OptIPuter-A High Performance SOA LambdaGrid Enabling Scientific Applications

IEEE Computer Society Tsutomu Kanai Award Keynote
At the Joint Meeting of the:
8th International Symposium on Autonomous Decentralized Systems
2nd International Workshop on Ad Hoc, Sensor and P2P Networks
11th IEEE International Workshop on Future Trends of Distributed Computing Systems
Sedona, Arizona
March 21, 2007

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

During the last few years, a radical restructuring of optical networks supporting e-Science projects is beginning to occur around the world. U.S. universities are beginning to acquire access to private, high bandwidth light pipes (termed "lambdas") through the National LambdaRail and the Global Lambda Integrated Facility, providing direct access to global data repositories, scientific instruments, and computational resources from Linux clusters in individual user laboratories. These dedicated connections have a number of significant advantages over shared internet connections, including high bandwidth (10Gbps+), controlled performance (no jitter), lower cost per unit bandwidth, and security. These lambdas enable the Grid program to be completed, in that they add the network elements to the compute and storage elements which can be discovered, reserved, and integrated by the Grid middleware to form global LambdaGrids. I will describe how Service Oriented Architecture LambdaGrids enable new capabilities in medical imaging, earth sciences, interactive ocean observatories, and marine microbial metagenomics.

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NCSA Telnet--"Hide the Cray"
One of the Inspirations for the Metacomputer

Source: Larry Smarr 1985



John Kogut Simulating
Quantum Chromodynamics
He Uses a Mac—The Mac Uses the Cray

- NCSA Telnet Provides Interactive Access
  - From Macintosh or PC Computer
  - To Telnet Hosts on TCP/IP Networks

"Metacomputer"
Coined in 1988:

A User-Defined
"Virtual PC"
Composed of
Computers, Storage,
Visualization
Tied Together
By the Internet

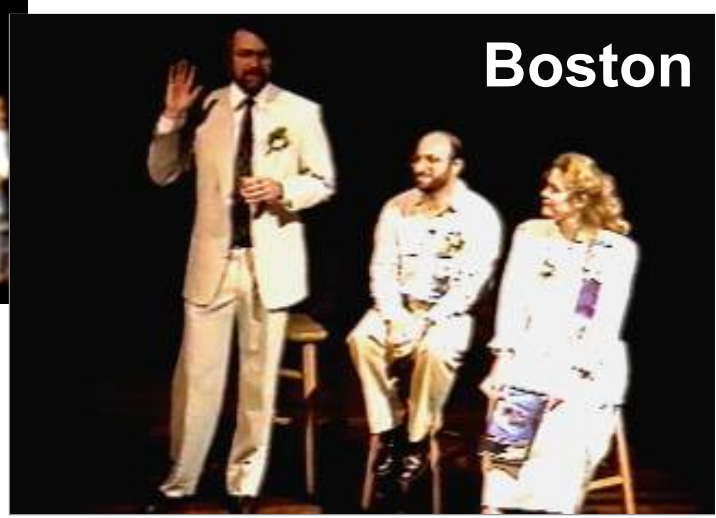
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Foreshadowing the OptIPuter:
Using Analog Communications to Prototype the Digital Future

"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

- **Collaboration:**
  - **Metacomputing**
  - **Remote Interactive Visual Supercomputing**
  - **Telepresence**





ATT & Sun



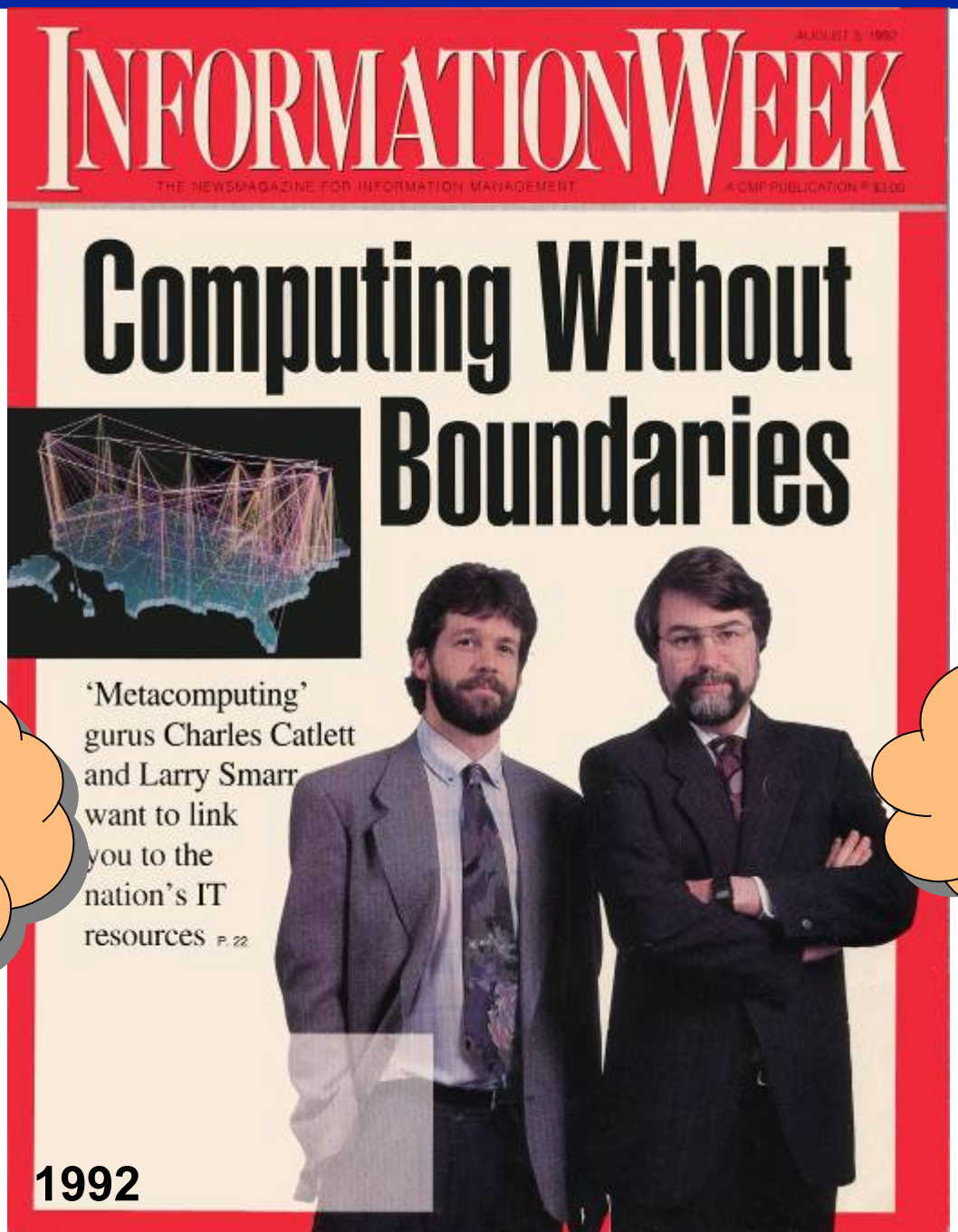
"We're using satellite technology…to demo what It might be like to have high-speed fiber-optic links between advanced computers in two different geographic locations."

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

NCSA™

SIGGRAPH 1989

From Metacomputer to TeraGrid and OptIPuter: Nearly 20 Years of Development…



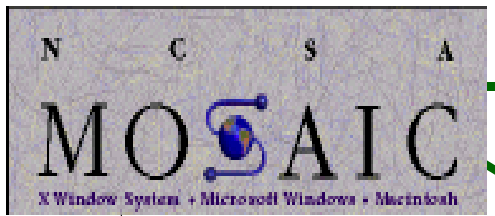
TeraGrid PI

OptIPuter PI

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NCSA Mosaic, a Module in *NCSA Collage* Desktop Collaboration Software, Led to the Modern Web World



Licensing

SPYGLASS

100 Commercial Licensees

NCSA Programmers

NETSCAPE

Microsoft Internet Explorer 4.0

1993

NCSA Collage

1990

CERN

The world's largest particle physics laboratory ... where the web was born!

