OptIPuter Overview

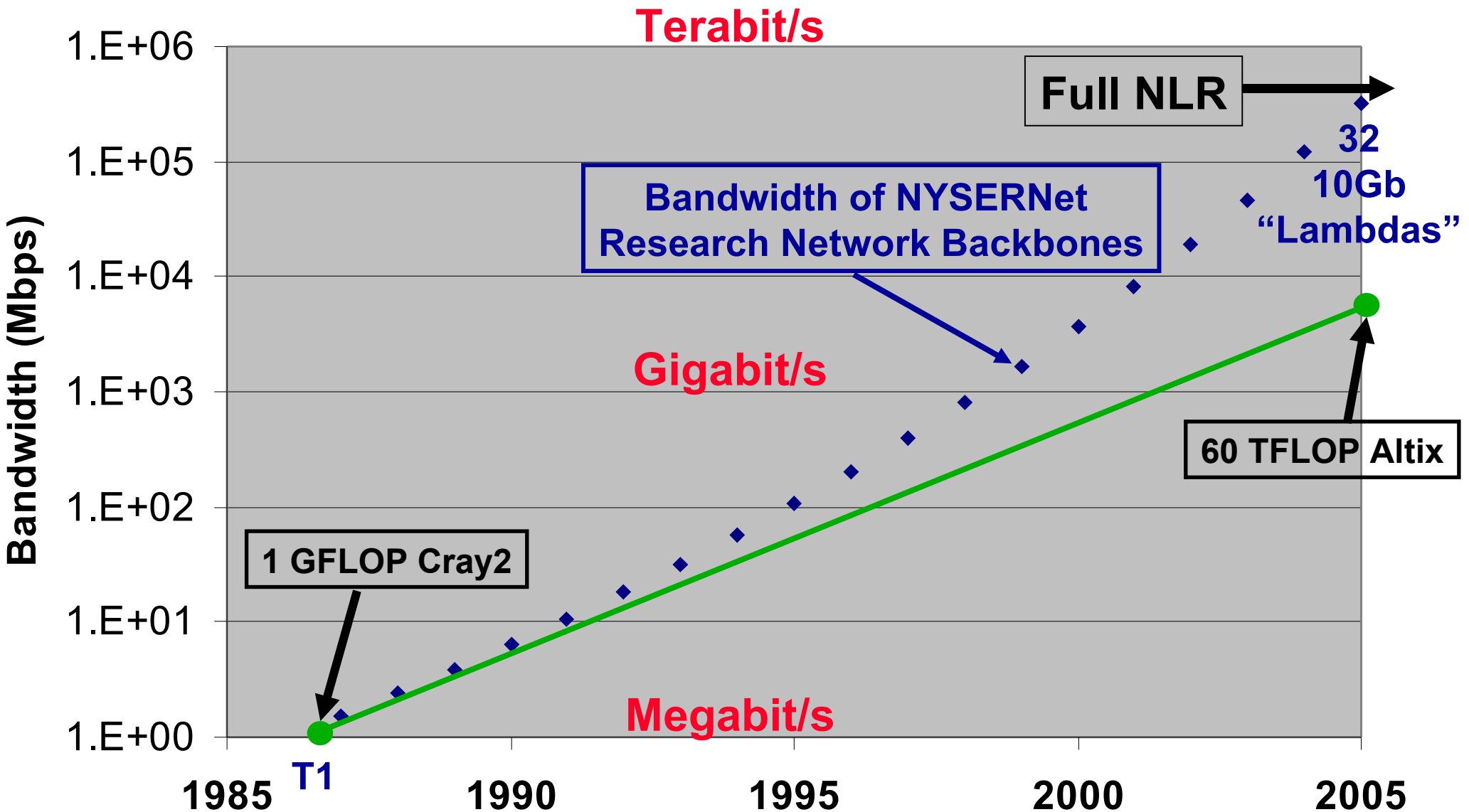
Third All Hands Meeting
OptIPuter Project
San Diego Supercomputer Center
University of California, San Diego
January 28 , 2005

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

it2

Optical WAN Research Bandwidth Has Grown Much Faster than Supercomputer Speed!



Source: Timothy Lance, President, NYSERNet

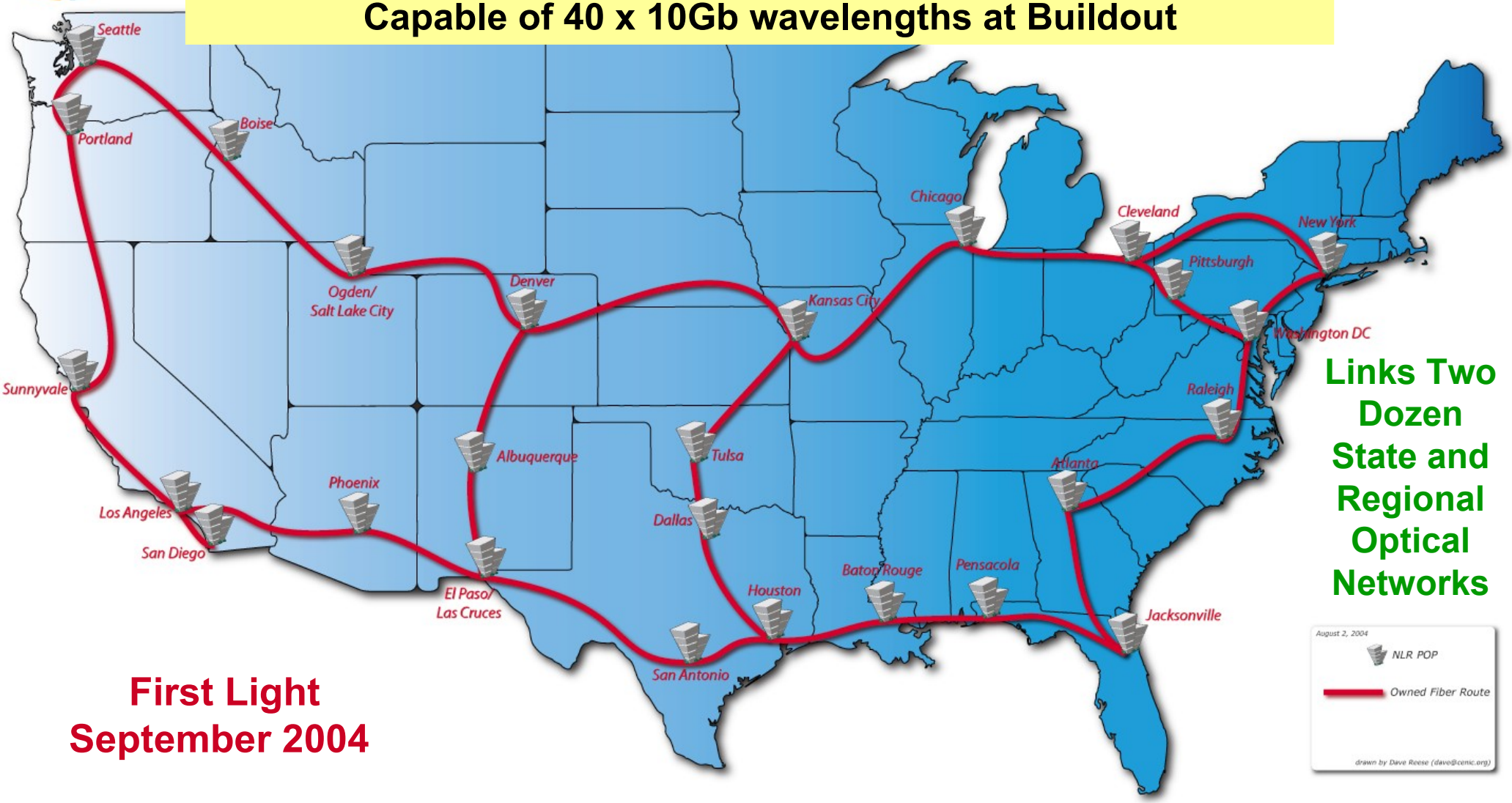
NLR Will Provide an Experimental Network Infrastructure for U.S. Scientists & Researchers

"National LambdaRail" Partnership

Serves Very High-End Experimental and Research Applications

4 x 10Gb Wavelengths Initially

Capable of 40 x 10Gb wavelengths at Buildout



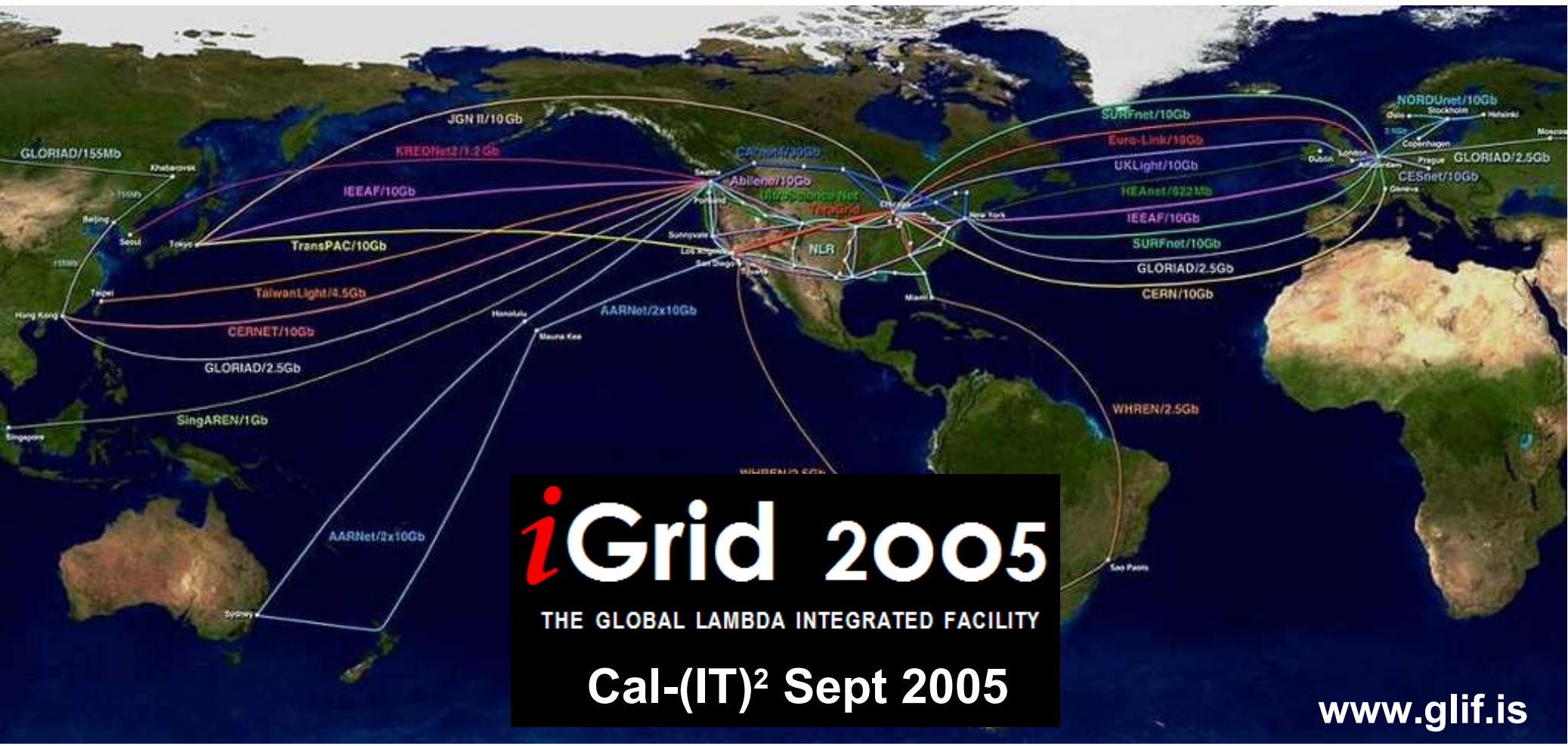
Links Two Dozen State and Regional Optical Networks

First Light September 2004

For more information regarding NLR see http://www.nlr.net or contact info@nlr.net

Global Lambda Integrated Facility: Coupled 1-10 Gb/s Research Lambdas

Predicted Bandwidth, to be Made Available for Scheduled Application and Middleware Research Experiments by December 2004



