Bringing 3D, Ultra-Resolution, and Virtual Reality into the Global LambaGrid Collaboratory

Keynote
ACM Virtual Reality Software and Technology (VRST)
Newport Beach, CA
November 7, 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

UCSD
UCIrvine

Abstract

While there have been experiments for at least 15 years in distributed virtual reality, most of these have occurred using the best effort shared internet.

As a result of the OptiPuter project, Calit2 and the Electronic Visualization Lab at UIC have been experimenting with innovative 3D, ultra-resolution, and Virtual Reality user interfaces to dedicated 10 gigabit per second light pipes.

I will describe these ultra resolution 3D environments as well as the National and Global-scale LambdaGrid in which they are embedded.

UCSD
UCIrvine

The Bellcore VideoWindow -- A Working Telepresence Experiment



(1989)

"Imagine sitting in your work place lounge having coffee with some colleagues. Now imagine that you and your colleagues are still in the same room, but are separated by a large sheet of glass that does not interfere with your ability to carry on a clear, two-way conversation. Finally, imagine that you have split the room into two parts and moved one part 50 miles down the road, without impairing the quality of your interaction with your friends."

UCSD
UCIrvine

Source: Fish, Kraut, and Chalfonte-CSCW 1990 Proceedings

it²

A Simulation of Telepresence
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

- **Televisualization:**
  - **Telepresence**
  - **Remote Interactive Visual Supercomputing**
  - **Multi-disciplinary Scientific Visualization**