NCSA HTTPd

Open Source

APACHE HTTP SERVER PROJECT

Mac OS X Server



IBM WebSphere Software



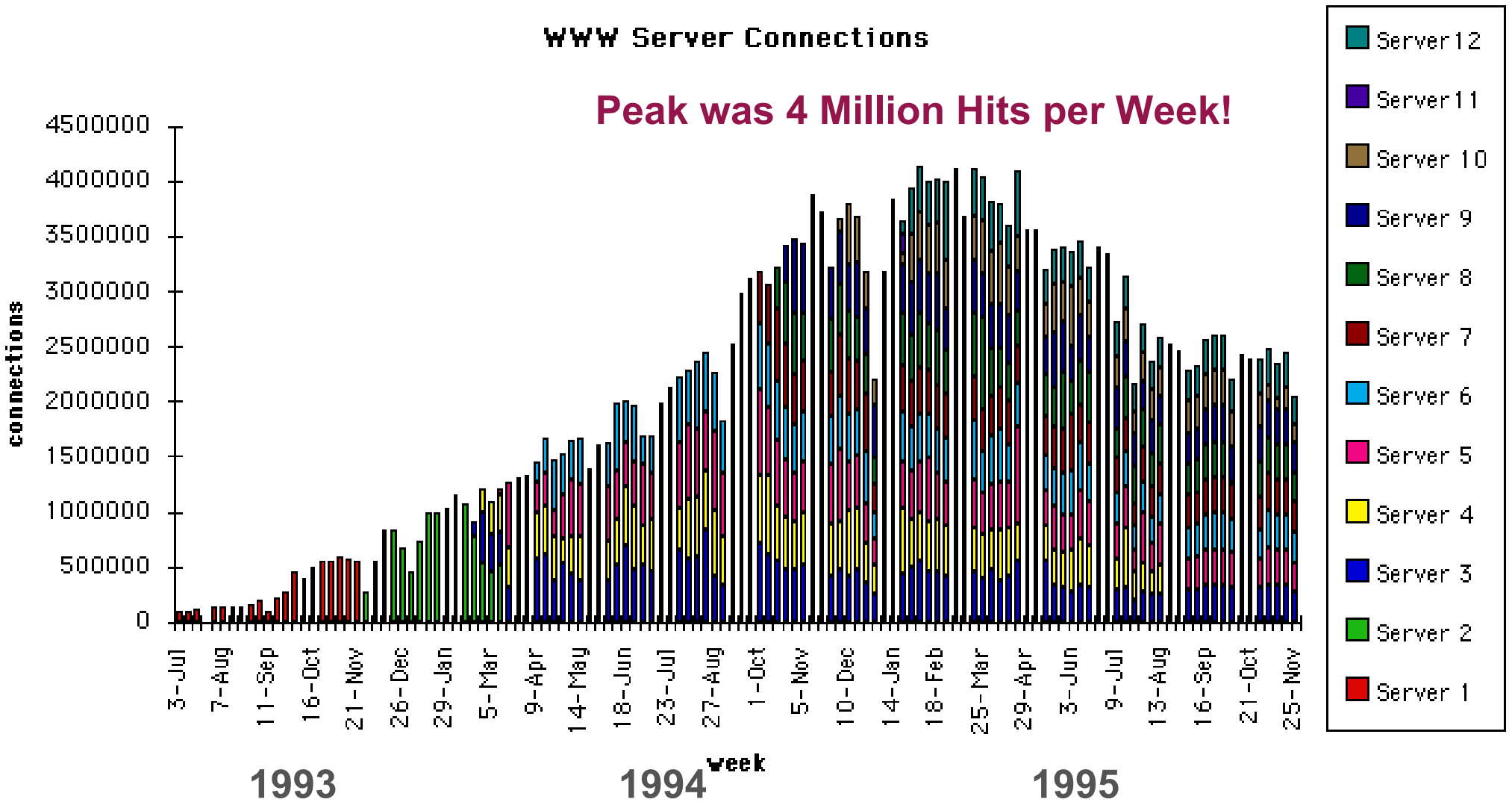
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Source: Larry Smarr

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NCSA Web Server Traffic Increase Led to NCSA Creating the First Parallel Web Server



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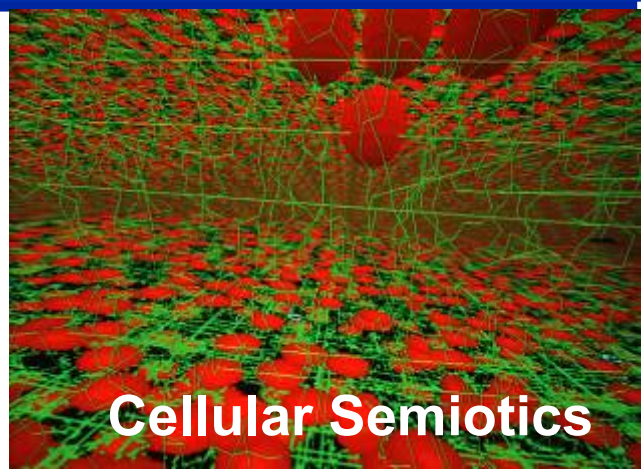
Data Source: Software Development Group, NCSA,
Graph: Larry Smarr

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Supercomputing 95
I-WAY: Information Wide Area Year

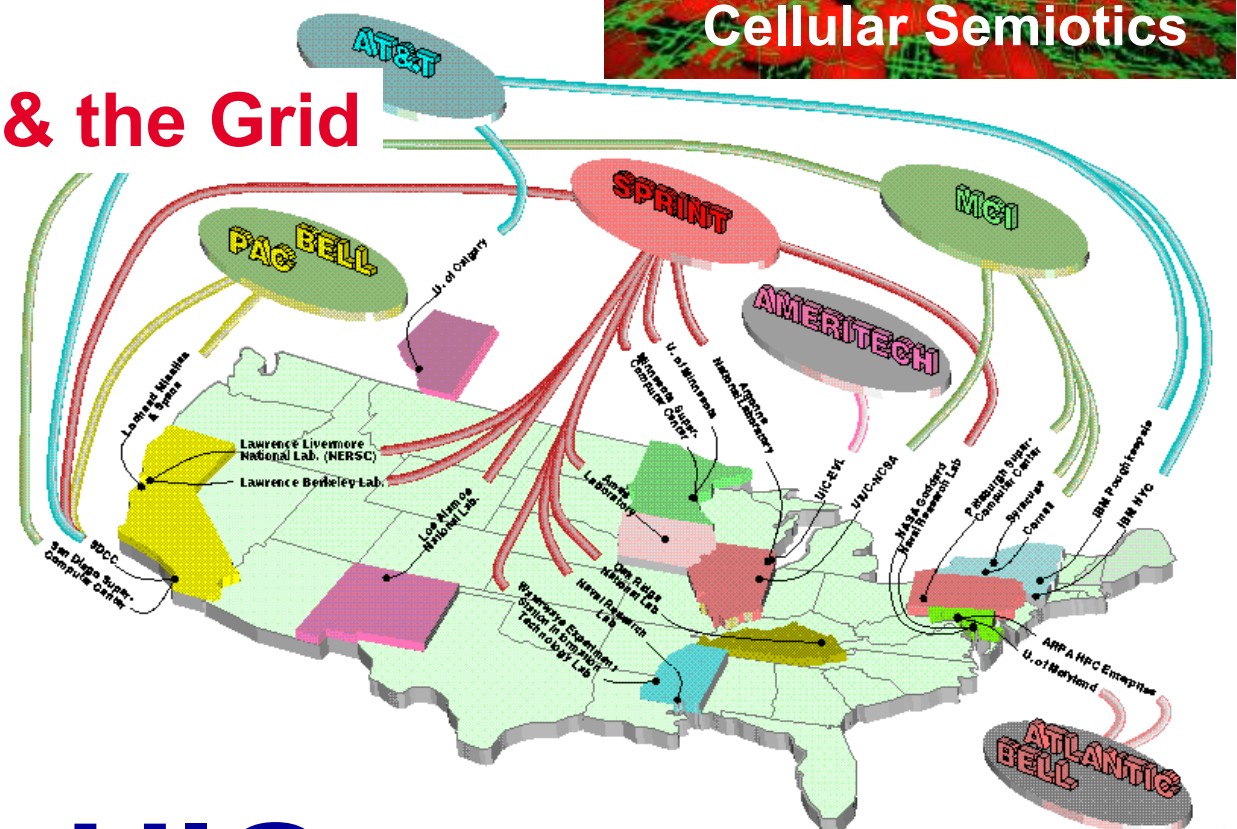
I-Way Featured:

- Networked Visualization Application Demonstrations
- OC-3 (155Mbps) Backbone
- Large-Scale Immersive Displays
- I-Soft Programming Environment