OptIPuter

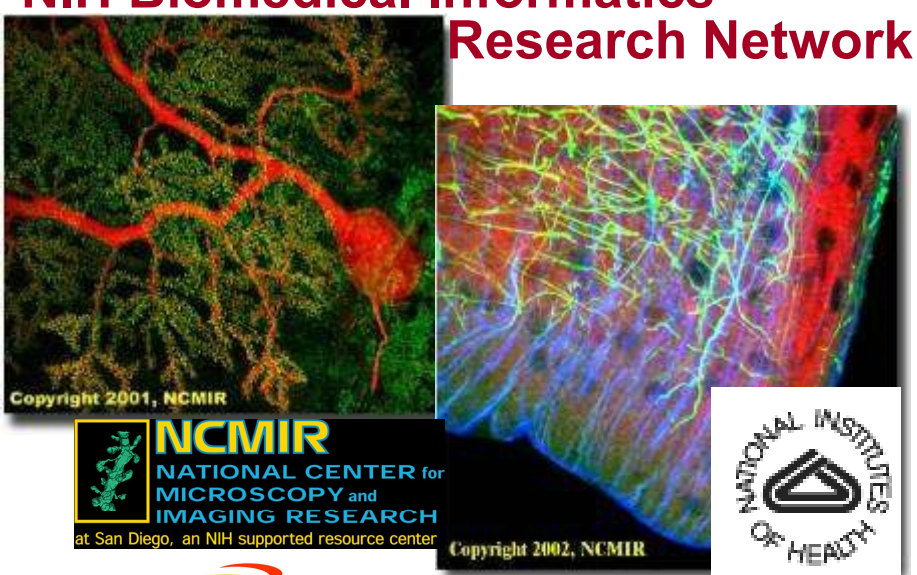
Visualization courtesy of
Bob Patterson, NCSA

it²

The OptIPuter Project –
Creating a LambdaGrid "Web" for Gigabyte Data Objects

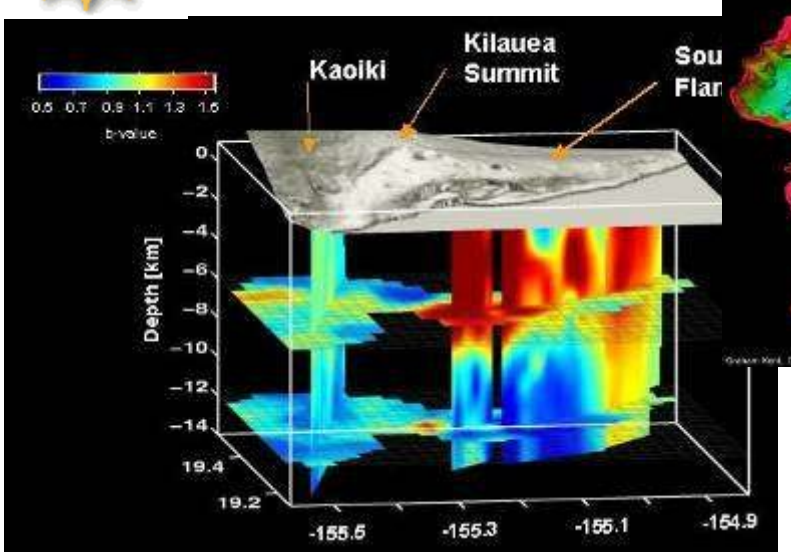
- **NSF Large Information Technology Research Proposal**
  - Calit2 (UCSD and UCI) and UIC Lead Campuses—Larry Smarr PI
  - USC, SDSU, NW, Texas A&M, UvA, SARA Partnering Campuses
- **Industrial Partners**
  - IBM, Sun, Telcordia, Chiaro, Calient, Glimmerglass, Lucent
- **$13.5 Million Over Five Years**
- **Optical IP Streams From Lab Clusters to Large Data Objects**

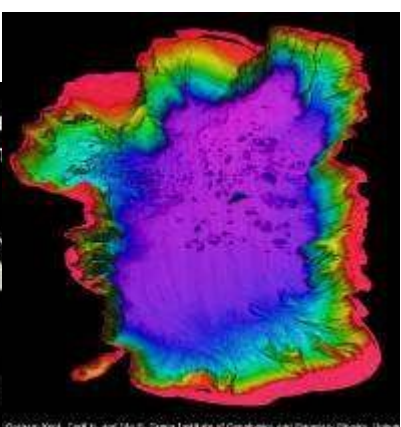
NIH Biomedical Informatics Research Network



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

NSF EarthScope and ORION





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

OptIPuter SDSC

What is the OptIPuter?

- **Optical networking, Internet Protocol, Computer Storage, Processing and Visualization Technologies**
  - **Dedicated Light-pipe (One or More 1-10 Gbps WAN Lambdas)**
  - **Links Linux Cluster End Points With 1-10 Gbps per Node**
  - **Clusters Optimized for Storage, Visualization, and Computing**
  - **Does NOT Require TCP Transport Layer Protocol**
  - **Exploring Both Intelligent Routers and Passive Switches**

- **Applications Drivers:**
  - **Interactive Collaborative Visualization of Large Remote Data Objects**
    - **Earth and Ocean Sciences**
    - **Biomedical Imaging**

- **The OptIPuter Exploits a New World in Which the Central Architectural Element is Optical Networking, NOT Computers - Creating "SuperNetworks"**

OptIPuter

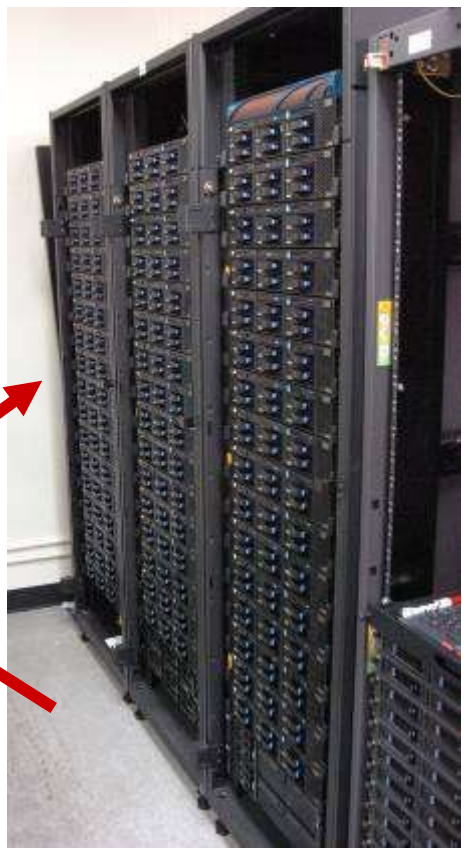
it²

UCSD Campus LambdaStore Architecture

SIO Ocean Supercomputer

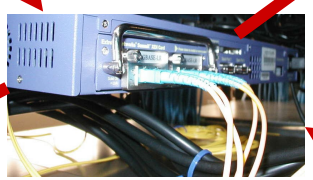


IBM Storage Cluster



Streaming Microscope





Extreme switch with 2 ten gigabit uplinks





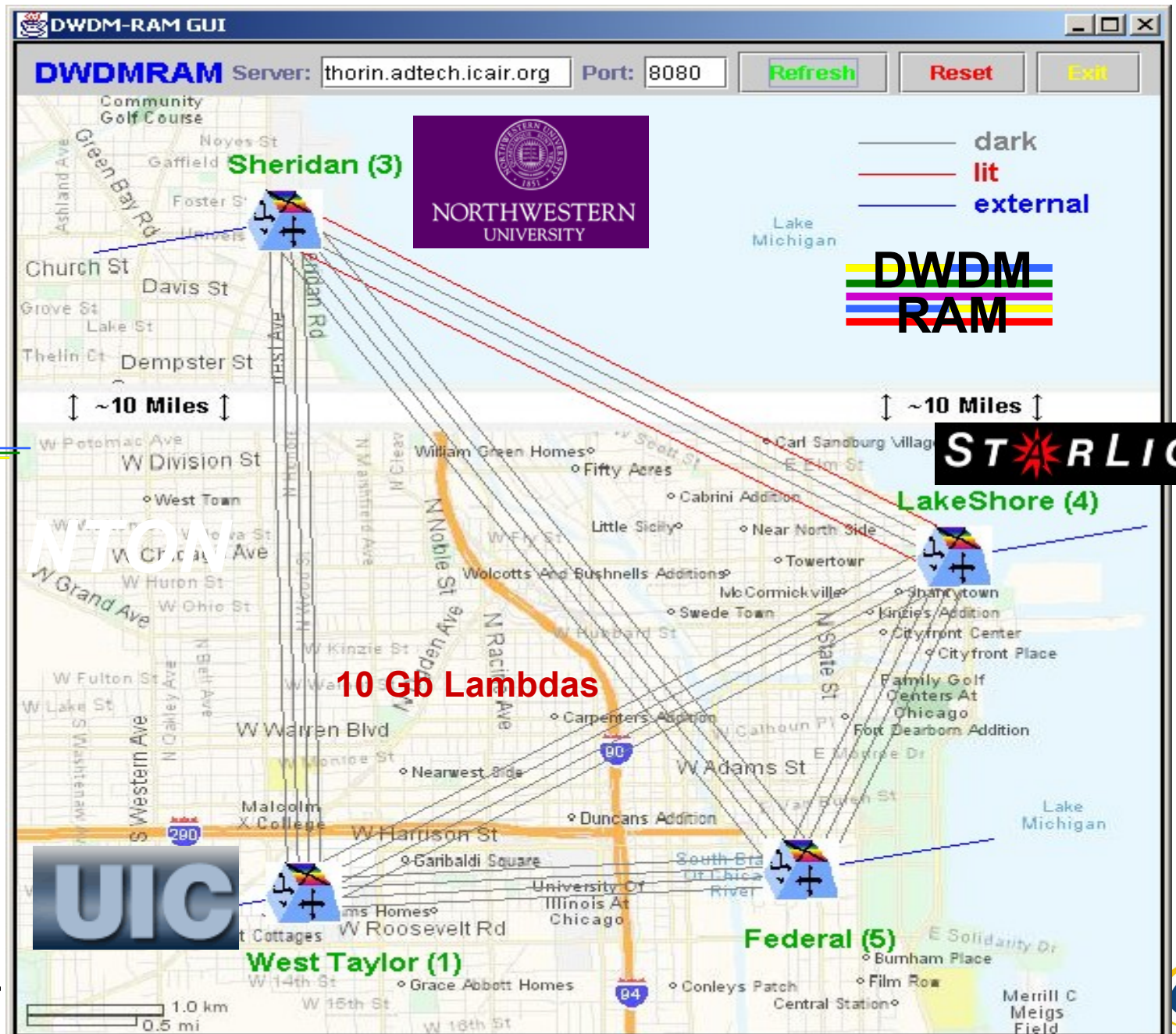




OptIPuter

it2

OMNInet
The Metro Area OOO Tesbed



10GE OptIPuter CAVEWAVE Helped Launch the National LambdaRail



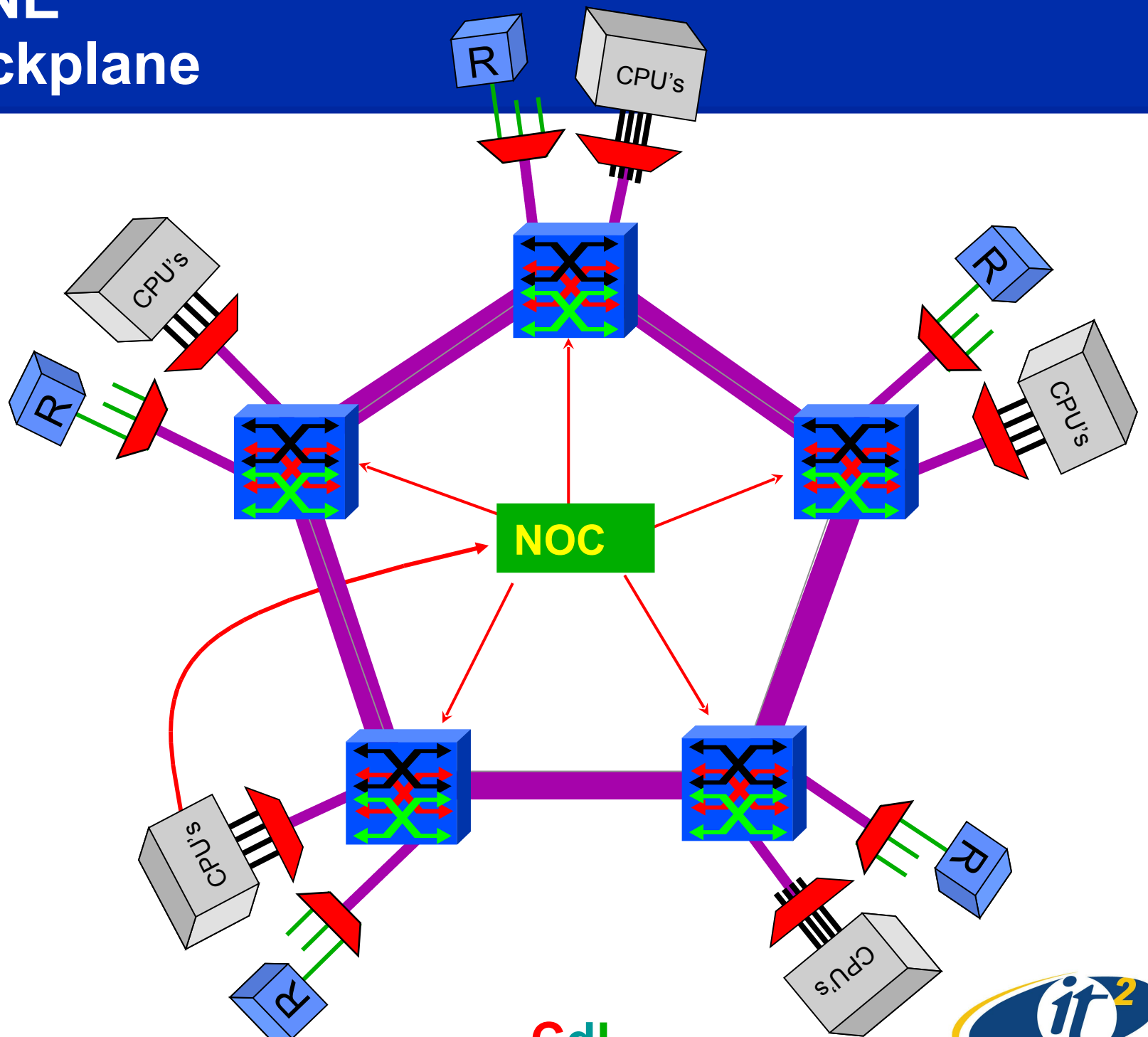
Next Step: Coupling NASA Centers to NSF OptIPuter