"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

ATT & Sun

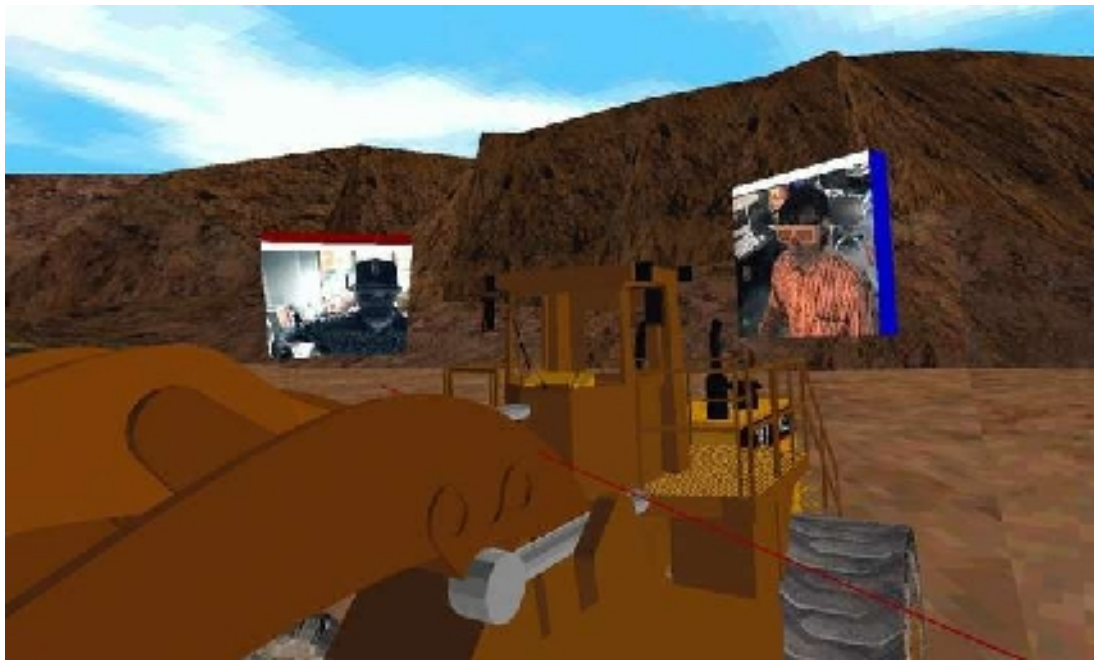
UCSD
UCIrvine

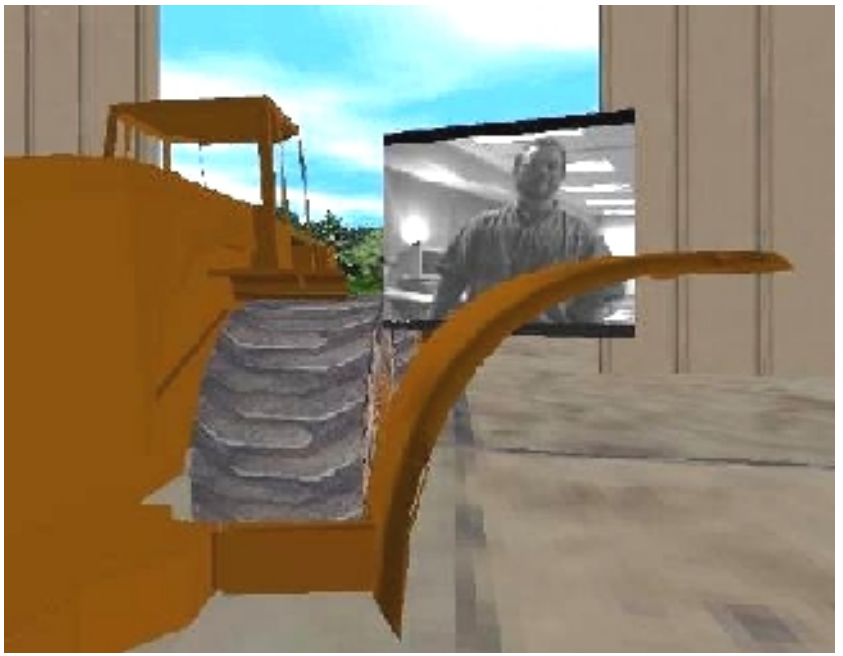
SIGGRAPH 1989

NCSA

it²

Caterpillar / NCSA: Distributed Virtual Reality for Global-Scale Collaborative Prototyping





NCSA™

Real Time Linked Virtual Reality and Audio-Video Between NCSA, Peoria, Houston, and Germany

UCSD
UCIrvine

1996

www.sv.vt.edu/future/vt-cave/apps/CatDistVR/DVR.html

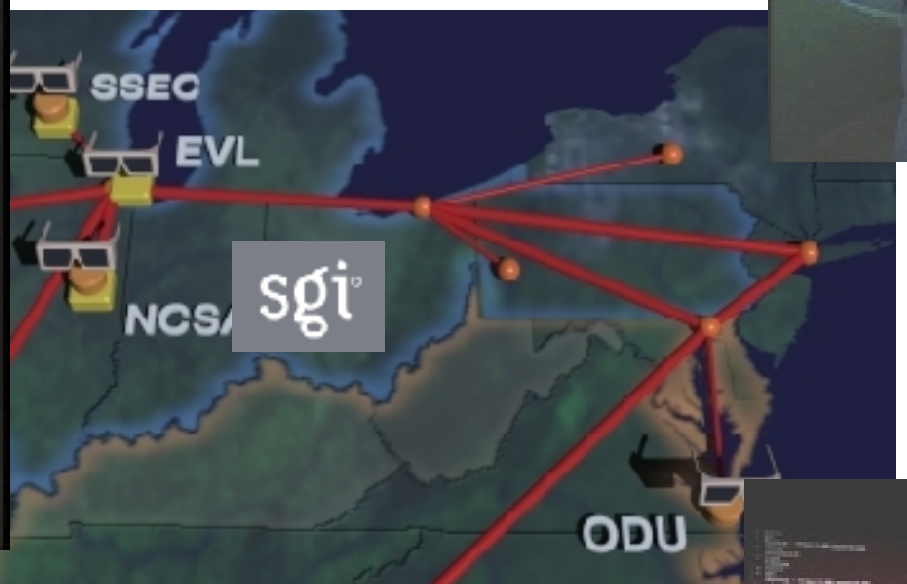
it²

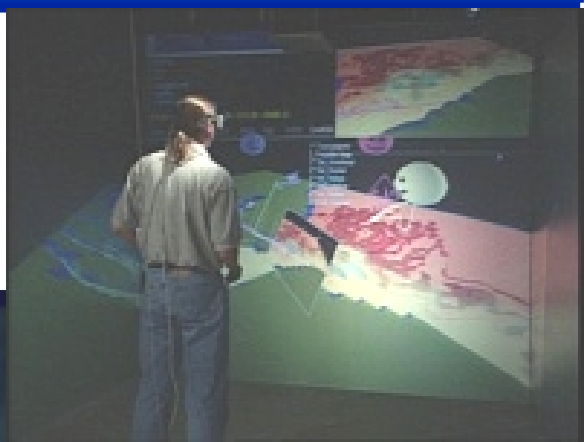
Alliance 1997: Collaborative Video Production via Tele-Immersion and Virtual Director