Led Directly to Globus & the Grid





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UIC

mcs

Concept of NCSA Alliance National Technology Grid

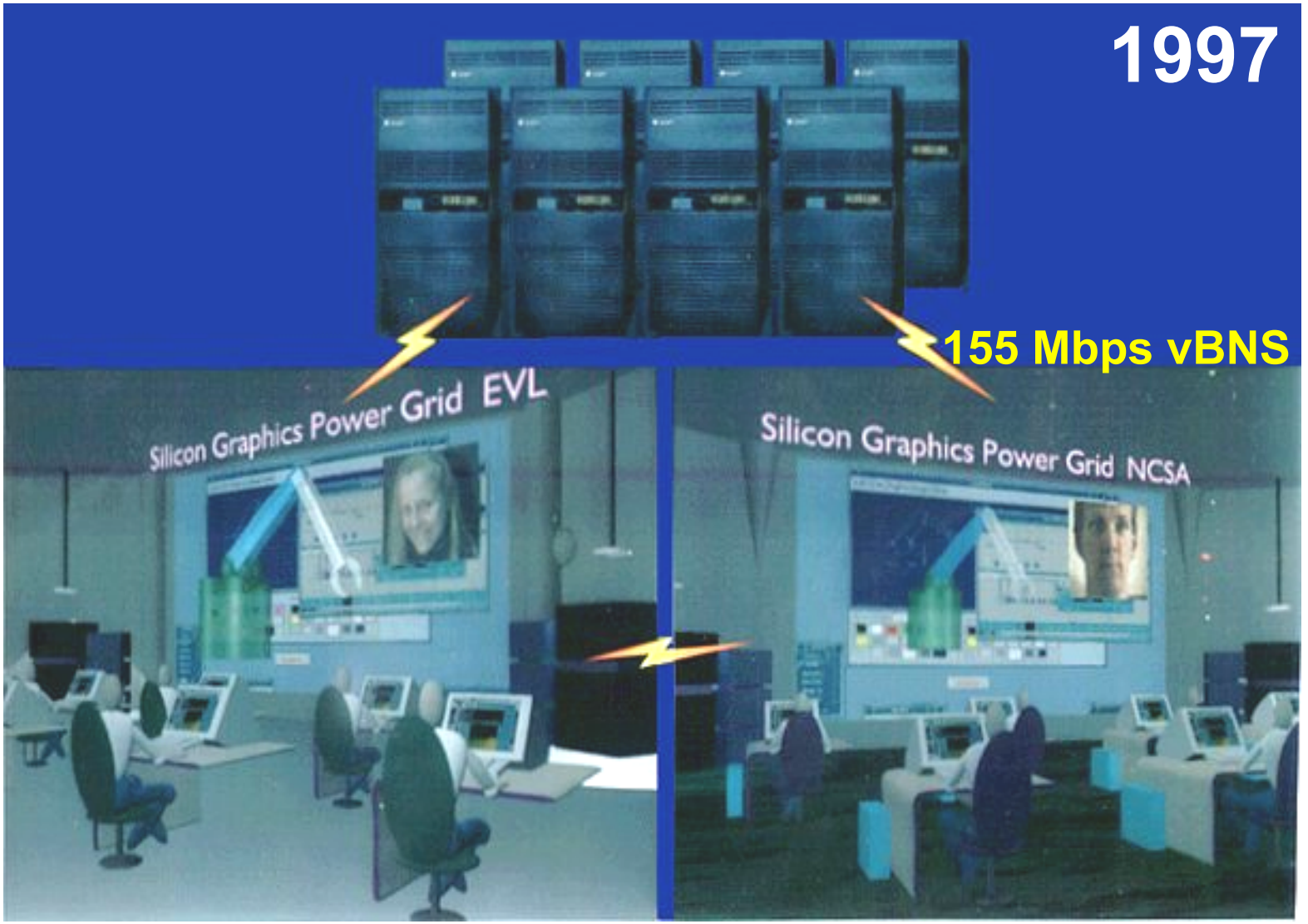


Image From LS Talk at Grid Workshop Argonne Sept. 1997

The NCSA Alliance Research Agenda- Create a National Scale Metacomputer

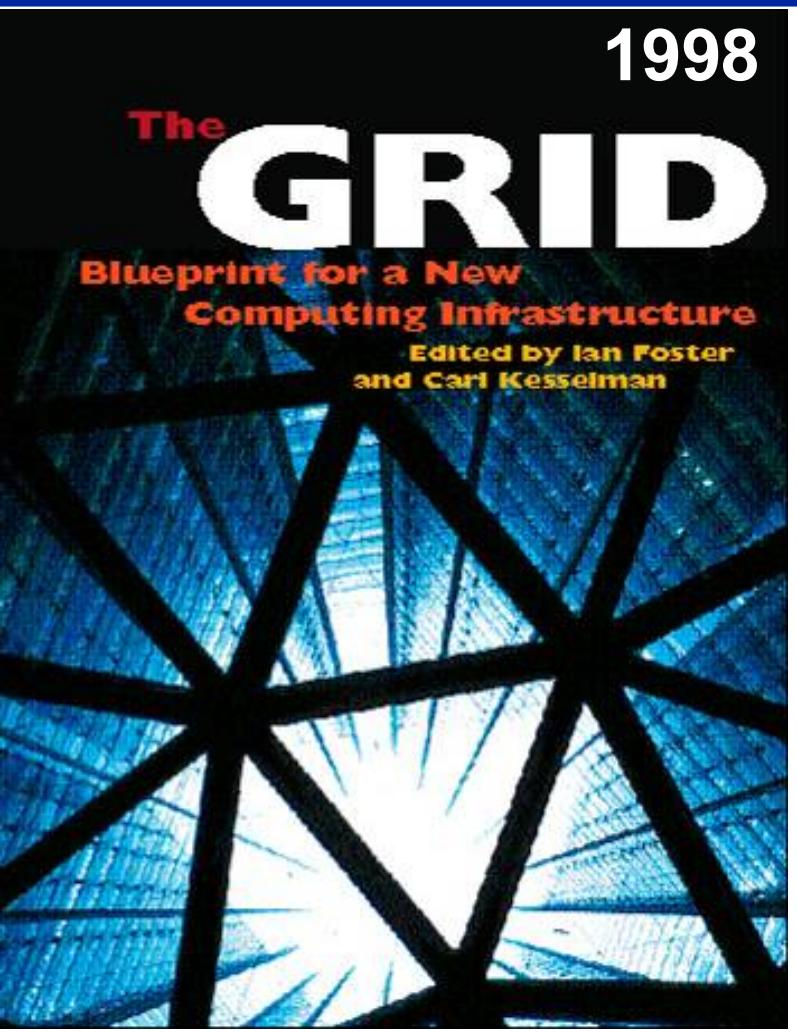
A Nationwide Parallel Computing Environment

How to get there? Through a scalable software environment coupling the small parallelism (a few processors) of the desktop to the large-scale parallelism (thousands of processors) in Alliance machines.

Ken Kennedy, Charles F. Bender, John W.D. Connolly, John L. Hennessy, Mary K. Vernon, and Larry Smarr

The Alliance will strive to make computing routinely parallel, distributed, collaborative, and immersive.
--Larry Smarr, CACM Guest Editor

The Grid Middleware Emerges



"A source book for the history of the future" -- Vint Cerf

Science Portals & Workbenches

Twenty-First Century Applications

Access Grid

Computational Grid

Access Services & Technology

Computational Services

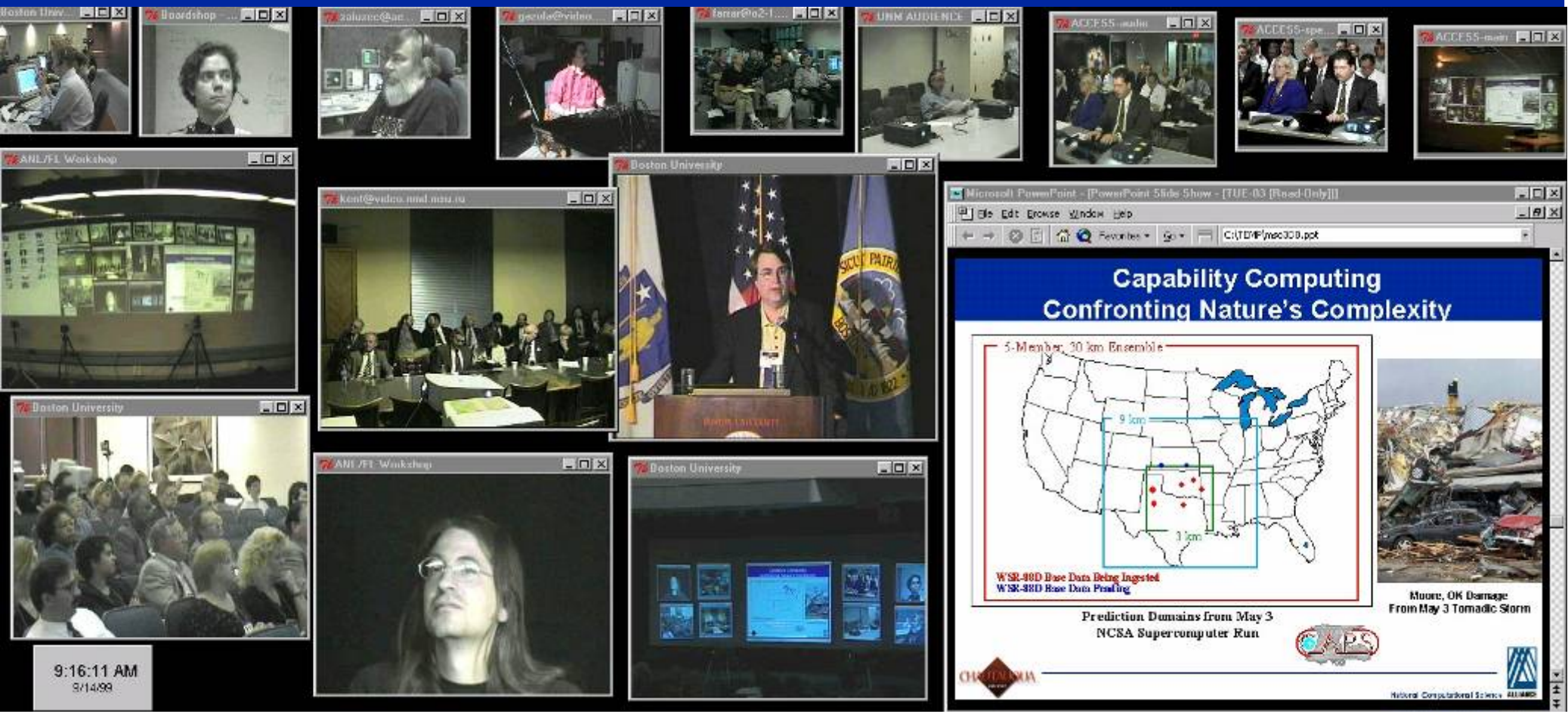
Grid Services
(resource independent)

Grid Fabric
(resource dependent)

Networking, Devices and Systems

Performance

Extending Collaboration From Telephone Conference Calls to Access Grid International Video Meetings



1999

Can We Create Realistic Telepresence Using Dedicated Optical Networks?