NASA

OptIPuter

Source: Tom DeFanti, OptIPuter co-PI

STARPLANE
DWDM Backplane



UvA-VLE
UvA-MM
VU
ULeiden
TUDelft

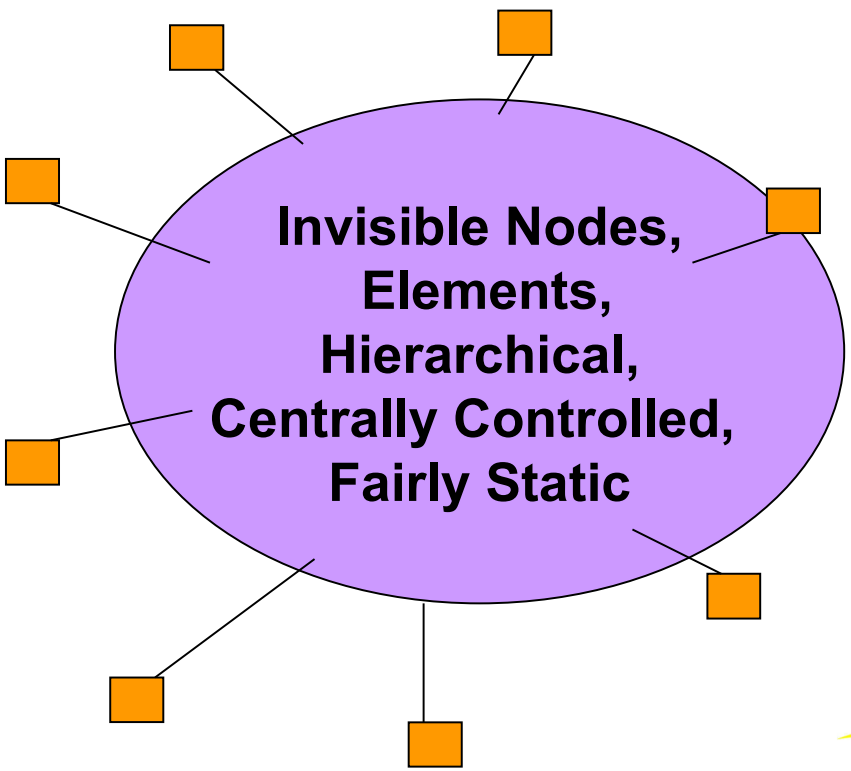
OptIPuter

CdL

it2

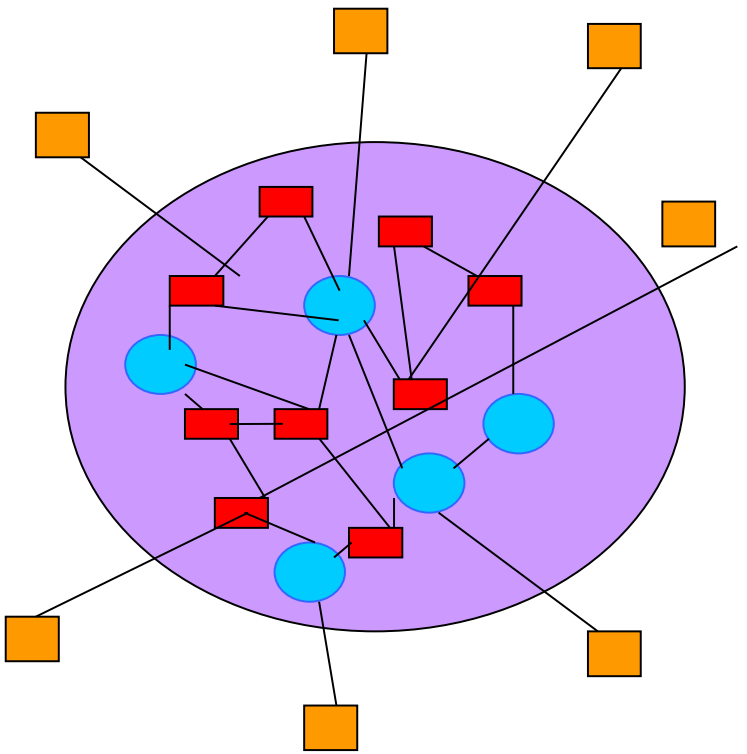
LambdaGrid Control Plane Paradigm Shift

Traditional Provider Services:
Invisible, Static Resources,
Centralized Management



Limited Functionality,
Flexibility

OptIPuter:
Distributed Device, Dynamic Services,
Visible & Accessible Resources,
Integrated As Required By Apps



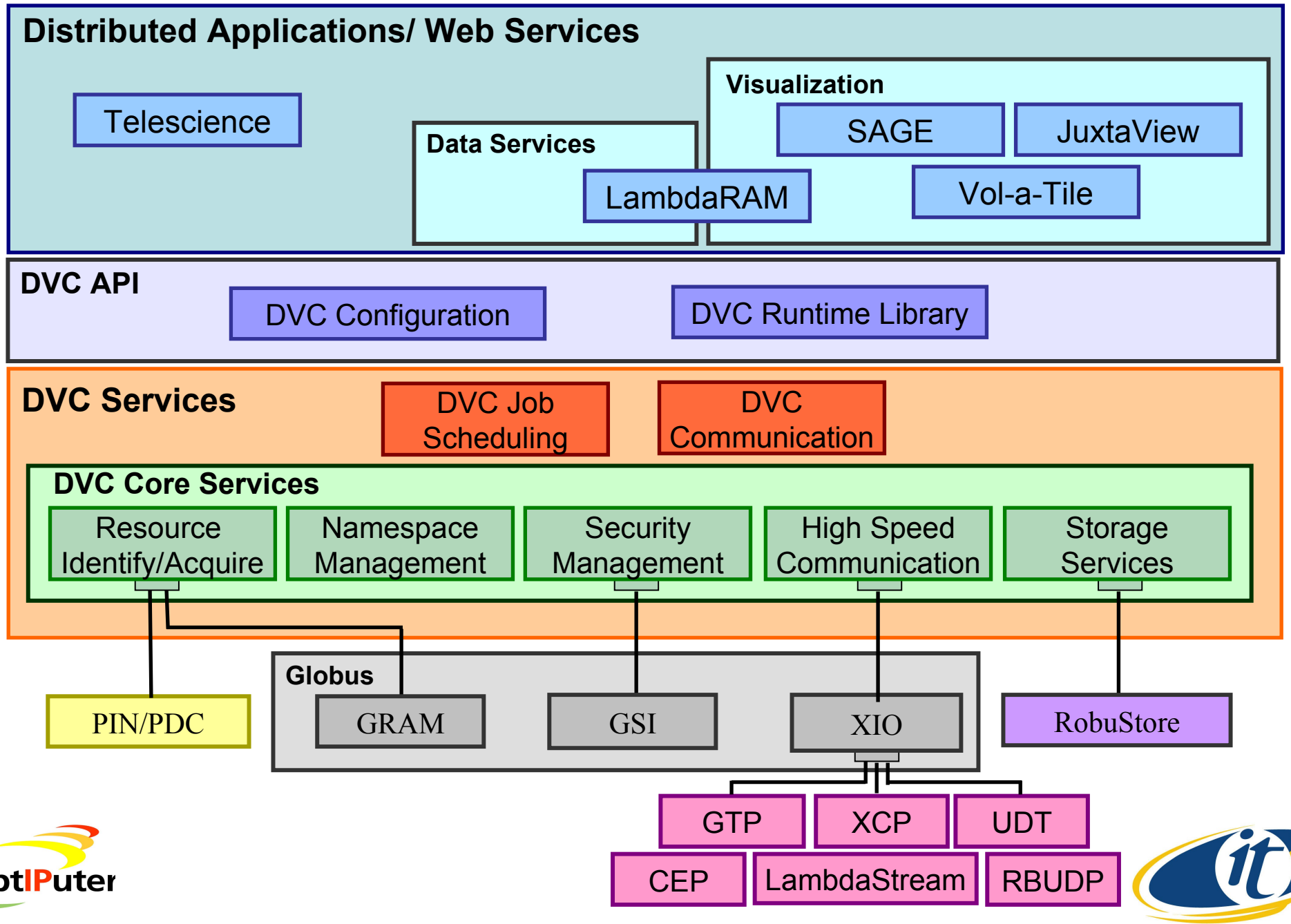
Unlimited Functionality,
Flexibility

OptIPuter

OptIPuter

Source: Joe Mambretti, Oliver Yu, George Clapp

OptIPuter Software Architecture



OptIPuter End Nodes Are Smart Bit Buckets
i.e. Scalable Standards-Based Linux Clusters with Rocks & Globus

Building RockStar at SC2003







Complete SW Install and HW Build

- From Piles of Parts to Running Cluster in Under 2 Hours
- Computational Chemistry & Brain Image Segmentation Ran
- Included the NSF Middleware (NMI) R3 Release of Software

Rocks is the 2004 Most Important Software Innovation
HPCwire Reader's Choice and Editor's Choice Awards

Source: Phil Papadopoulos, SDSC

Sun microsystems
SDSC
ROCKS
GAMESS
BIRN
OMEDICAL INFORMATICS RESEARCH NETWORK
NPACI

OptIPuter Scalable Display Systems



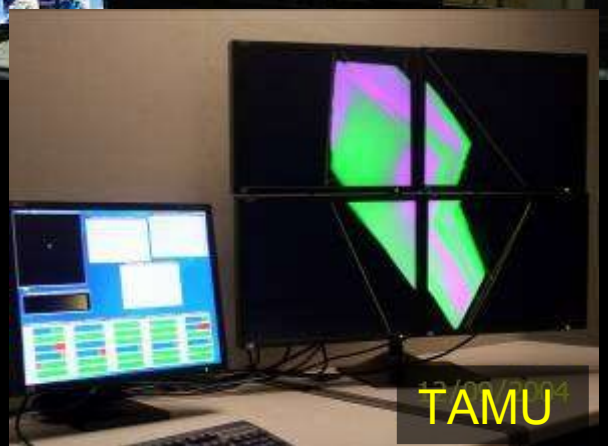
















Terabits to the Desktop by 2010

- Simplified User View
- Terabit Fiber Connection To The Desktop
- Integrated Photonics And Electronics
- Single Fiber Dense-WDM
- Packets And Flows
- Encryption
- …

“ Ethernet ”	
1990	10 Mb
1995	100 Mb
1998	1 Gb
2002	10 Gb
2006	100 Gb
2008	1 Tb
2010	10 Tb

Source: Steven Squires,
Chief Scientist HP

OptIPuter is Prototyping The PC of 2010

- Terabits to the Desktop…
- 100 Megapixels Display
  - 55-Panel
- 1/3 Terabit/sec I/O
  - 30 x 10GE interfaces
  - Linked to OptIPuter
- 1/4 TeraFLOP
  - Driven by 30 Node Cluster of 64 bit Dual Opterons
- 1/8 TB RAM
- 60 TB Disk



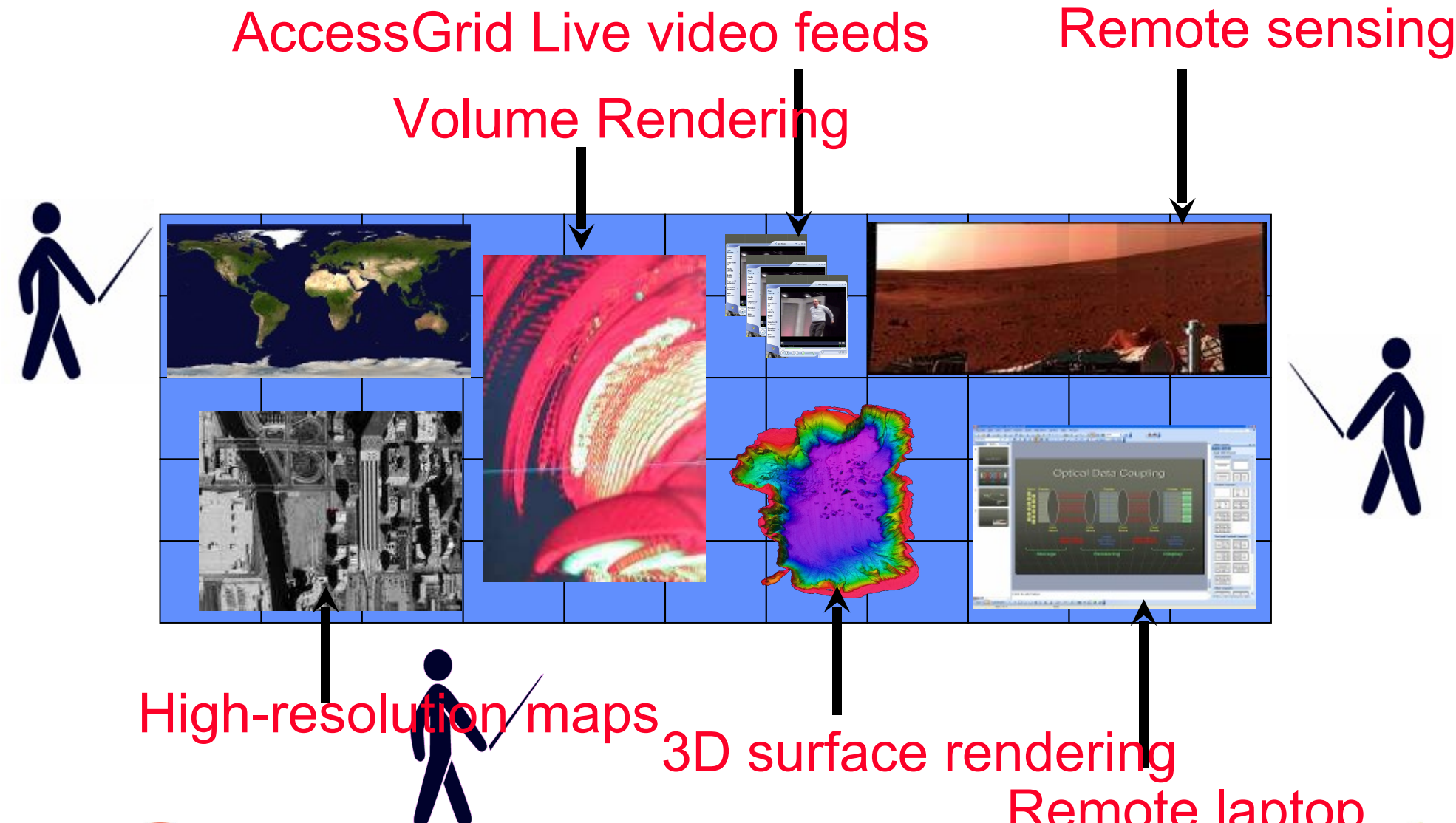
OptIPuter

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

it²

Scalable Adaptive Graphics Environment (SAGE) Required for Working in Display-Rich Environments