Alliance Project Linking CAVE, ImmersaDesk, Power Wall, and Workstation

Alliance Application Technologies
Environmental Hydrology Team











NCSA UIC

sgi

ALLIANCE

UCSD UCIrvine

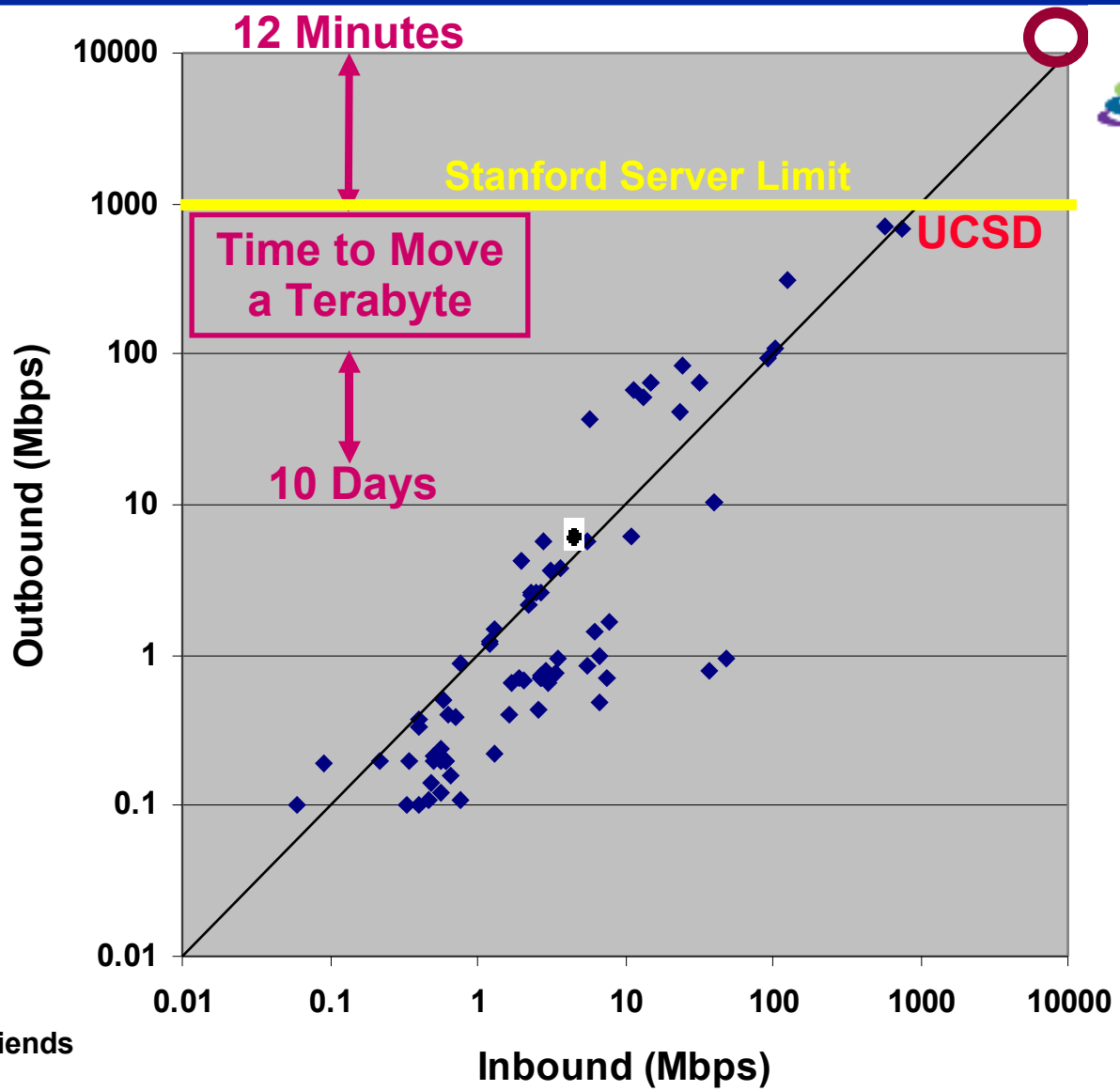
Donna Cox, Robert Patterson, Stuart Levy, NCSA Virtual Director Team
Glenn Wheless, Old Dominion Univ.