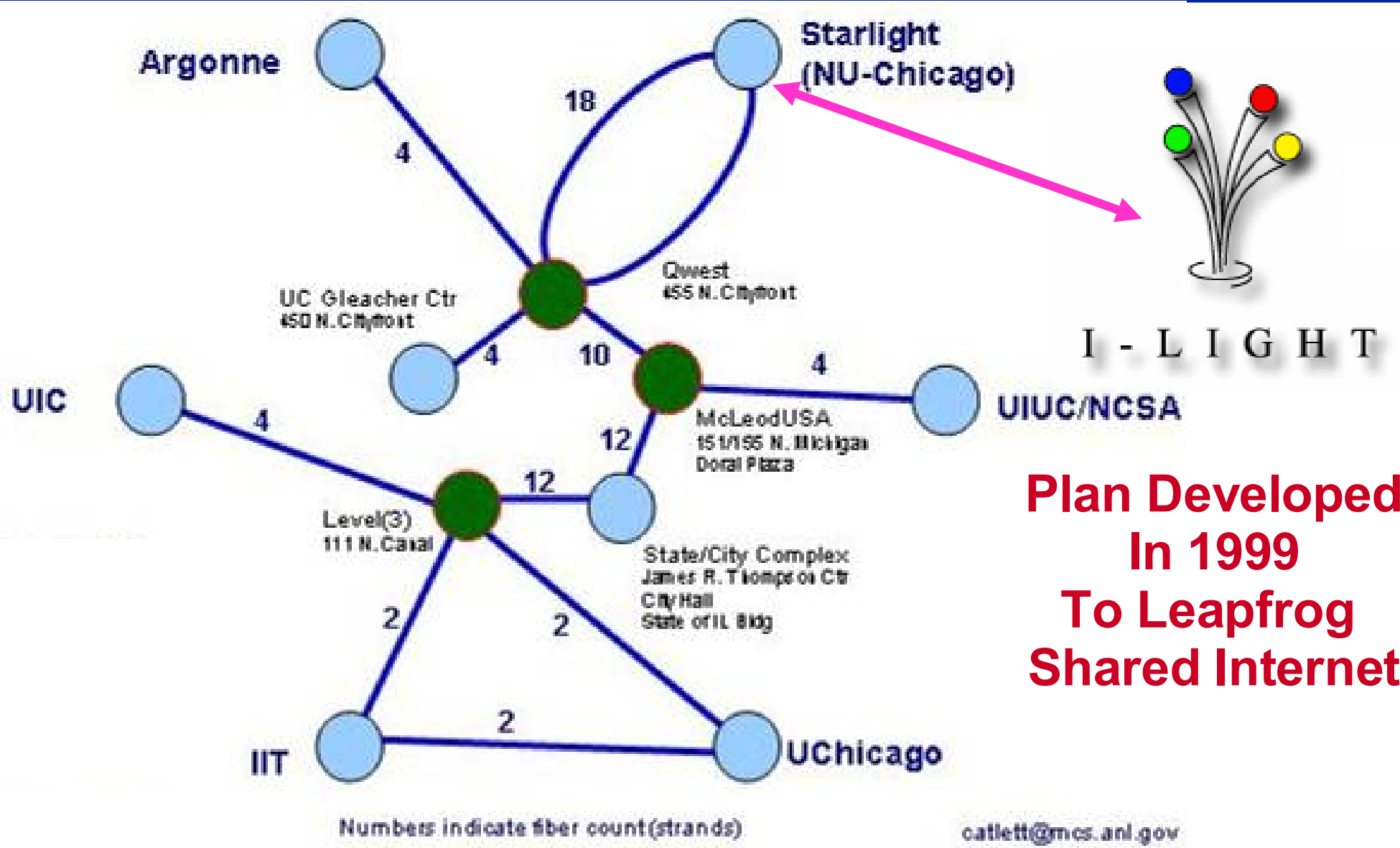
Access Grid Lead-Argonne

NSF STARTAP Lead-UIC's Elec. Vis. Lab

NCSA University of Illinois at Urbana-Champaign

National Computational Science ALLIANCE

States Began to Acquire Their Own Dark Fiber Networks -- Illinois's I-WIRE and Indiana's I-LIGHT



I - L I G H T

Plan Developed In 1999 To Leapfrog Shared Internet

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Source: Charlie Catlett, ANL

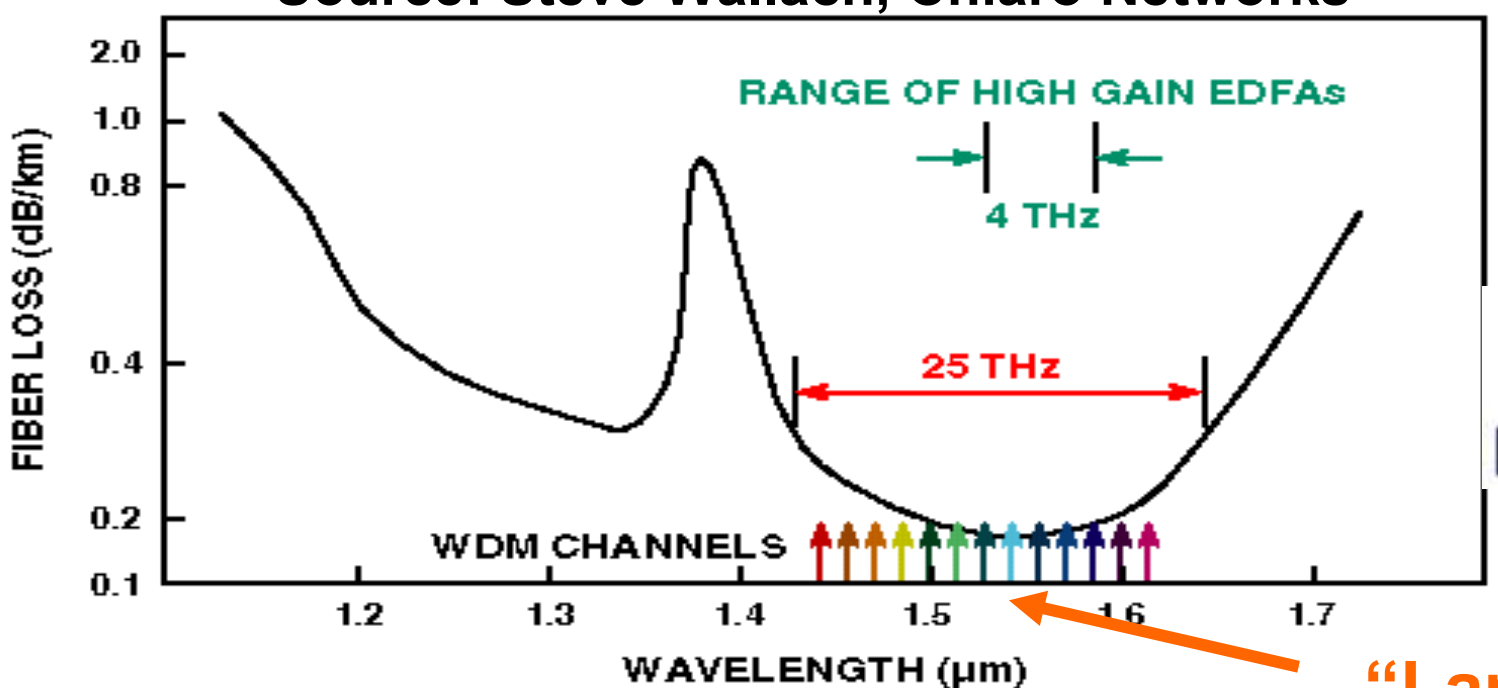
Dedicated Optical Channels Makes High Performance Cyberinfrastructure Possible

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



CHIARO

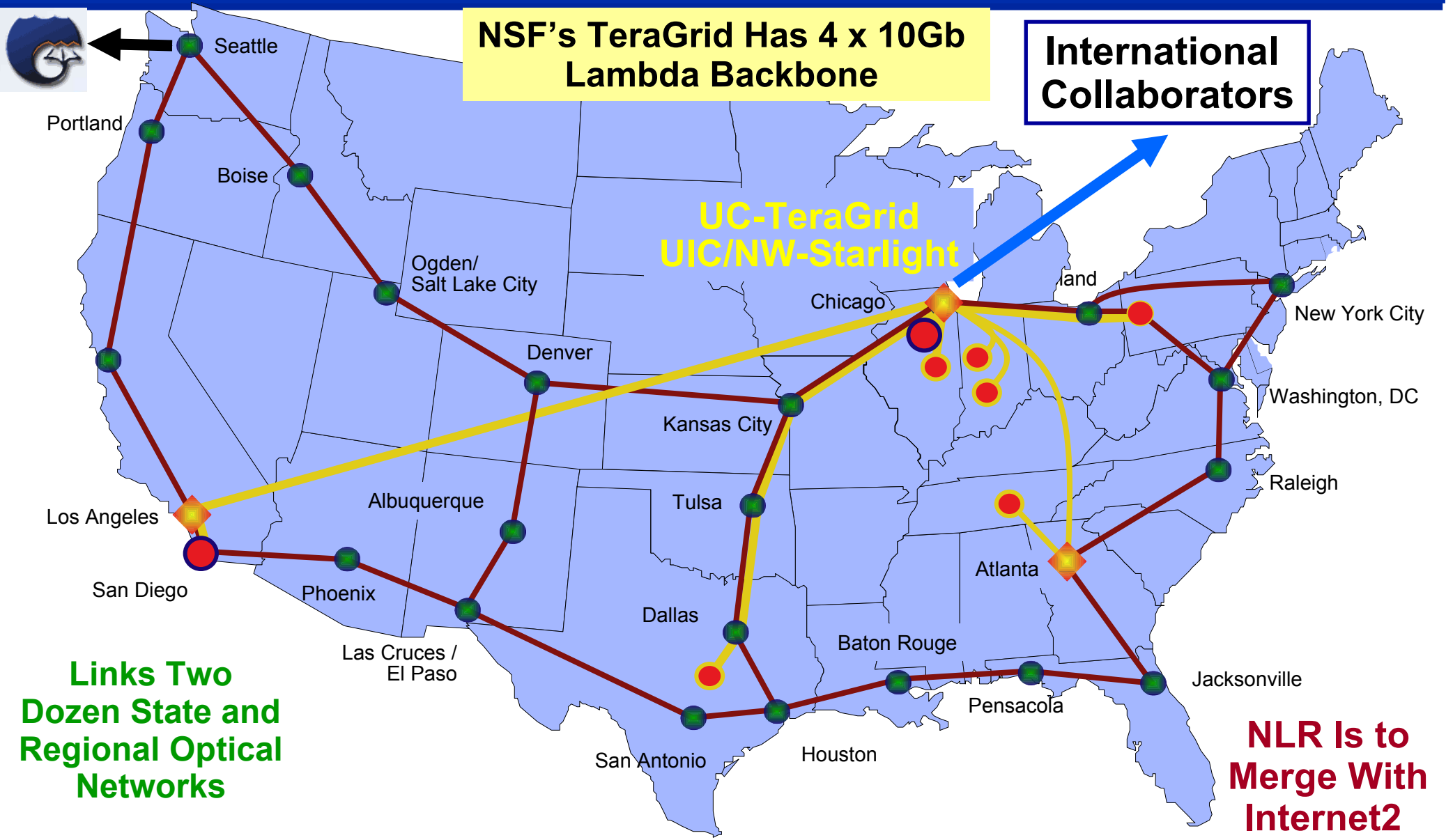
"Lambdas"

