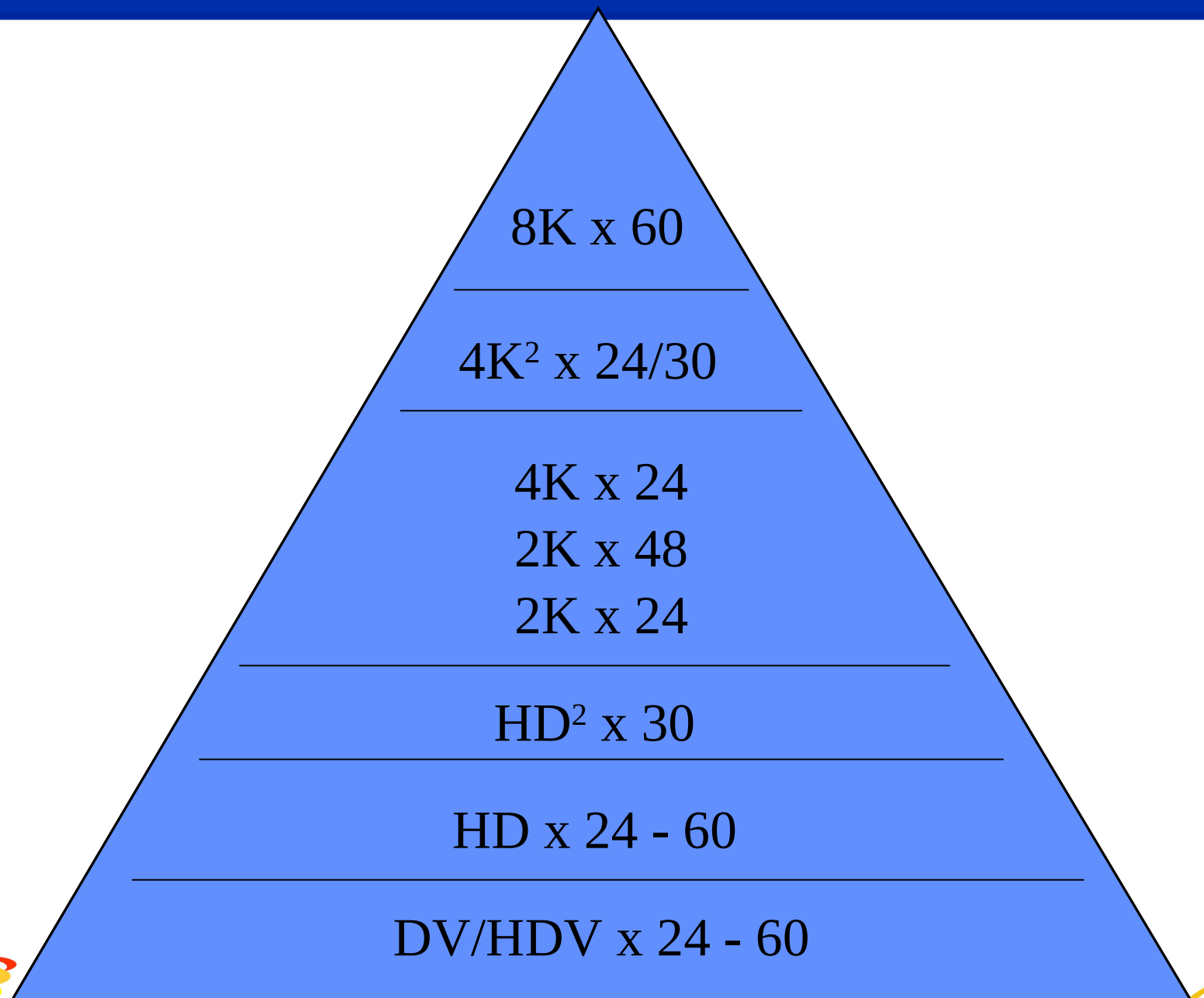
- **Educational and Research Testbed**
  - Scaling to 4K SHD and Beyond!
- **Implement Using OptIPuter Architecture**
  - Distributed Computing, Storage, Visualization & Collaboration
  - CAVEwave and Global Lambda Infrastructure Facilty (GLIF)
- **Support CineGrid Network Operations from Calit2**
- **Develop Partnerships with Industry and Universities**
  - For example, USC School of Cinema-Television, DCTF in Japan, National School of Cinema in Italy, others
- **Connect a Global Community of Users and Researchers**
  - Engineering a Camera-to-Theatre Integrated System
  - Create Digital CineGrid Production & Teaching Tools
  - Engage Artists, Producers, Scientists, Educators

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Source: Laurin Herr, Pacific-Interface

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Designing CineGrid Scalability



Summary

- Dedicated Optical Networks or “Lambdas” Are Change Agents
- A Global Research Lambda Facility (GLIF) Is Functioning
- OptIPuter Research Adds Middleware & Links to User Labs
- Remote Interactive Visualization at Super High Quality
- Many Applications are Beginning to Use LambdaGrids
- New Opportunities Created for Multi-Country Collaboration

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Thank You Very Much!

National Institute of Information and Communications Technology (NiCT)

NiCT/JGN II, NiCT/APAN

KDDI

NTT Group

WIDE Project

University of California San Diego/Calit2

University of Washington

Pacific Northwest Gigapop

Pacific Wave

ResearchChannel

Pacific Interface, Inc.

StarLight

(Argonne National Lab, Northwestern University, University of Illinois at Chicago)

Indiana University

Intel

Circuits

JGN II, WIDE, KDDI, NTT Group

IEEAF, NLR (National Lambda Rail)

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