it²

Shared Internet Bandwidth: Unpredictable, Widely Varying, Jitter, Asymmetric

Computers In:

Australia
Canada
Czech Rep.
India
Japan
Korea
Mexico
Moorea
Netherlands
Poland
Taiwan
United States



OptIPuter

1000x Normal Internet!

Data Intensive Sciences Require Fast Predictable Bandwidth

Source: Larry Smarr and Friends

Measured Bandwidth from User Computer to Stanford Gigabit Server in Megabits/sec
http://netspeed.stanford.edu/

UCSD
UCIrvine

it2

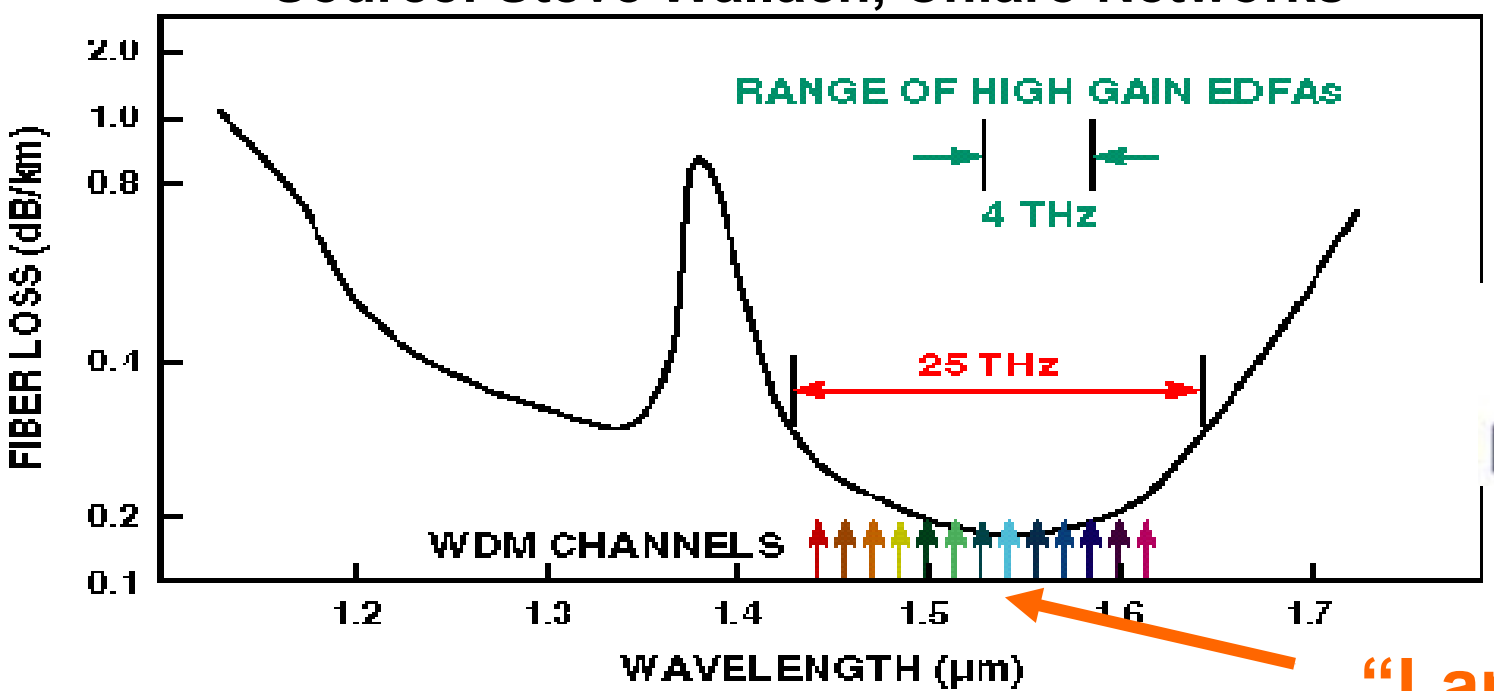
Dedicated Optical Channels Makes High Performance Cyberinfrastructure Possible