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

NLR Is to Merge With Internet2

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

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National Lambda Rail
Core Services

- **WaveNet - Layer 1**
  - Point-to-Point 10 GE or OC-192 Waves
  - Enables Big Science, Network Researchers, Production Services
- **FrameNet – Layer 2**
  - First Nationwide 10 Gb Ethernet Service for the R&E Community
  - GigE Interface and Non-Dedicated Service Comes With Membership
- **PacketNet – Layer 3**
  - Nationwide, Diverse, Redundant, Reliable Routed Network Service
  - 10 GE and 1 GE Access Part of Membership

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Since 2005 Two New Calit2 Buildings Provide New Laboratories for "Living in the Future"



- **Up to 1000 Researchers in Two Buildings**
  - **Linked via Dedicated Optical Networks**
  - **International Conferences and Testbeds**
- **New Laboratories**
  - **Nanotechnology**
  - **Virtual Reality, Digital Cinema**



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Preparing for a World in Which Distance is Eliminated…

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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

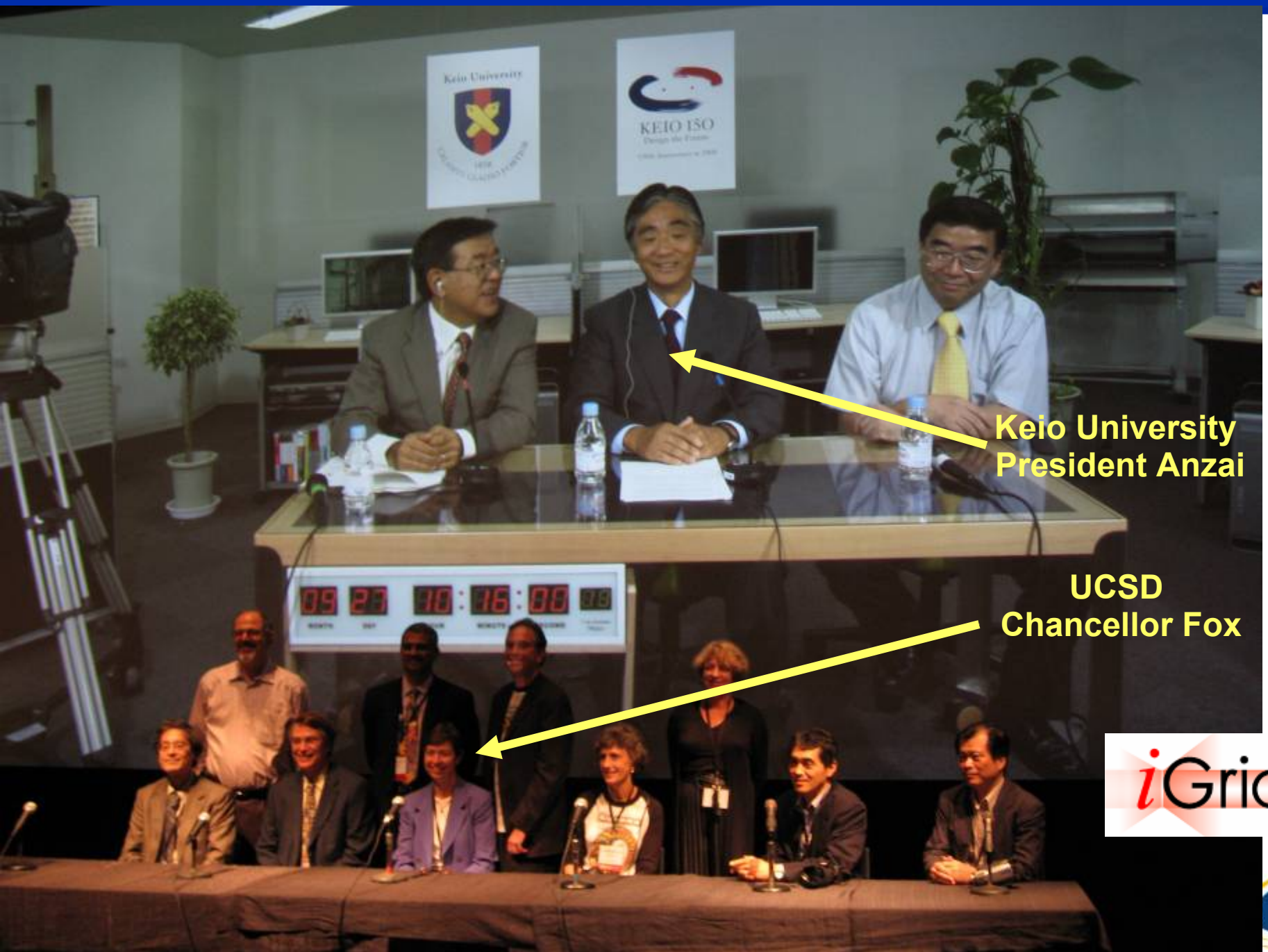
Calit2 @ University of California, San Diego

California Institute for Telecommunications and Information Technology



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

iGrid Lambda Digital Cinema Streaming Services: Telepresence Meeting in Calit2 Digital Cinema Auditorium



Lays Technical Basis for Global Digital Cinema

Sony
NTT
SGI

iGrid 2005

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Gigabit Fibers on the Ocean Floor-Using a SOA to Control Sensors and HDTV Cameras Remotely



LOOKING is Driven By NEPTUNE CI Requirements

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) Building on OptIPuter
- **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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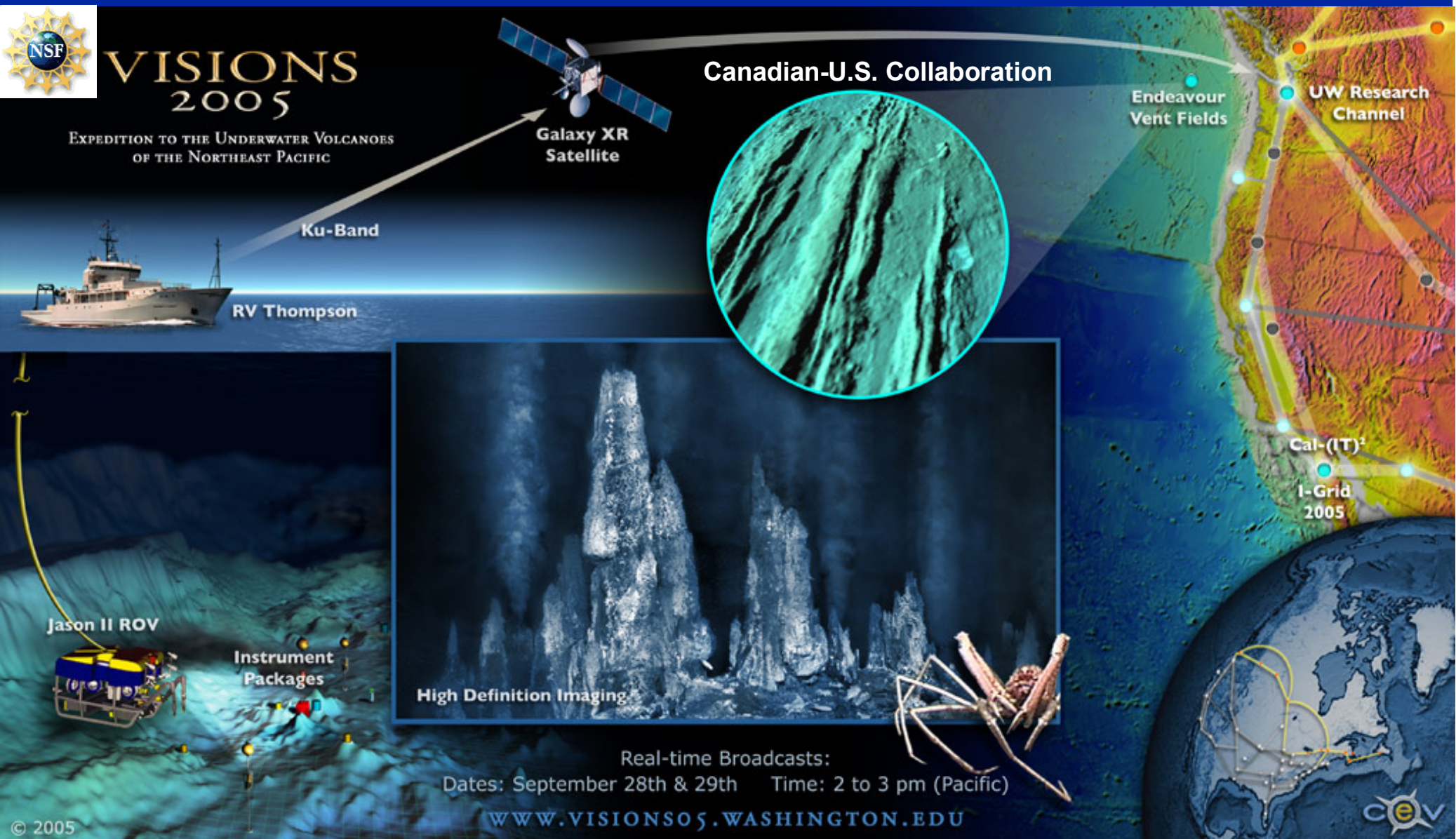
NSF

ocean research interactive ORION observatory networks

Adding Web Services to LambdaGrids

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First Remote Interactive High Definition Video Exploration of Deep Sea Vents