Information Must Be Able To Flexibly Move Around The Wall

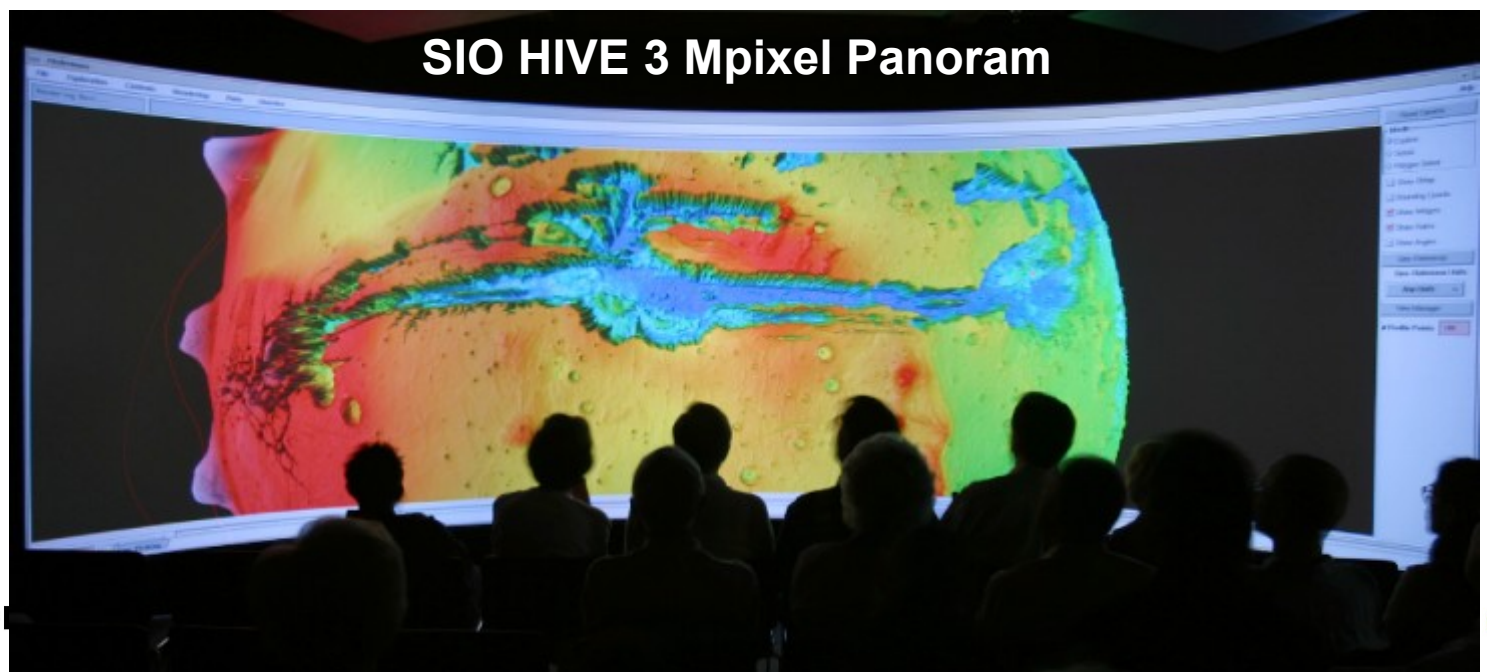


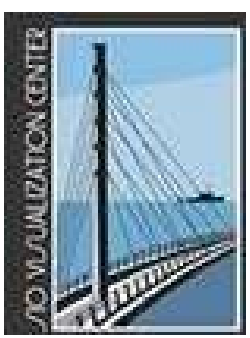
Source: Jason Leigh, UIC

Earth and Planetary Sciences are an OptIPuter Large Data Object Visualization Driver





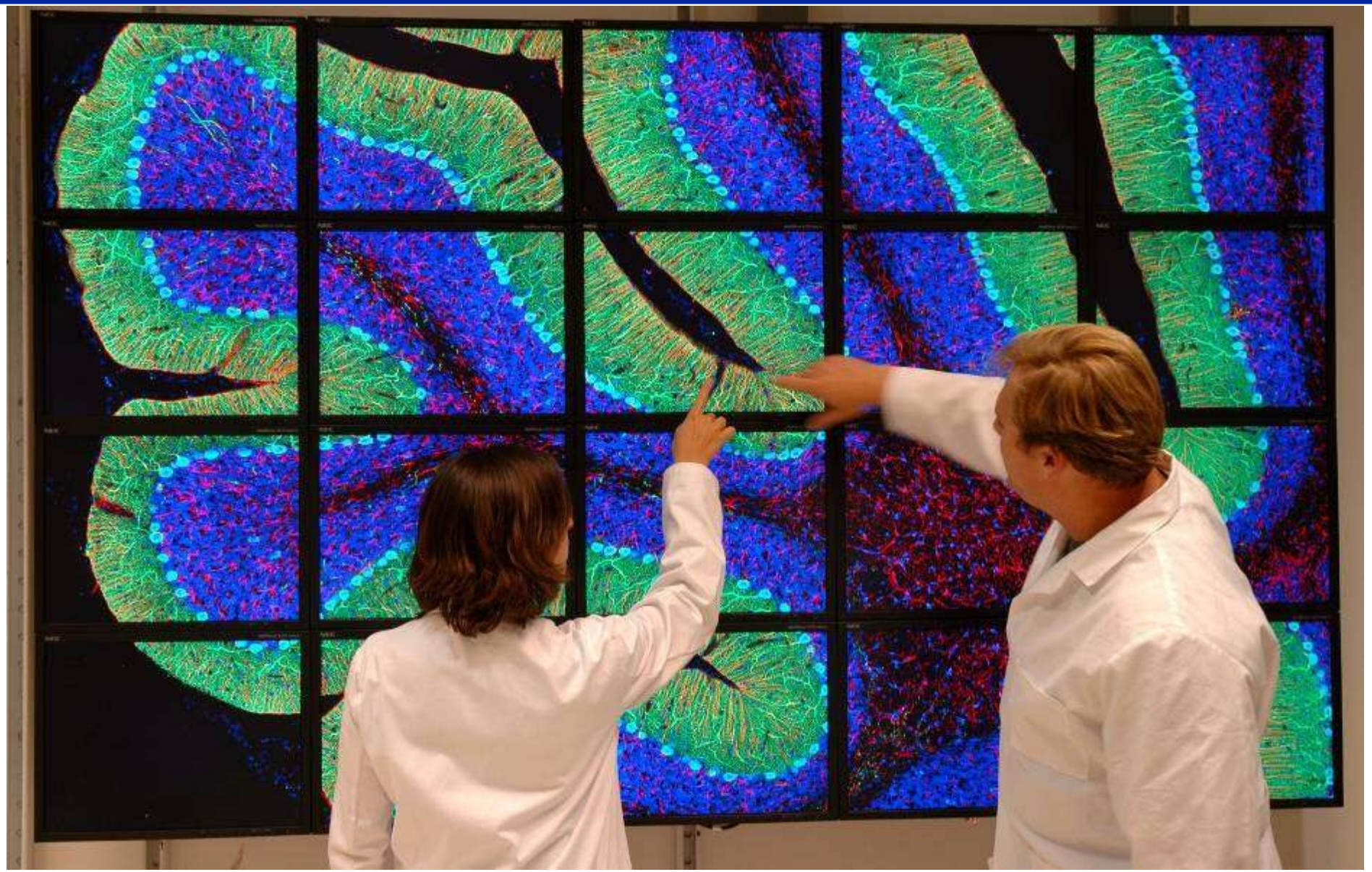




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OptIPuter JuxtaView Software for Viewing High Resolution Images on Tiled Displays



OptIPuter

30 Million Pixel Display
NCMIR Lab UCSD

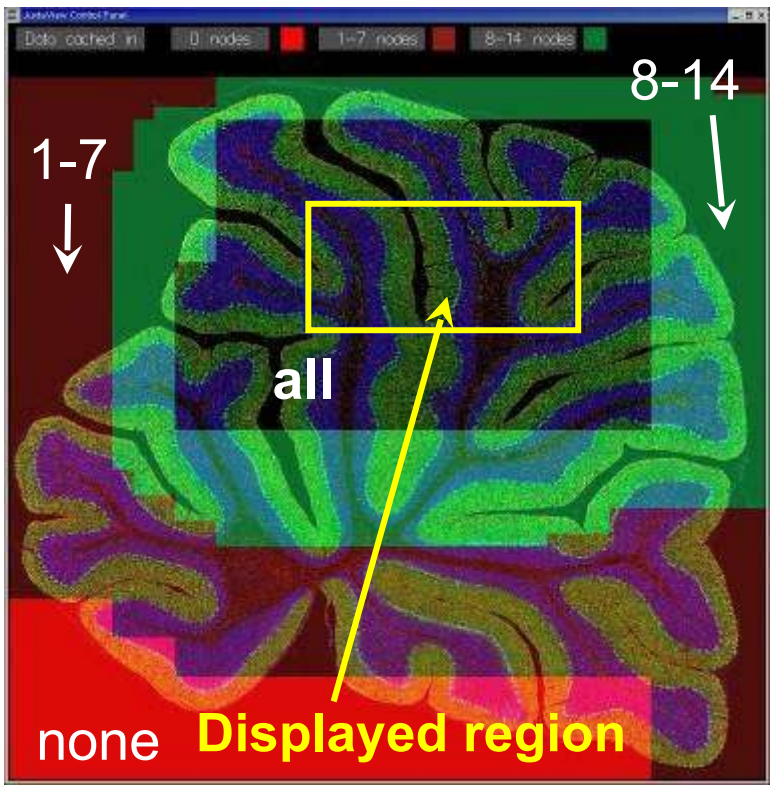
Source: David Lee, Jason Leigh

it²

LambdaRAM: Clustered Memory To Provide Low Latency Access To Large Remote Data Sets

- Giant Pool of Cluster Memory Provides Low-Latency Access to Large Remote Data Sets
  - Data Is Prefetched Dynamically
  - LambdaStream Protocol Integrated into JuxtaView Montage Viewer
- 3 Gbps Experiments from Chicago to Amsterdam to UIC
  - LambdaRAM Accessed Data From Amsterdam Faster Than From Local Disk