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"

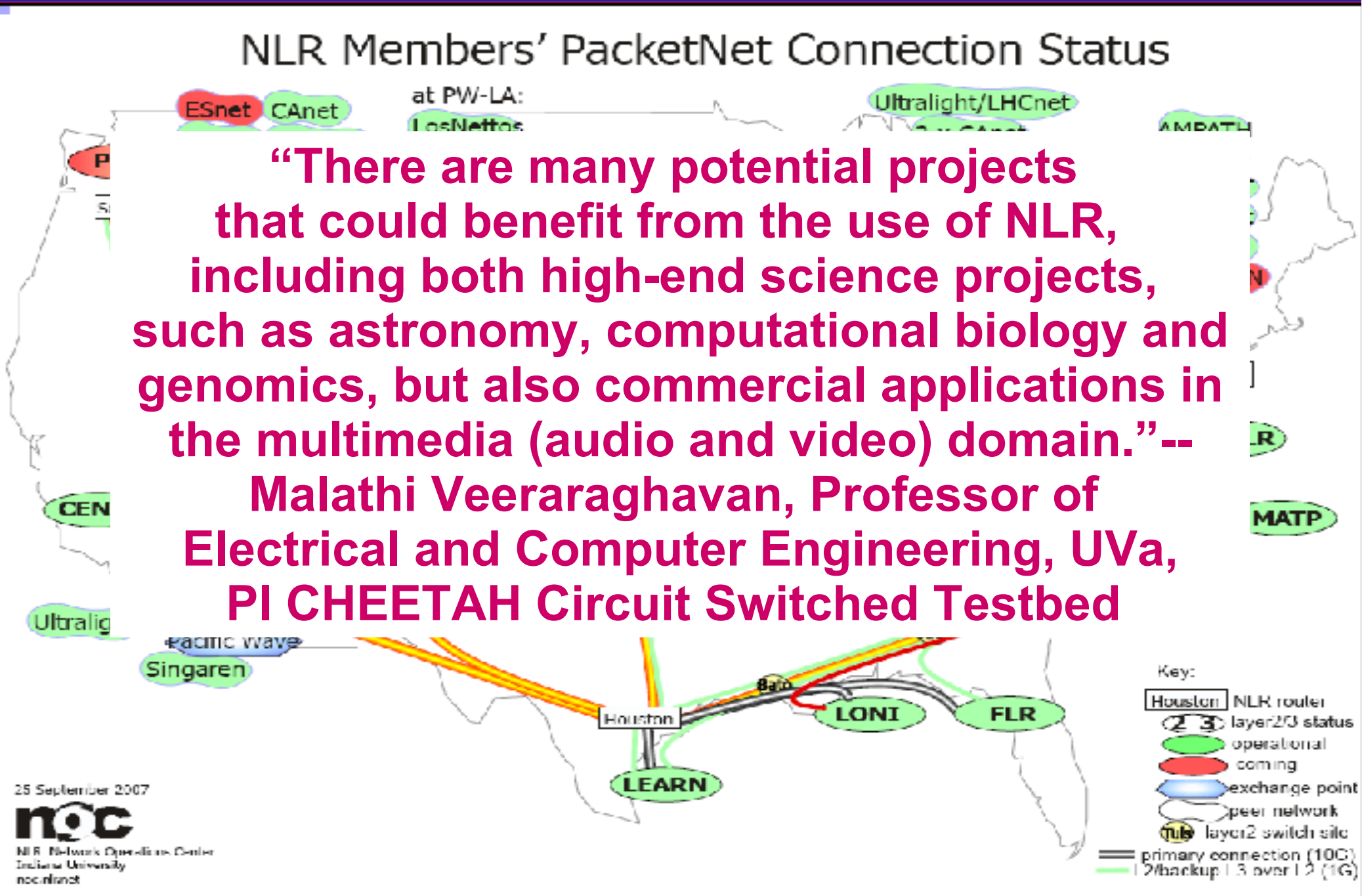
CHIARO

UCSD
UCIrvine

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

it²

National LambdaRail
Connects Regional Optical Networks



"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

How Do You Get From Your Lab to the National LambdaRail?