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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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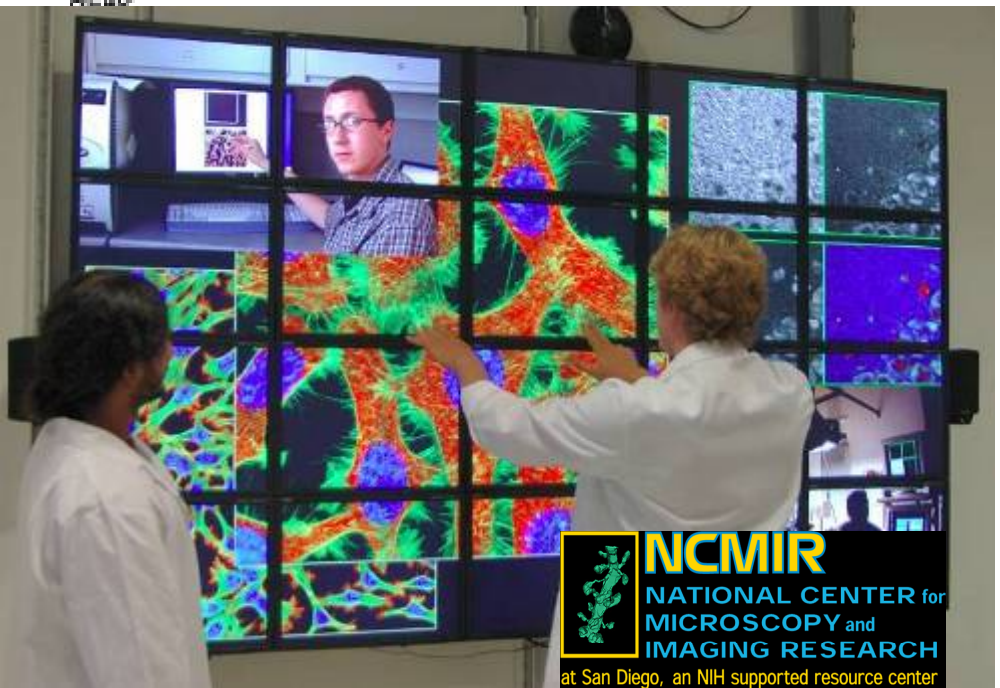
e-Science Data Intensive Science Will Require LambdaGrid Cyberinfrastructure



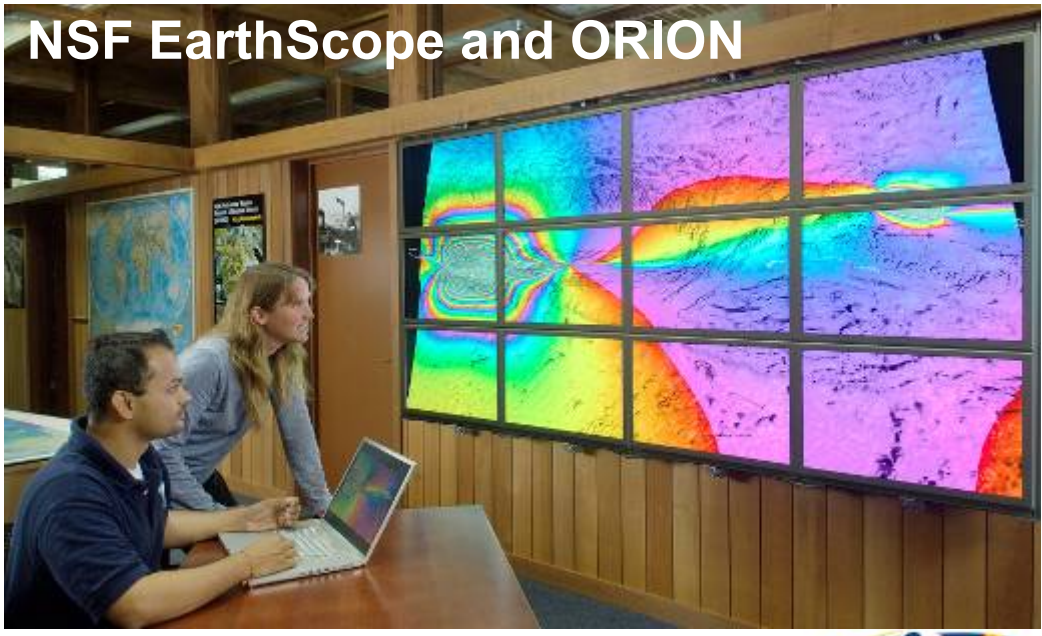
The OptIPuter Project – Creating High Resolution Portals Over Dedicated Optical Channels to Global Science Data