Visualization of the Pre-Fetch Algorithm



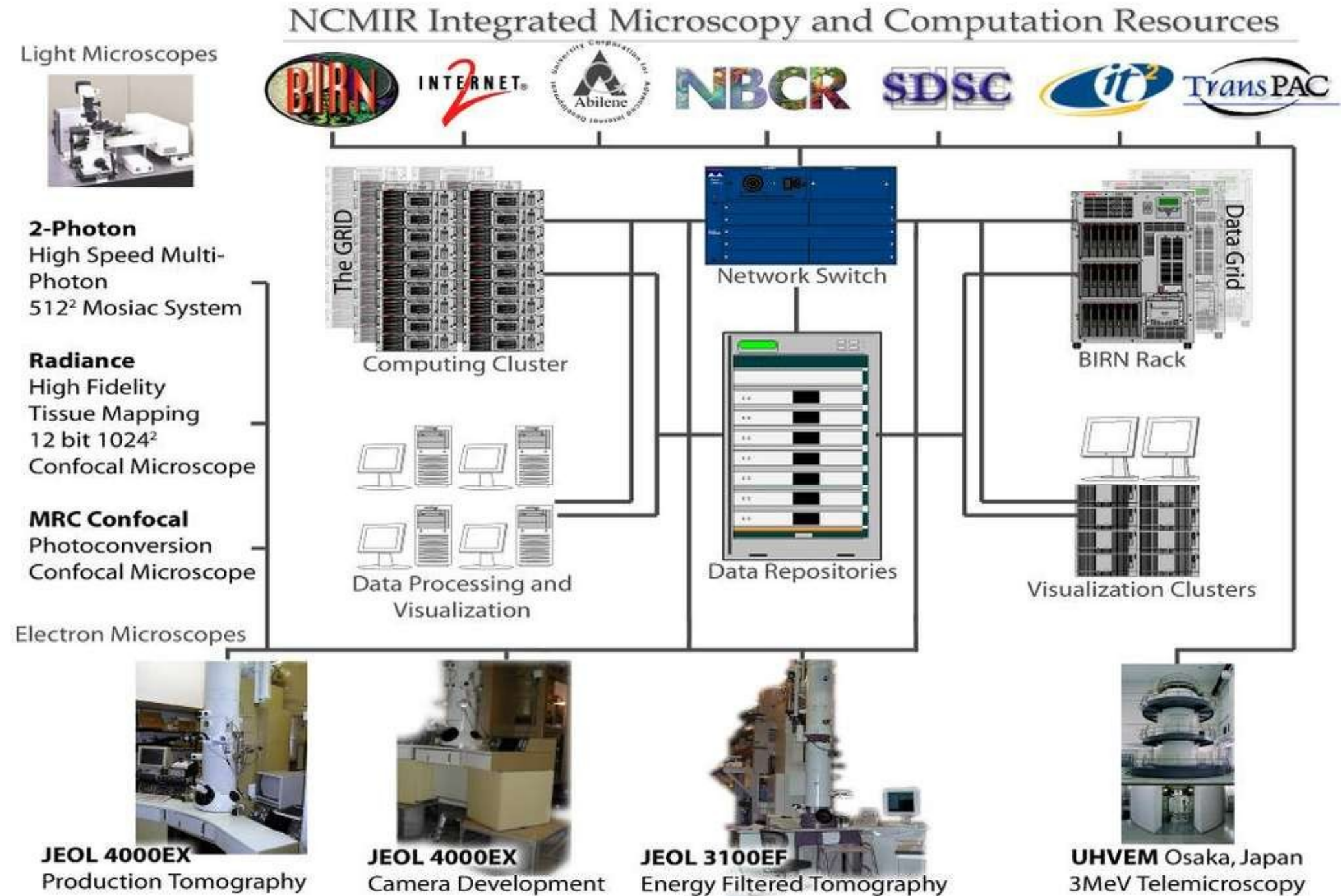


Data on Disk in Amsterdam

Source: David Lee, Jason Leigh

Accessible Resources for Advanced Biological Imaging

Fielding High-throughput Microscopes, Computational Analysis Tools and Databases



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

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



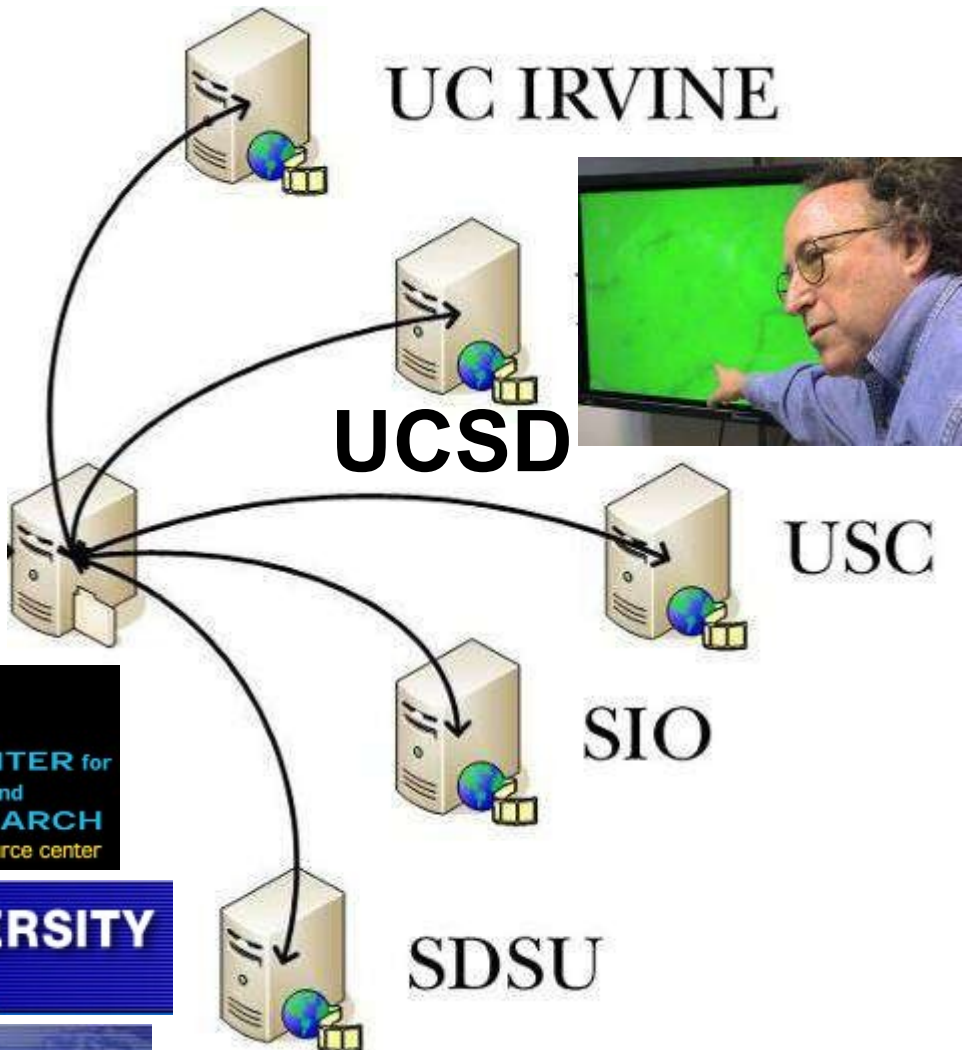




HDTV



Southern California OptIPuter



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

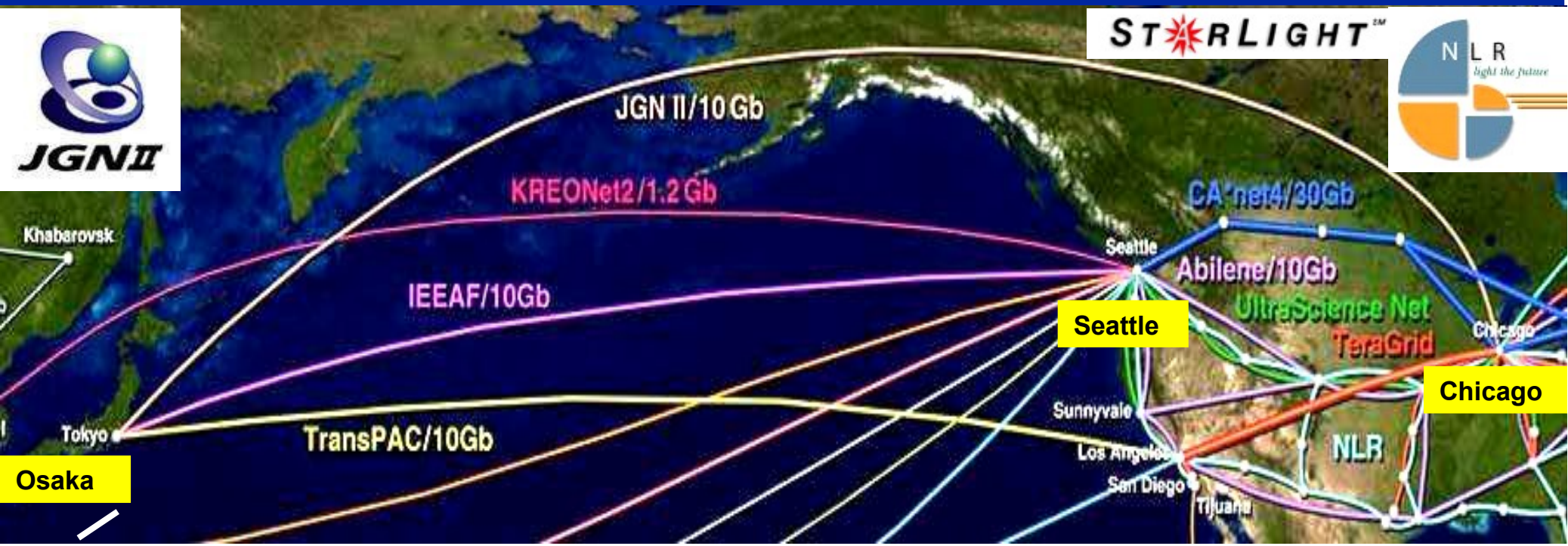
OSAKA UNIVERSITY

KDDI GROUP KDDI Labs USA

Source: Mark Ellisman, UCSD

it²

JGNII Keynote-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)

OptIPuter

Enabled by International Human Networks

it2

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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Telepresence Using Uncompressed HDTV Streaming Over IP on Fiber Optics







OptIPuter

JGN II Workshop
January 2005

it²

Cal-(IT)^2 UCI/UCSD Team Studying Collaborative Practice

- Biomedical Informatics Research Network
  - Integration of Collaboration Technologies into Medical Practice & Research
  - Integration of Collaboration & Distributed Visualization
- Supporting Communities of Practice
  - Collaboration is Not Just "Multiple Users"
  - Understand Collective Action & Collective Practice
    - How Subgroups Form & Act Within Communities
  - How Communities Shape Individual Actions
- Organic Growth Is Key
  - "Technology First" Solutions Fail
  - Let Technology & Practice Develop Together
  - Design for Evolution & Adaptation

OptIPuter

Source: Paul Dourish, UCI

it^2

The Continuum Project: A Mixed Set of Interfaces for Collaboration

Passive stereo Immersive Display

Access Grid

Plasma Touch-screen (annotations)

Mix Wireless Devices with Ultra-Broadband Fiber Back End

Tiled High Resolution Display



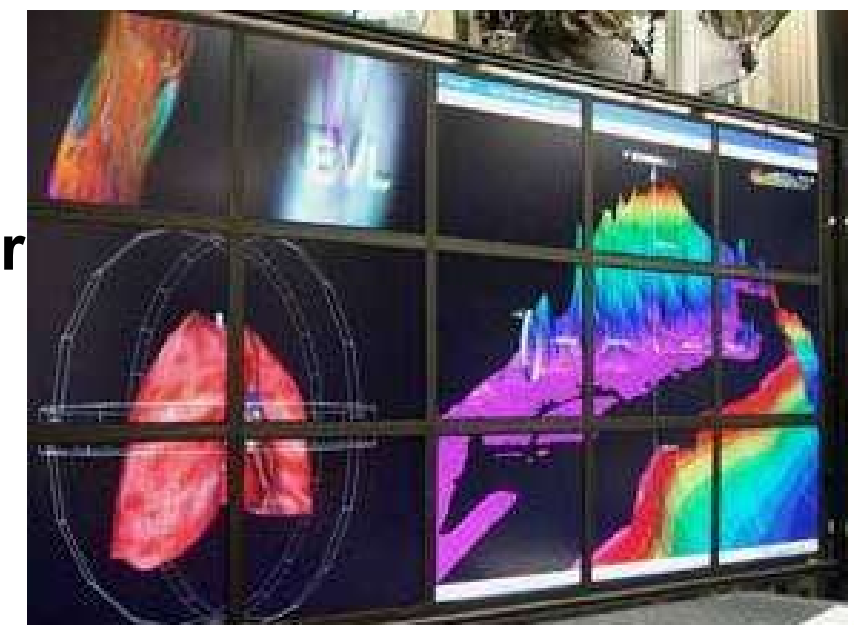
OptIPuter

Source: Jason Leigh, EVL, UIC

it2

TeraVision Multicasting Foundation for "Access LambdaGrid"

- **TeraVision** – Networked-Graphics Appliance for Streaming High Resolution DVI-Signals From Computers & High Definition Cameras Over Gigabit Lambdas
- **~600Mb/s MULTICAST** Graphics Streaming at 1024x768 at 30fps With No Compression Over I-WIRE Between UIC, TRECC (1 Hour From Chicago) & NCSA (2 Hours From Chicago)
- Currently Testing Streams Between EVL & UCSD Over 10 Gbps CAVEwave
- Will Conduct Higher Resolution & Wider Area Multicast **at SC Global 2004**
  - **Thursday, November 11, 11:30AM - 12:00PM**