"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."

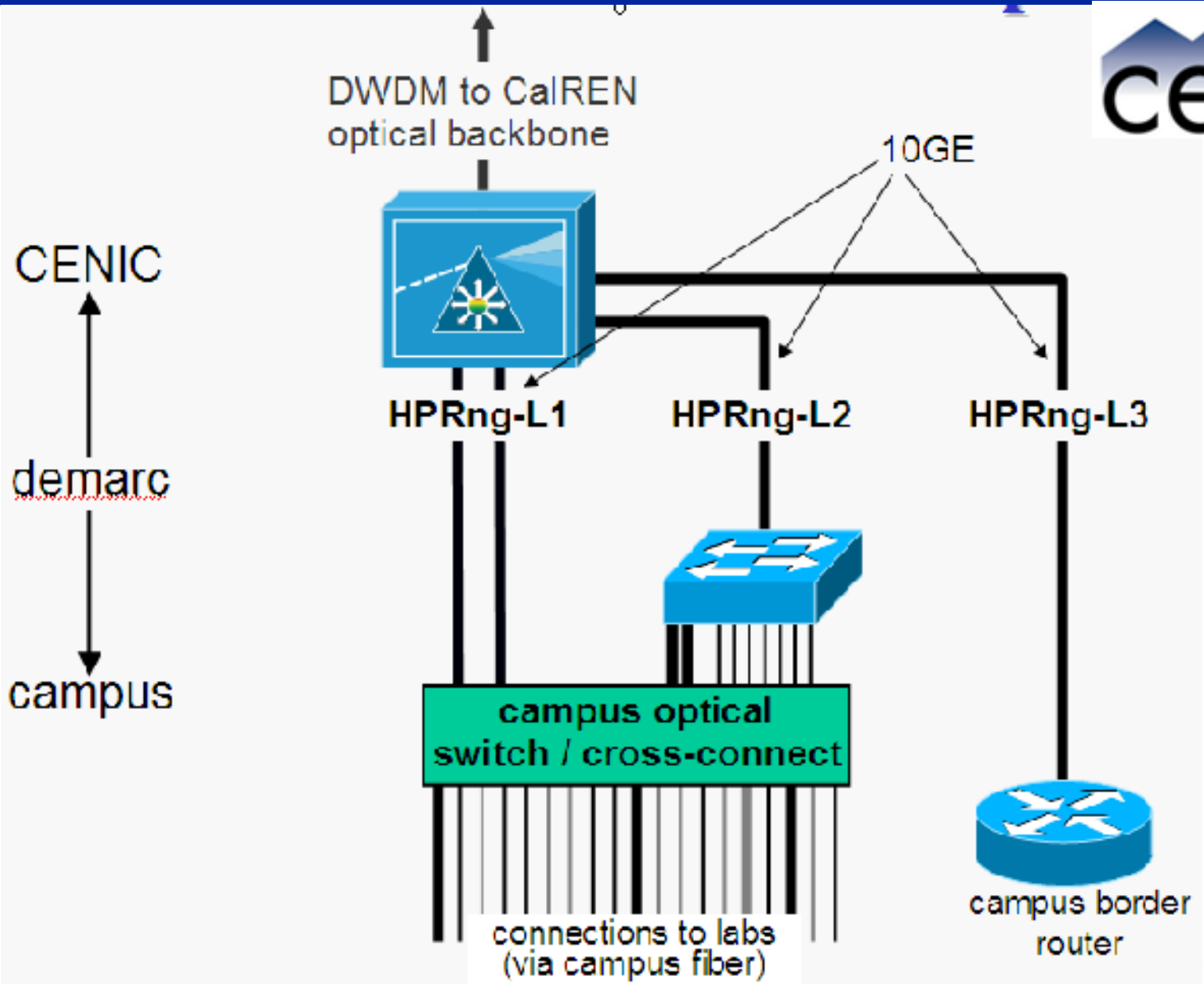
-- Arden Bement, the director of the National Science Foundation