- **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

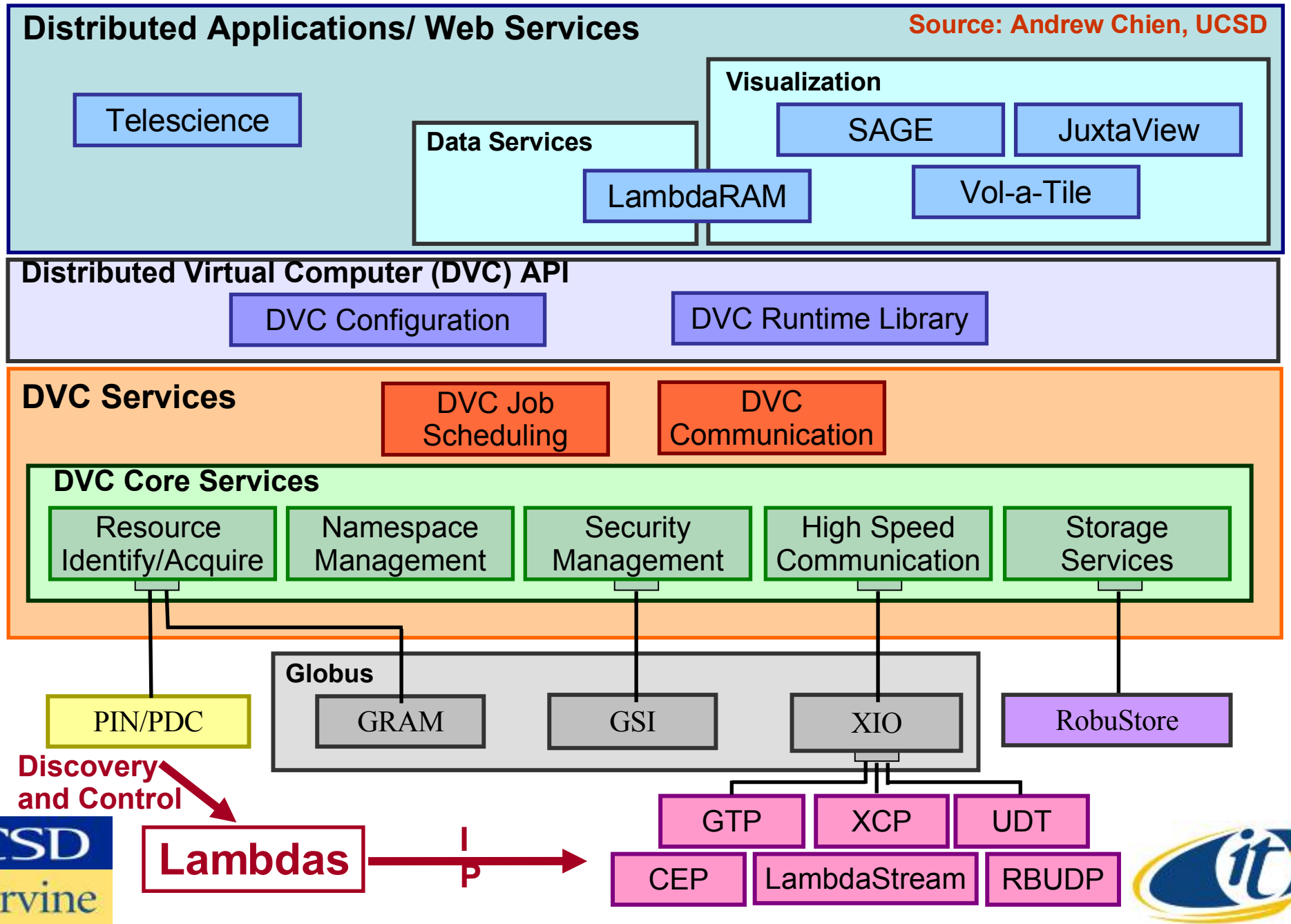


NSF EarthScope and ORION



SCRIPPS INSTITUTION OF OCEANOGRAPHY

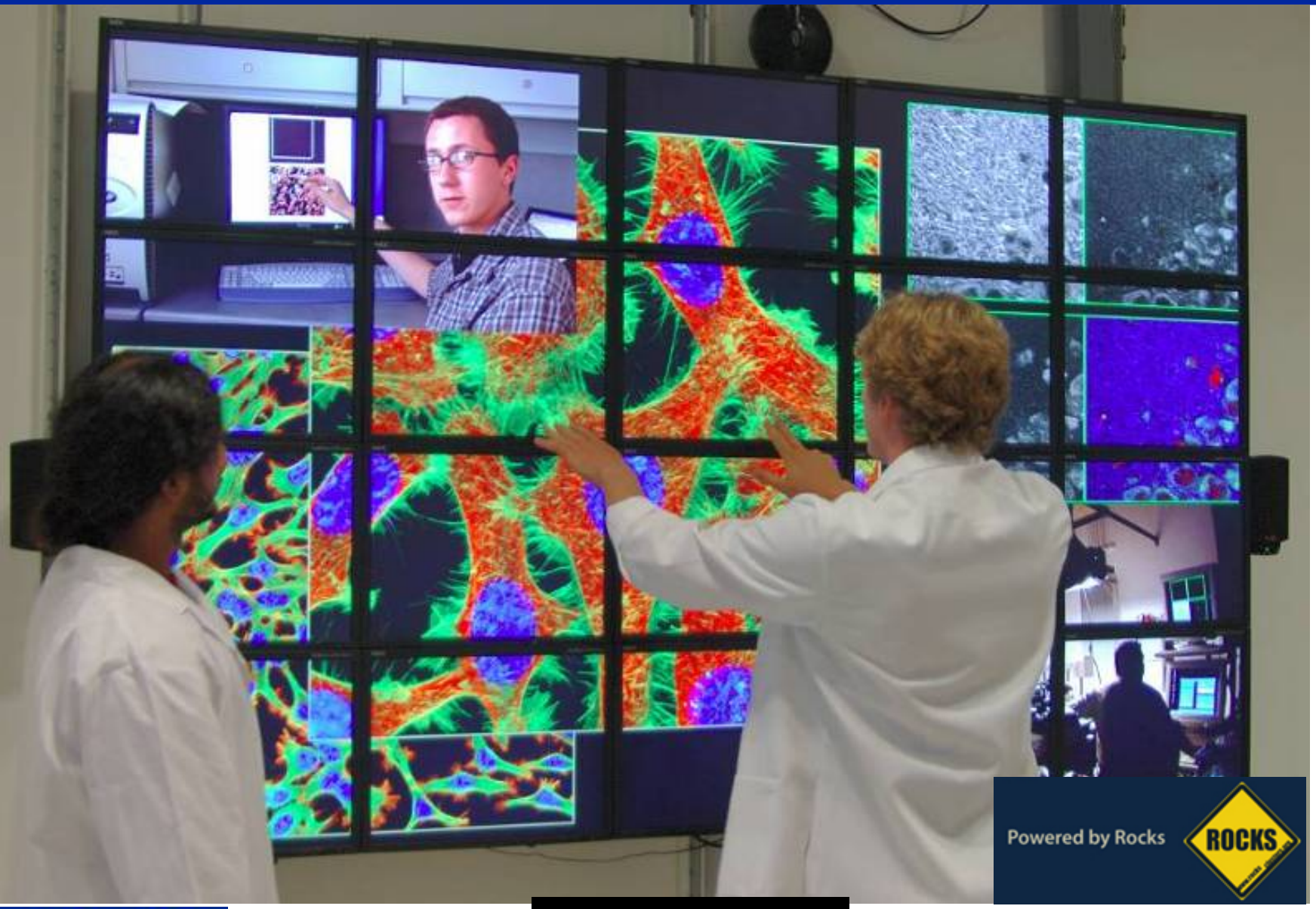
OptIPuter Software Architecture—a Service-Oriented Architecture (SOA) Integrating Lambdas Into the Grid



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OptIPuter Scalable Adaptive Graphics Environment (SAGE) Allows Integration of HD Streams



OptIPortal– Termination Device for the OptIPuter Global Backplane

Powered by Rocks

ROCKS

evl electronic visualization laboratory

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

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CAMERA: Community Cyberinfrastructure for Advanced Marine Microbial Ecology Research and Analysis

National LambdaRail
Direct Connect
Computation and Storage Complex

Funded by: Gordon and Betty Moore Foundation

PI Larry Smarr

Joint Partnership of:

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UCIrvine

Announced January 17, 2006
$24.5M Over Seven Years

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

Gordon and Betty MOORE FOUNDATION

Powered by Rocks

Sargasso Sea Data

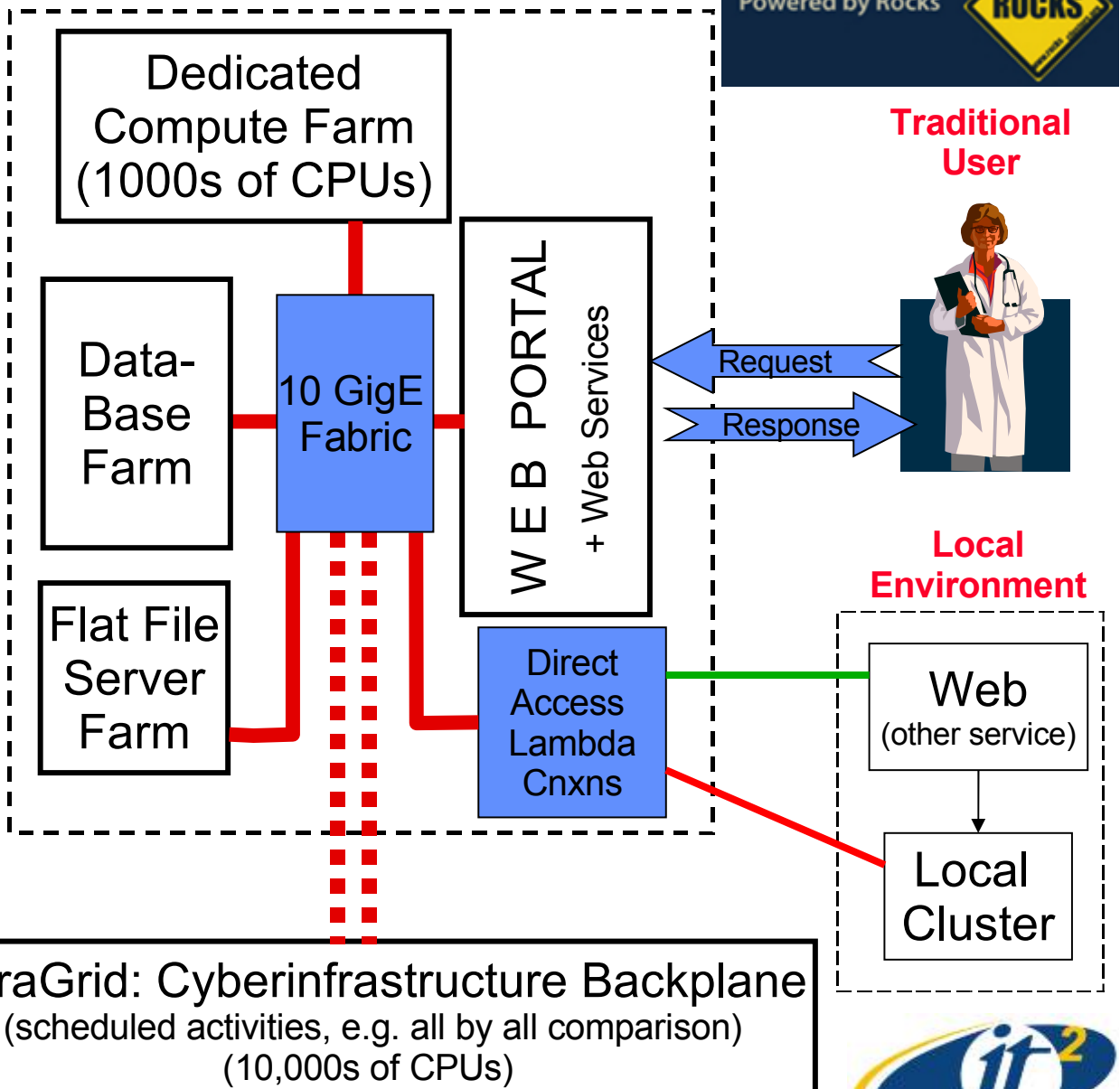
Sorcerer II Expedition (GOS)

JGI Community Sequencing Project

Moore Marine Microbial Project

NASA and NOAA Satellite Data

Community Microbial Metagenomics Data



Source: Phil Papadopoulos, SDSC, Calit2

CENTER FOR EARTH OBSERVATIONS & APPLICATIONS

SCRIPPS INSTITUTION OF OCEANOGRAPHY

SDSC SAN DIEGO SUPERCOMPUTER CENTER

UCSD UCIrvine

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Calit2 CAMERA Production
Compute and Storage Complex is On-Line