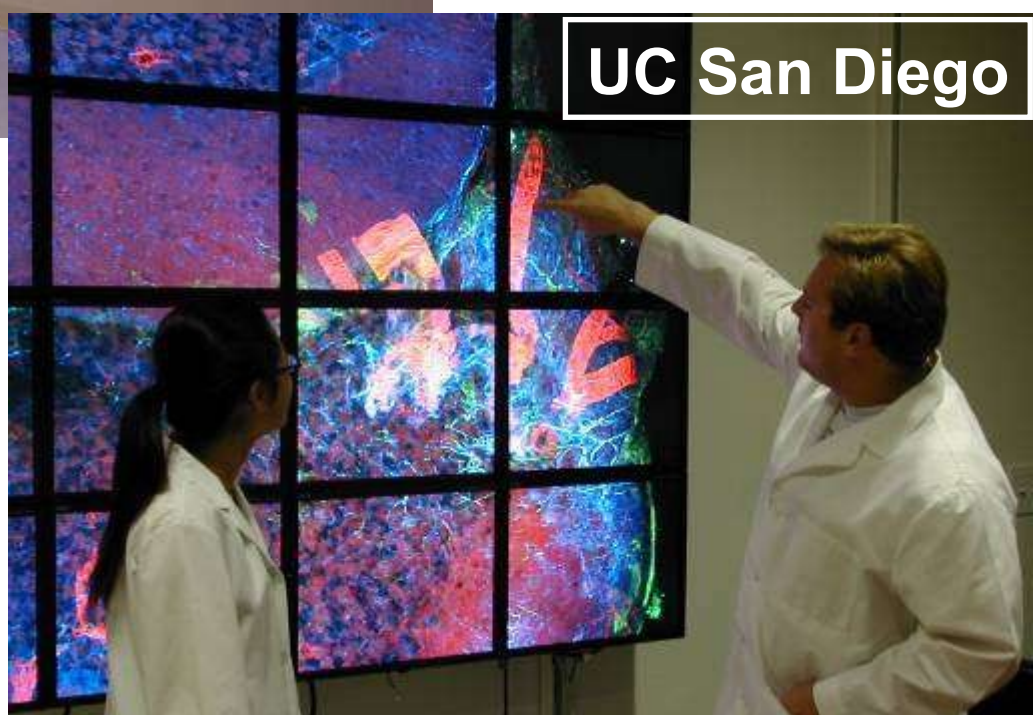


Source: Jason Leigh, EVL, UIC

Enhanced Collaboration Using DV, HD and SHD over IP



OptIPuter



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

OptIPuter

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

OptIPuter

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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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Interactive Remote Data and Visualization Services

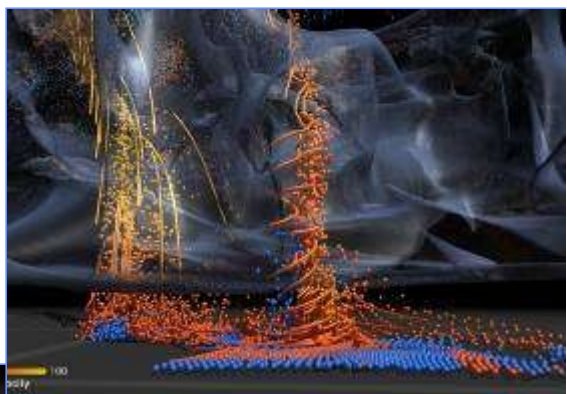


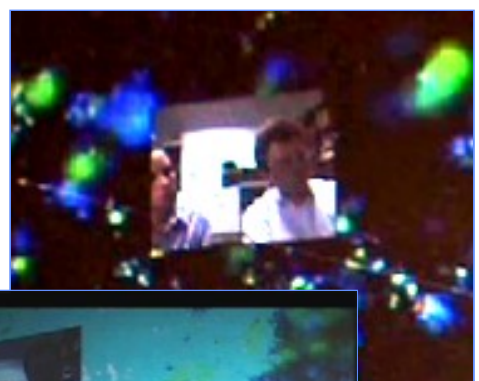
- Scientific-Info Visualization
- AMR Volume Visualization
- Glyph and Feature Vis
- Visualization Services

- Multiple Scalable Displays
- Hardware Pixel Streaming
- Distributed Collaboration

NCSA Altix Data and Vis Server



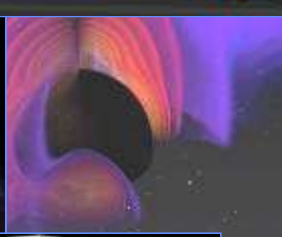


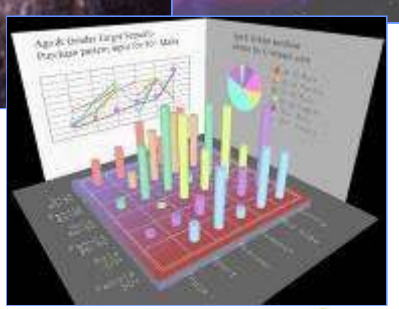












Linking to OptIPuter Over I-WIRE

- Data Mining for Areas of Interest
- Analysis and Feature Extraction
- Data Mining Services

Source: Donna Cox, Bob Patterson, NCSA

OptIPuter

National Laboratory for Advanced Data Research

An SDSC/NCSA Data Collaboration

it2

The OptIPuter: GeoScience

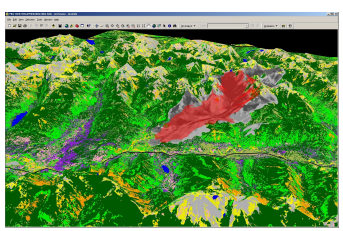
- **USGS leverages OptIPuter technologies to utilize high-resolution (0.3-meter) ortho-imagery of 133 most-populated metropolitan areas of the United States in support of Homeland Security initiatives**
- **USGS looks to the OptIPuter project to provide leadership in developing and deploying next-generation affordable, interactive, large-scale display and Earth science analysis technologies**

China Minister of Science and Technology, USGS Director Chip Groat





Predictive Forest Fire Model Animation, Virtual Forest Simulation





Senate Minority Leader (at the time) Sen. Daschle



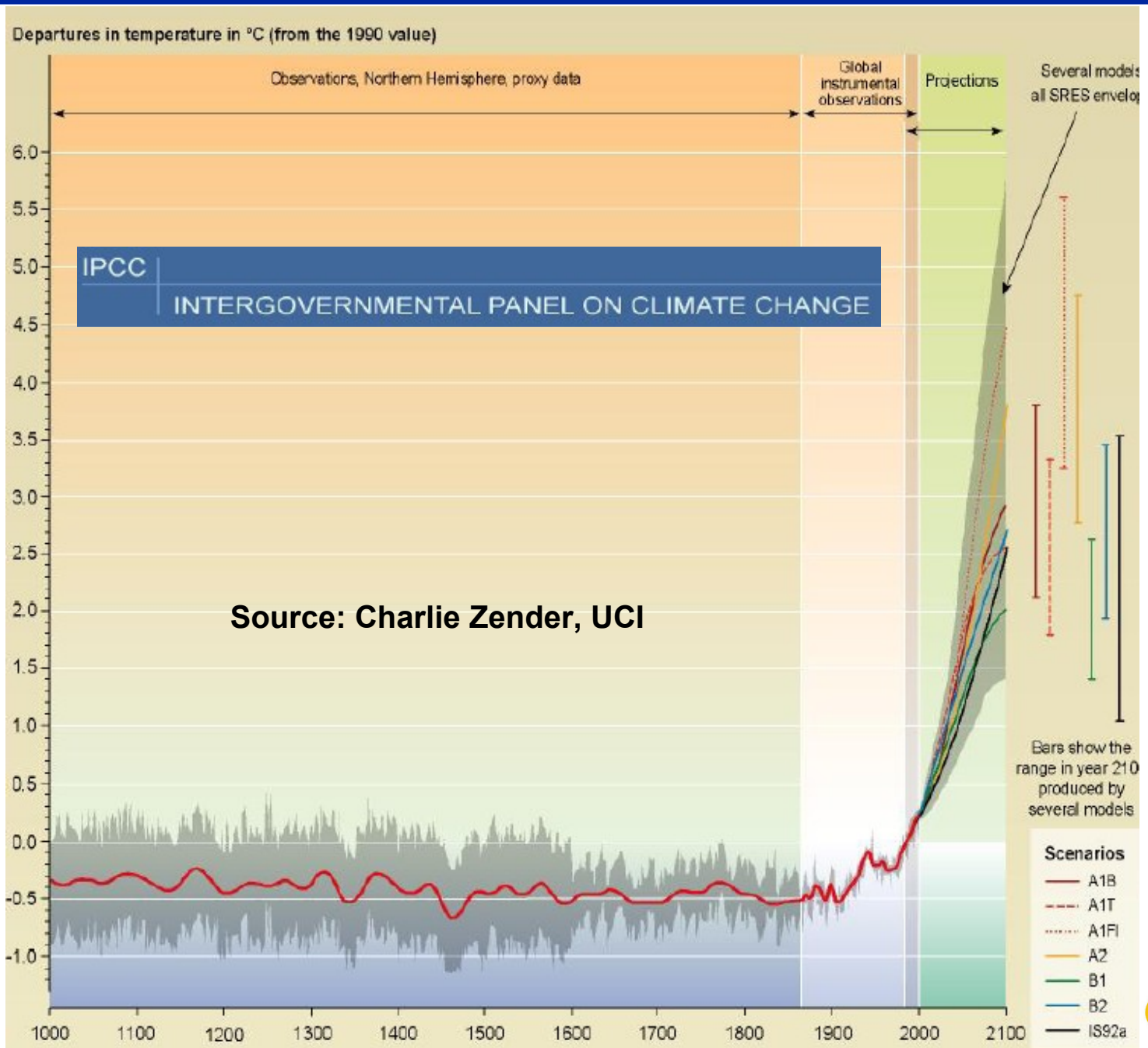
USGS Earth Resources Observation Systems (EROS) Data Center http://edc.usgs.gov
UIC Electronic Visualization Laboratory www.evl.uic.edu/cavern/optiputer

OptIPuter

USGS science for a changing world

it2

Variations of the Earth Surface Temperature Over One Thousand Years



OptIPuter

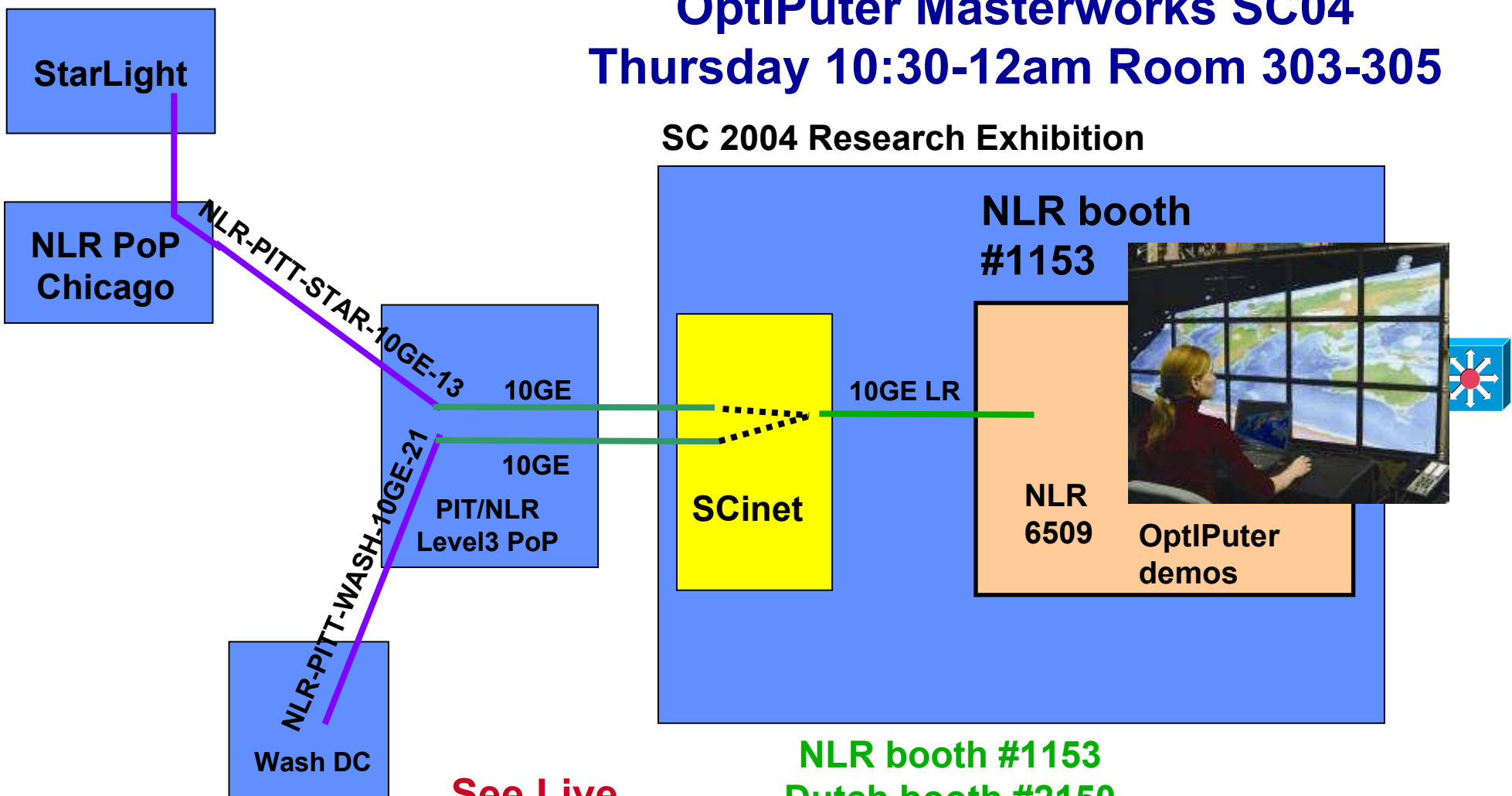
it2

Prototyping OptIPuter Technologies in Support of the IPCC

- **UCI Earth System Science Modeling Facility**
  - **Calit2 is Adding ESMF to the OptIPuter Testbed**
- **ESMF Challenge:**
  - **Improve Distributed Data Reduction and Analysis**
  - **Extending the NCO netCDF Operators**
    - **Exploit MPI-Grid and OPeNDAP**
  - **Link IBM Computing Facility at UCI over OptIPuter to:**
    - **Remote Storage**
      - at UCSD
      - Earth System Grid (LBNL, NCAR, ONRL) over NLR
- **Support Next IPCC Assessment Report**

Source: Charlie Zender, UCI

For SC 2004, NLR is Extending CAVEwave to Pittsburgh, and Providing a DC Link to NASA Goddard



See Live OptIPuter/NLR Demos at SC04!