www.ctwatch.org

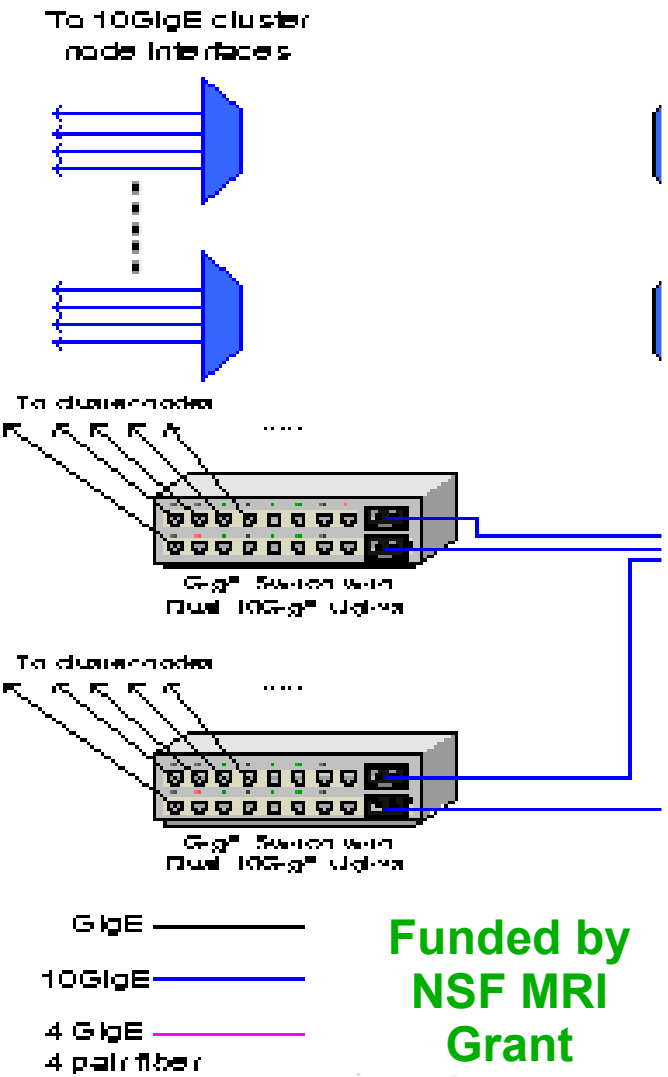
UCSD
UCIrvine

Campus Preparations Needed to Accept CENIC CalREN Handoff to Campus



Source: Jim Dolgonas, CENIC

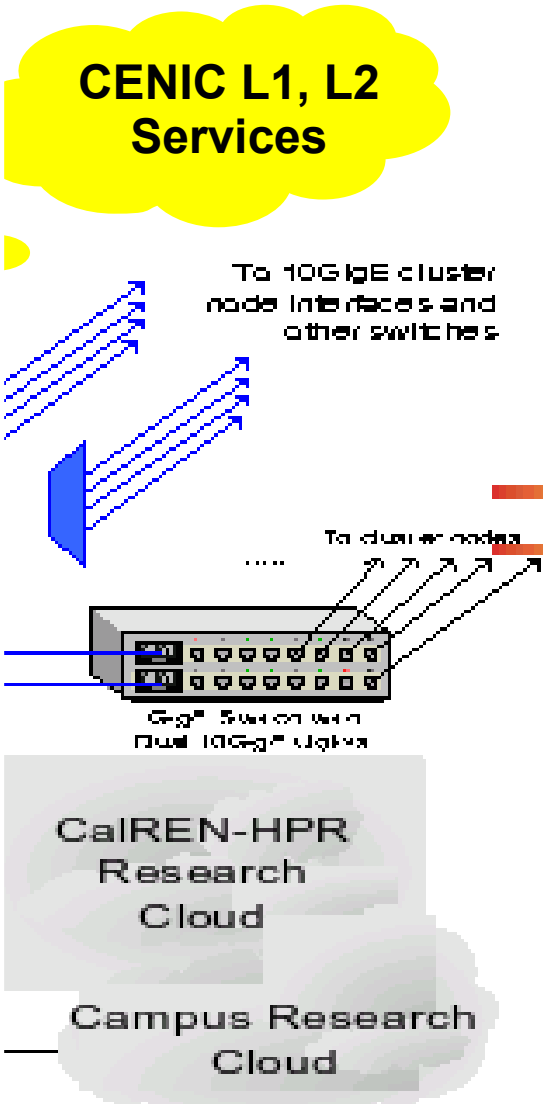
Current UCSD Experimental Optical Core: Ready to Couple to CENIC L1, L2, L3 Services