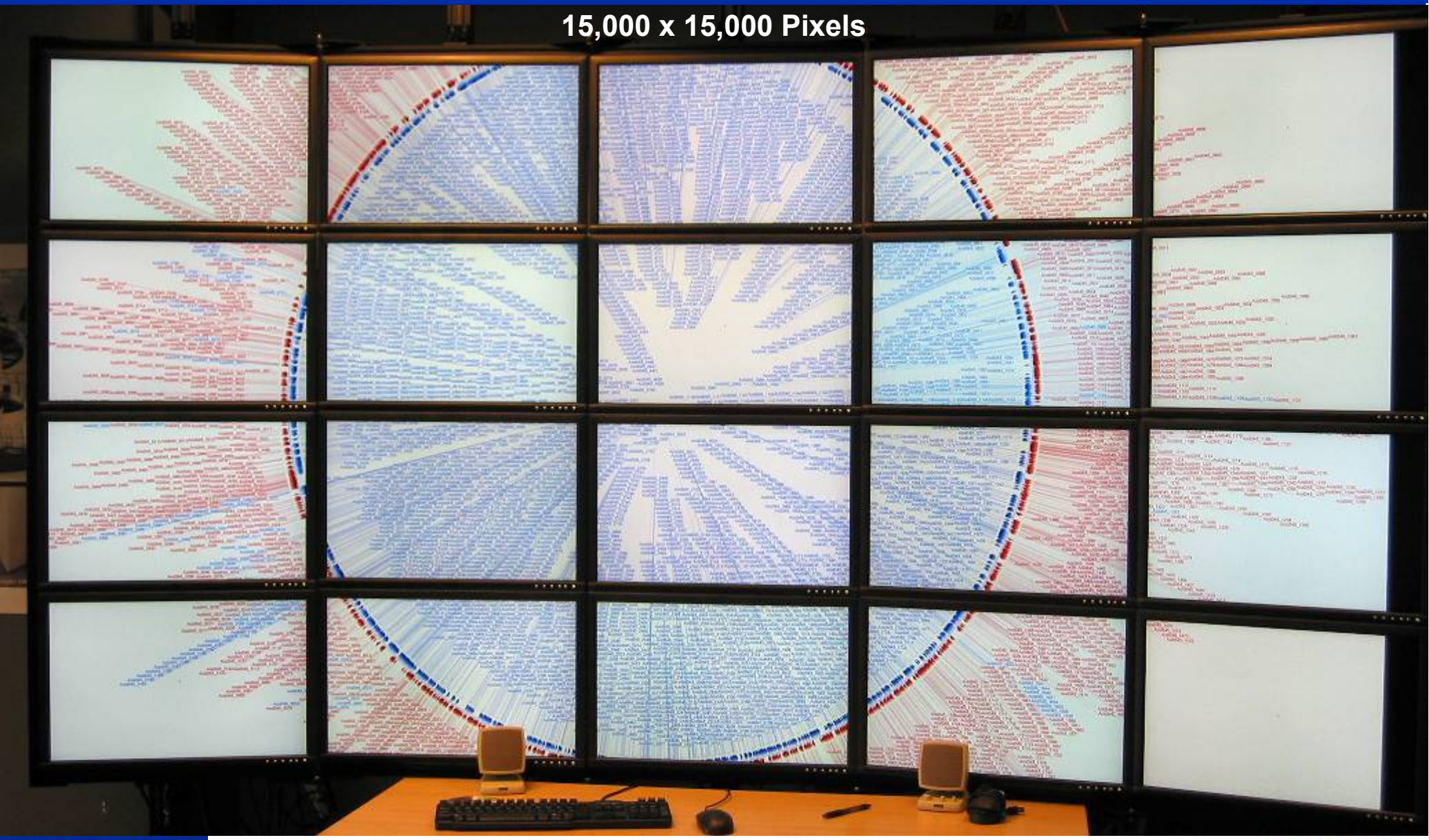


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camera
Marine Microbial Ecology

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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



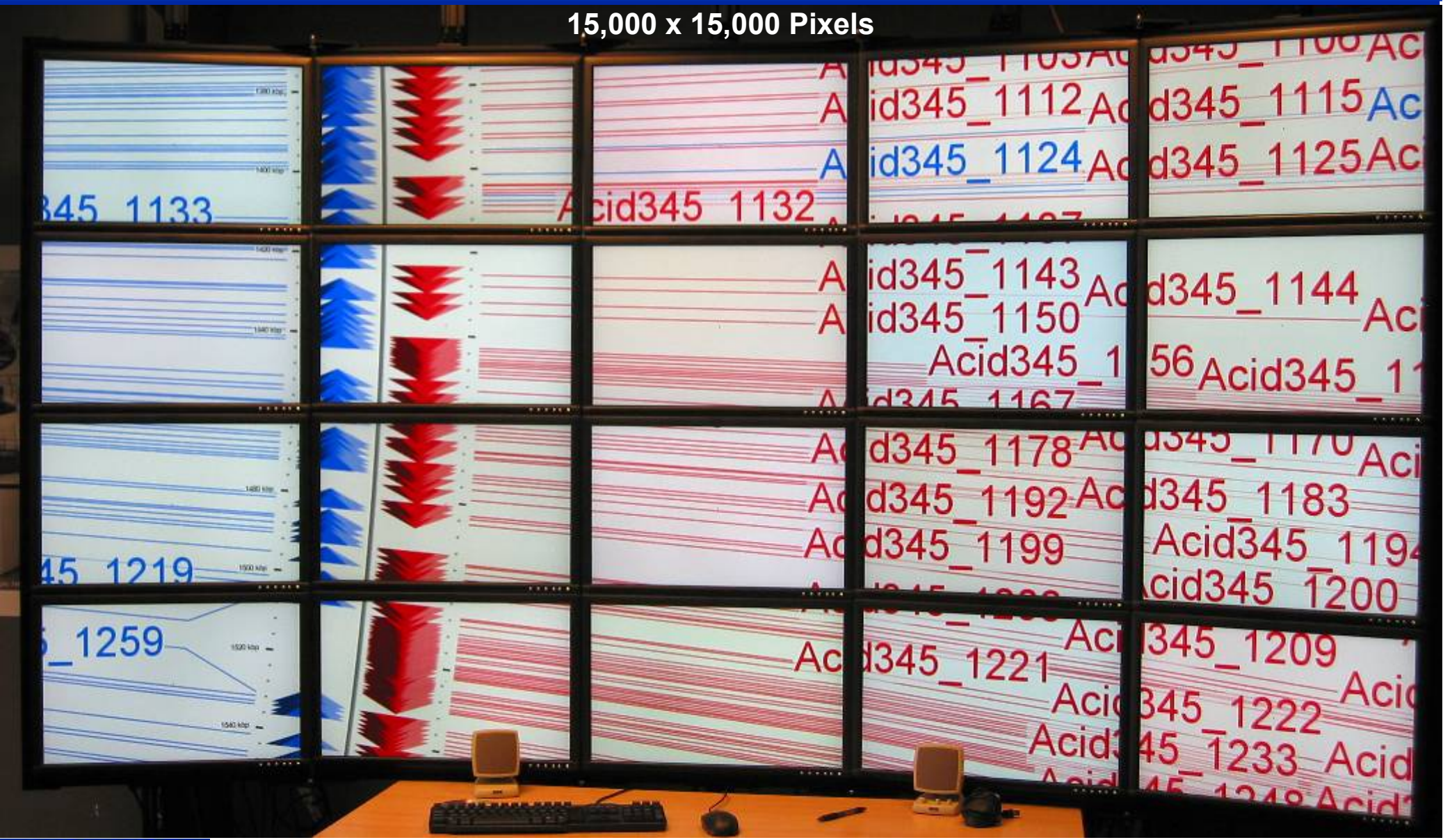
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Source: Raj Singh, UCSD

Acidobacteria bacterium Ellin345 (NCBI)
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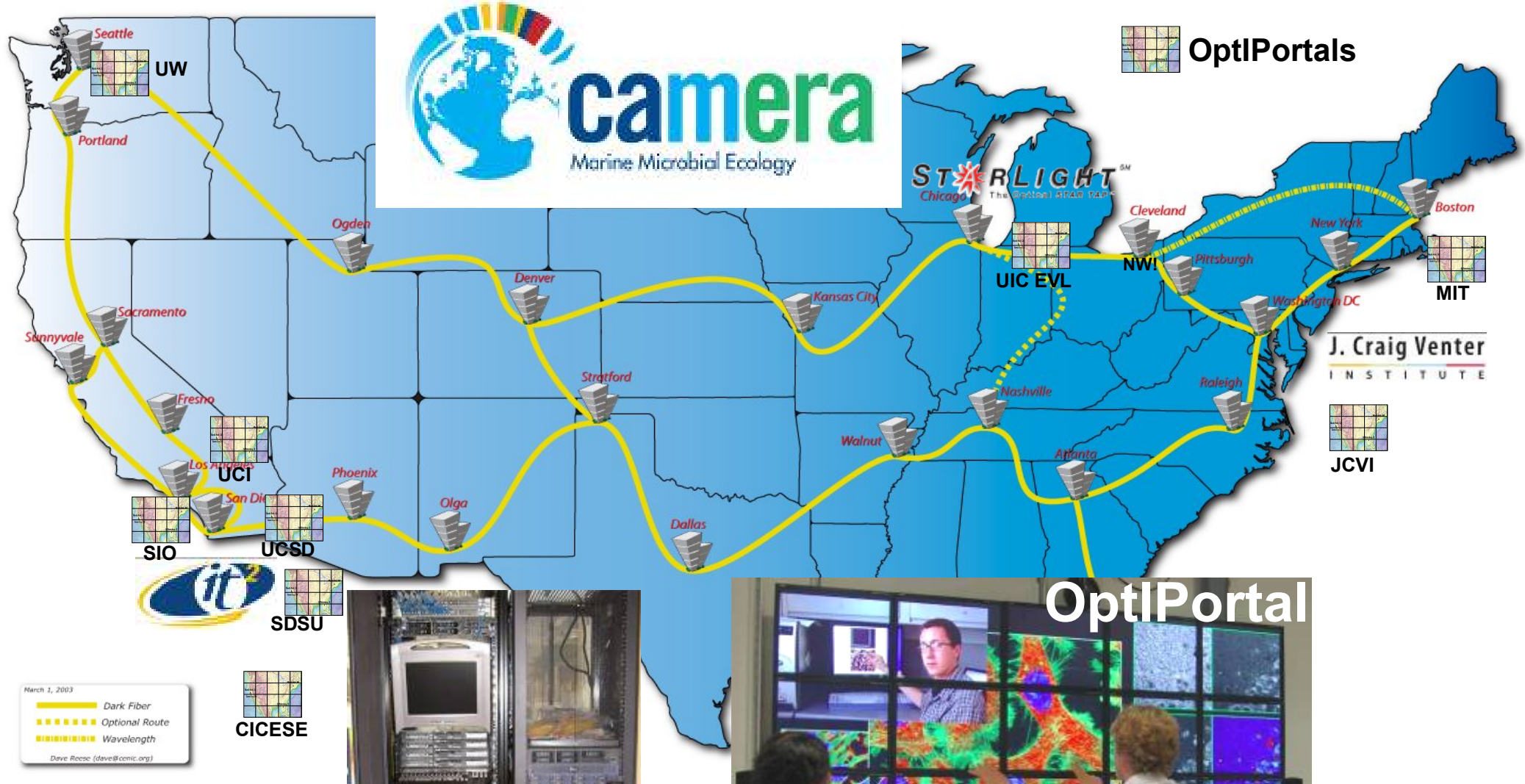
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Source: Raj Singh, UCSD

Acidobacteria bacterium Ellin345 (NCBI)
Soil Bacterium 5.6 Mb

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Calit2 is Now OptIPuter Connecting Remote OptIPortals Creating a National-Scale SOA Metacomputer



CAMERA Servers

OptIPortal

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