NLR booth #1153
Dutch booth #2150
Nortel booth #1333
USC booth #2649
NCSA booth #548

Interactive Retrieval and Hyperwall Display of Earth Sciences Images on a National Scale

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 and San Diego and from GSFC servers in McLean, VA, and displayed at the SC2004 in Pittsburgh

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

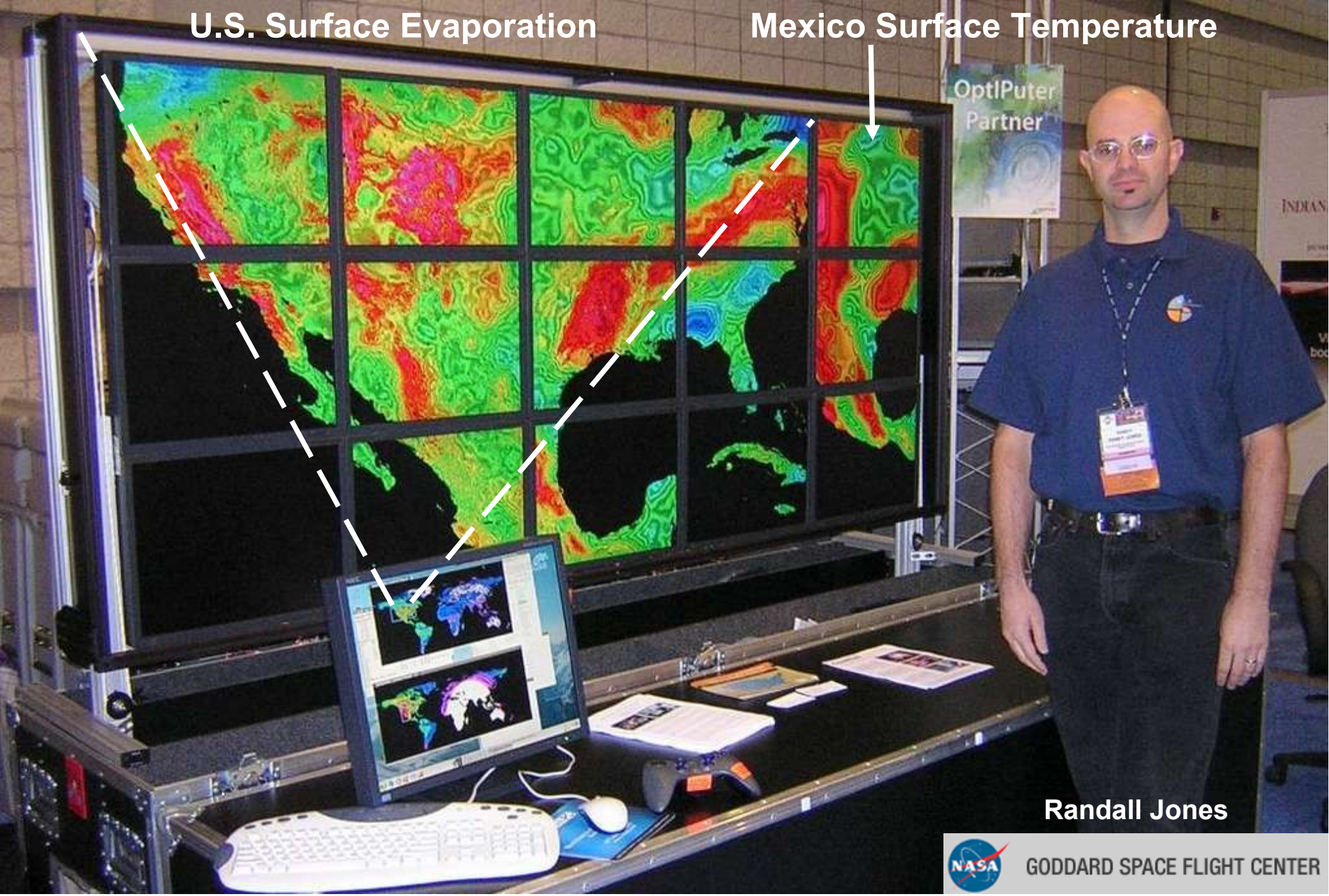
OptIPuter and NLR will Enable Daily Land Information System Assimilations

- **The Challenge:**
  - More Than Dozen Parameters, Produced Six Times A Day, Need to be Analyzed
- **The LambdaGrid Solution:**
  - Sending this Amount of Data to NASA Goddard from Project Columbia at NASA Ames for Human Analysis Would Require < 15 Minutes/Day Over NLR
- **The Science Result:**
  - Making Feasible Running This Land Assimilation System Remotely in Real Time

OptIPuter

Source: Milt Halem, NASA GSFC

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OptIPuter

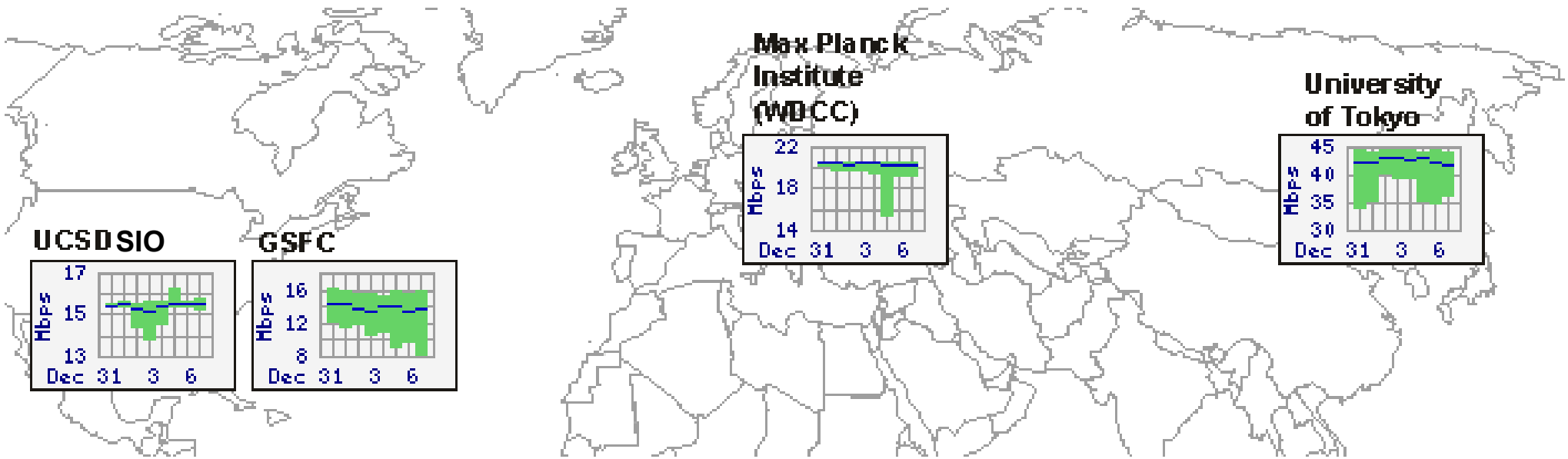
Global 1 km x 1 km Assimilated Surface Observations Analysis
Remotely Viewing ~ 50 GB per Parameter

it²

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

Source: Milt Halem, NASA GSFC

Accessing 300TB's of Observational Data in Tokyo and 100TB's of Model Assimilation Data in MPI in Hamburg -- Analyzing Remote Data Using GRaD-DODS at These Sites Using OptIPuter Technology Over the NLR and Starlight



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

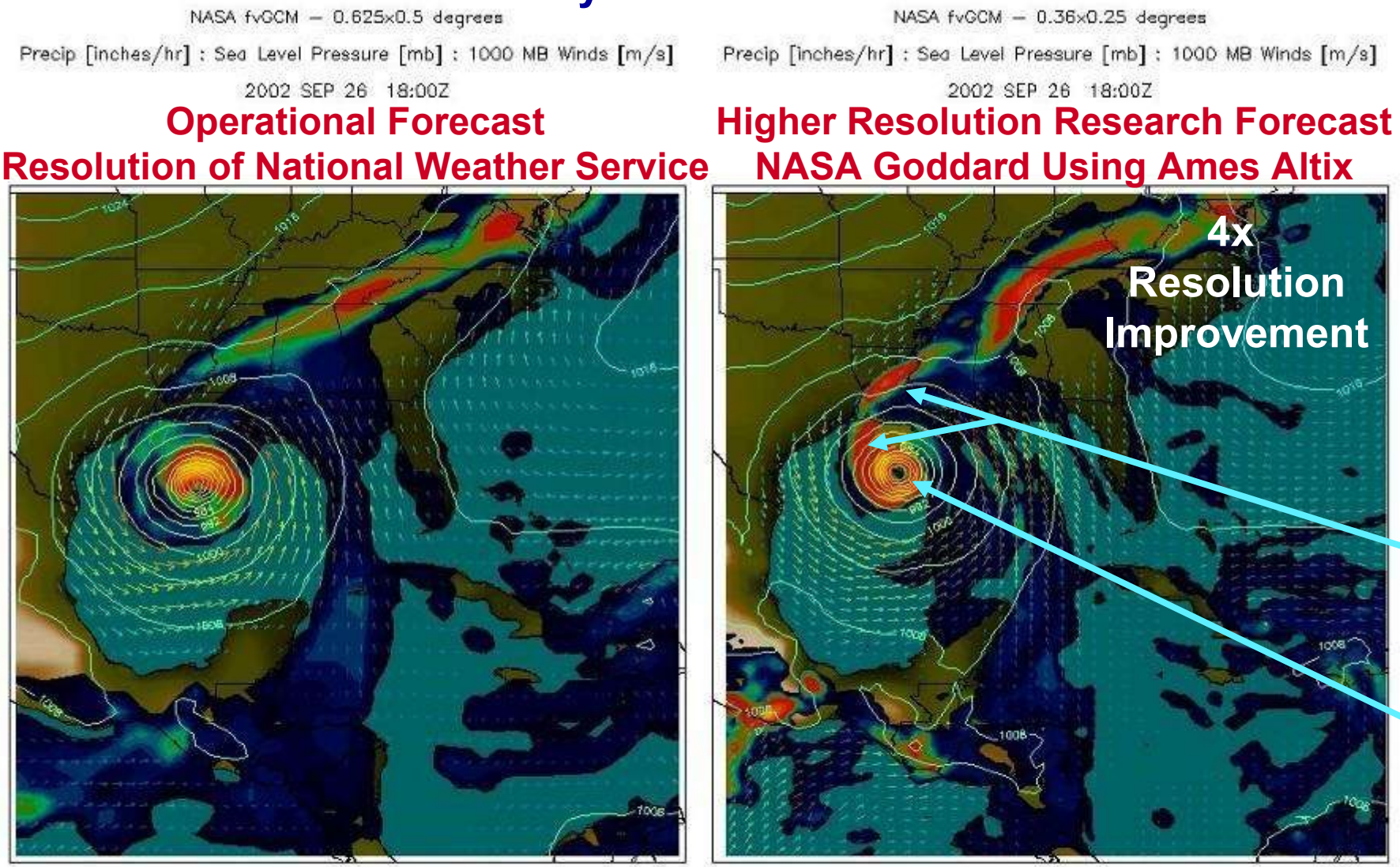
OptIPuter

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

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Increasing Accuracy in Hurricane Forecasts Ensemble Runs With Increased Resolution

5.75 Day Forecast of Hurricane Isidore



Operational Forecast Resolution of National Weather Service

Higher Resolution Research Forecast NASA Goddard Using Ames Altix

InterCenter Networking is Bottleneck

Intense Rain-Bands

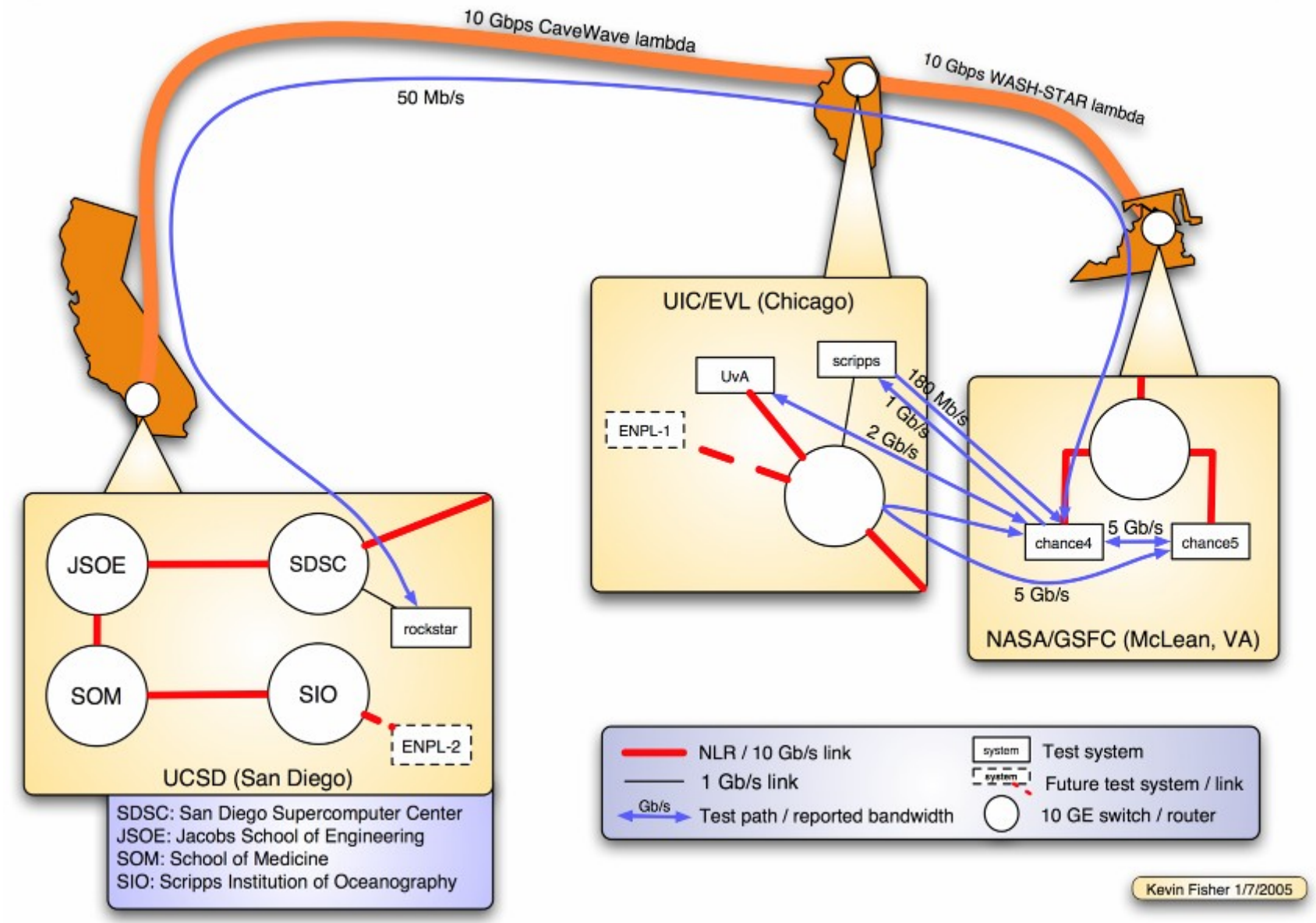
Resolved Eye Wall

Source: Bill Putman, Bob Atlas, GFSC

Further NASA OptIPuter Projects Being Defined

- **Global Aerosols**
  - GSFC and SIO Remote computing and analysis tools running over the NLR will enable acquisition and assimilation of the Project ABC data.
- **Remote Viewing and Manipulation of Large Earth Science Data Sets**
  - Remote viewing and manipulation of data sets at GSFC and JPL is needed to support EOSDIS and Earth system modeling.
- **Integration of Laser and Radar Topographic Data with Land Cover Data**
  - GSFC, JPL, and SIO will use the NLR and local data mining and subsetting tools to permit systematic fusion of global data sets, which are not possible with current bandwidth.

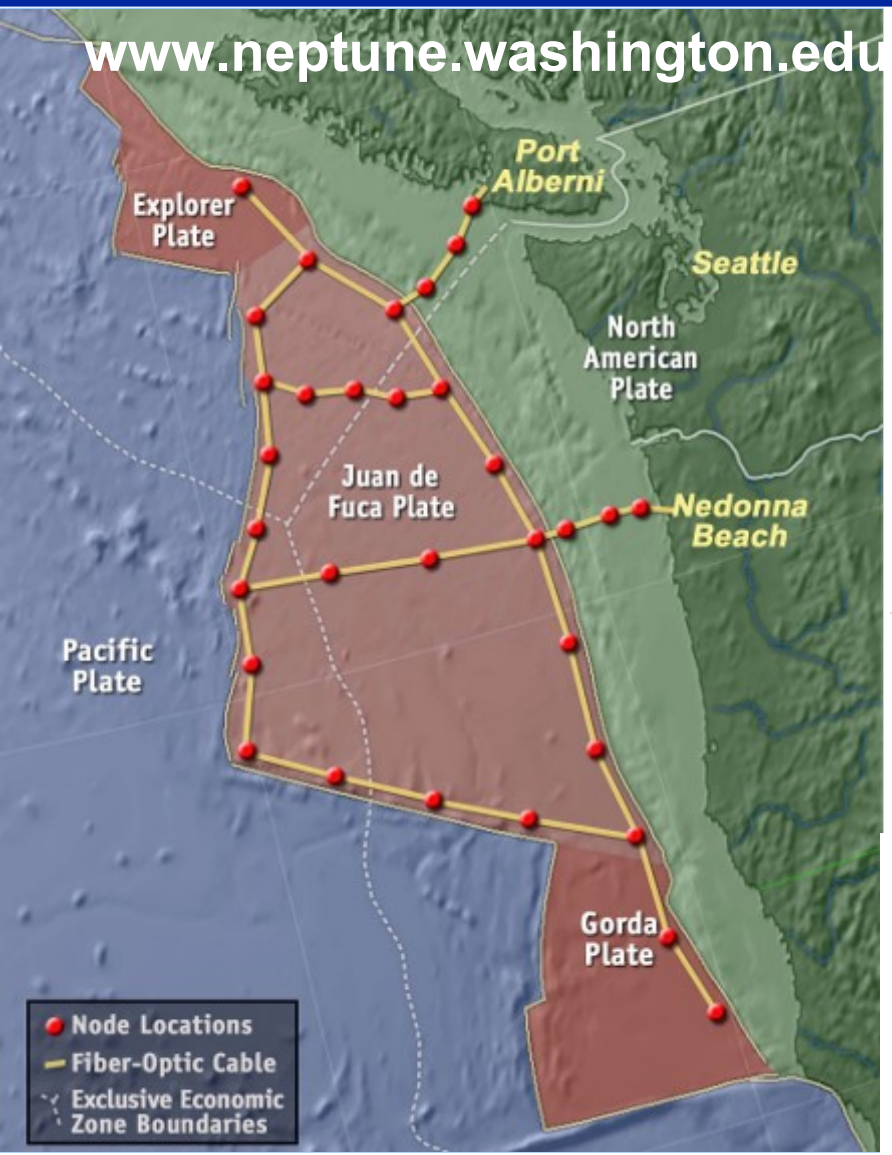
NASA GSFC Tests with OptIPuter Across the National Lambda Rail



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New OptIPuter Driver: Gigabit Fibers on the Ocean Floor
A Working Prototype Cyberinfrastructure for NSF's ORION



- NSF ITR with Principal Investigators
  - John Orcutt & Larry Smarr - UCSD
  - John Delaney & Ed Lazowska –UW
  - Mark Abbott – OSU
- Collaborators at:
  - MBARI, WHOI, NCSA, UIC, CalPoly, UVic, CANARIE, Microsoft, NEPTUNE-Canada







Southern California Coastal Ocean Observing System



LOOKING (Laboratory for the Ocean Observatory Knowledge Integration Grid) – Adding Web Services to LambdaGrids

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Goal – From Expedition to Cable Observatories with Streaming Stereo HDTV Robotic Cameras

http://disney.go.com/disneypictures/aliensofthedeep/alienseduguide.pdf

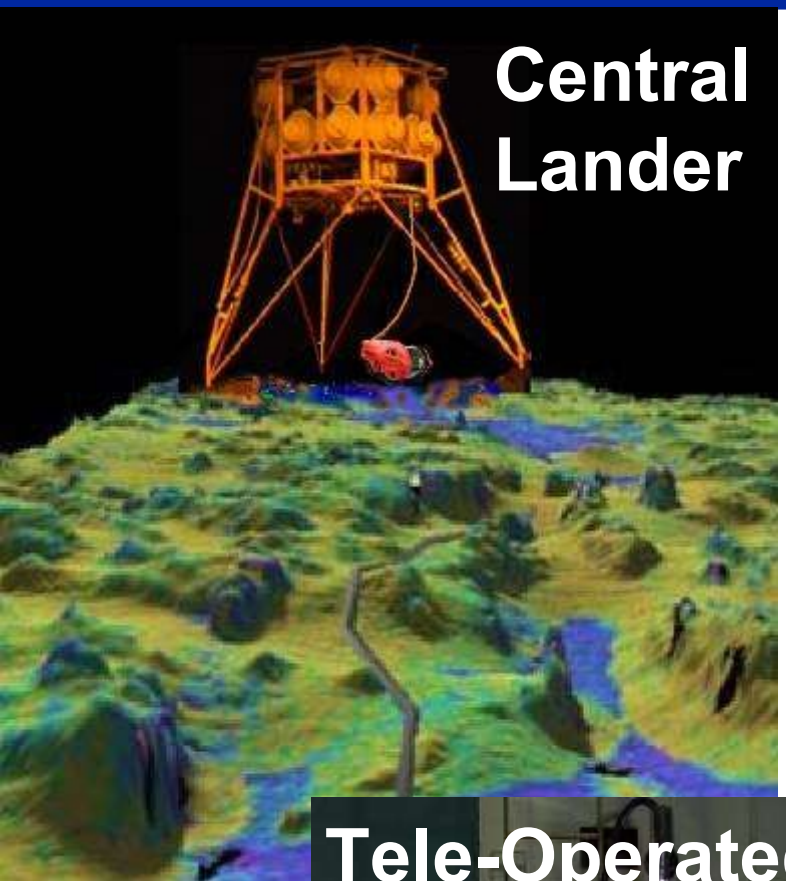




Scenes from The Aliens of the Deep, Directed by James Cameron & Steven Quale

OptIPuter

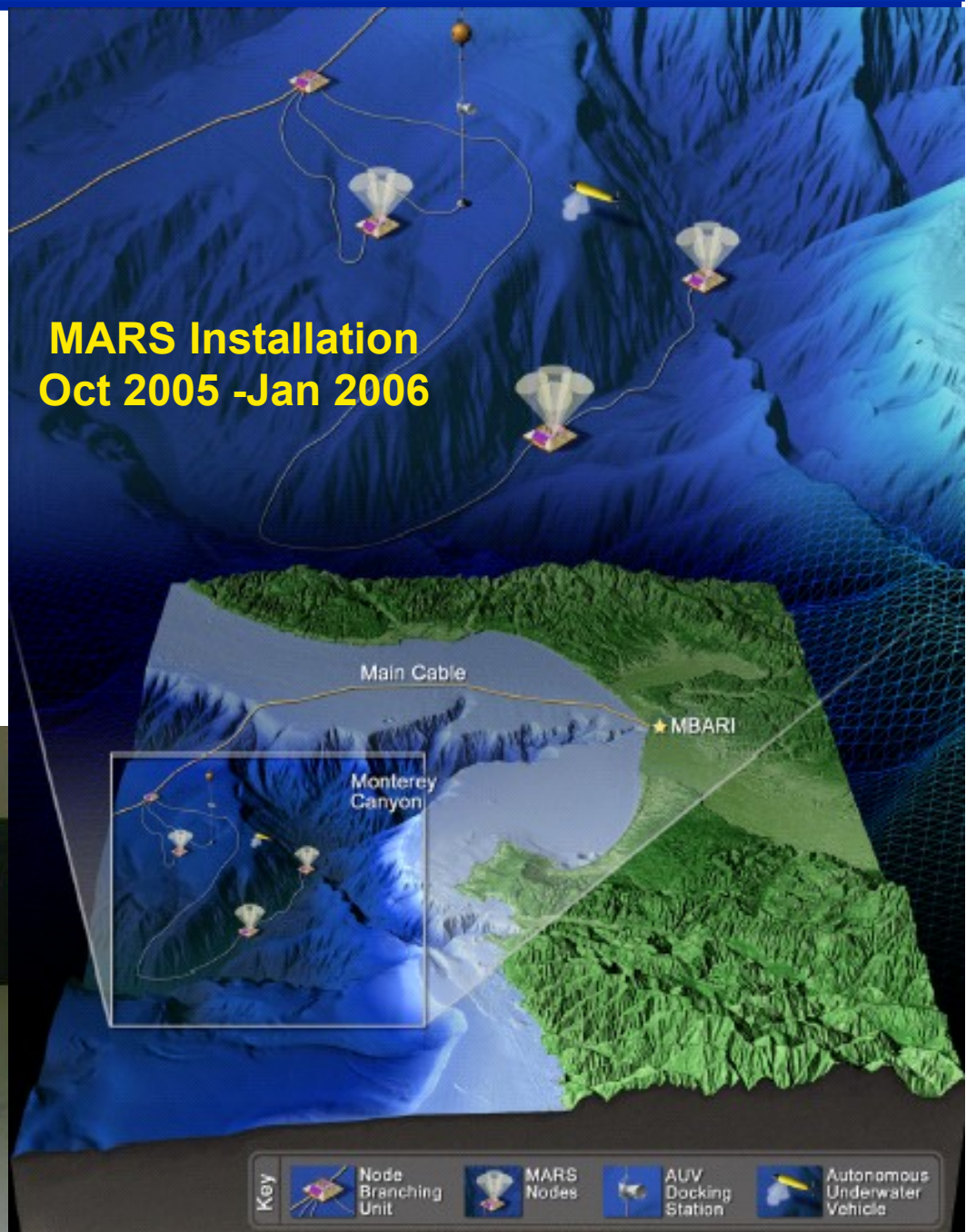
MARS New Gen Cable Observatory Testbed - Capturing Real-Time Basic Environmental Data





Source:
Jim
Bellingham,
MBARI

OptIPuter



OptIPuter is Expanding the Reach of its Education and Outreach Programs



OptIPuter Integration with Applications Will Be Driven by iGrid 2005…

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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