Goals by 2008:

- >= 50 endpoints at 10 GigE
- >= 32 Packet switched
- >= 32 Switched wavelengths
- >= 300 Connected endpoints

Approximately 0.5 TBit/s Arrive at the "Optical" Center of Campus
Switching will be a Hybrid Combination of:
Packet, Lambda, Circuit -- OOO and Packet Switches Already in Place

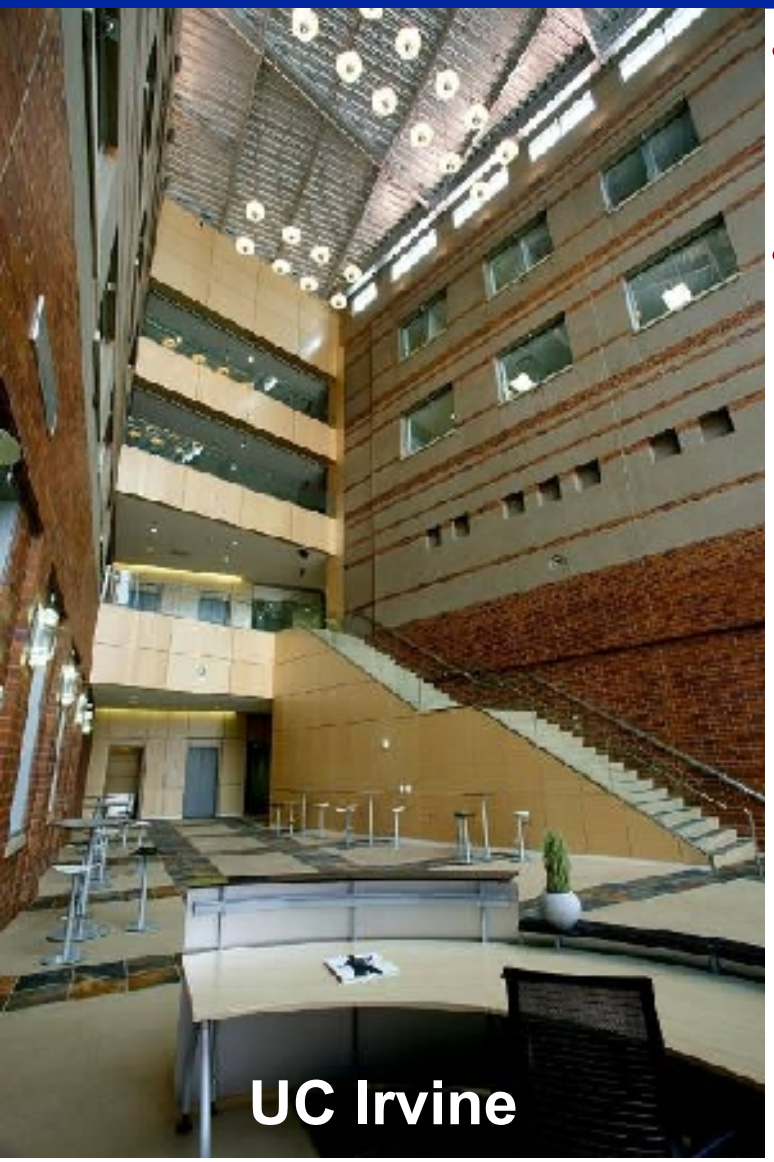


Funded by NSF MRI Grant

OptIPuter Border Router

Source: Phil Papadopoulos, SDSC/Calit2 (Quartzite PI, OptIPuter co-PI)

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

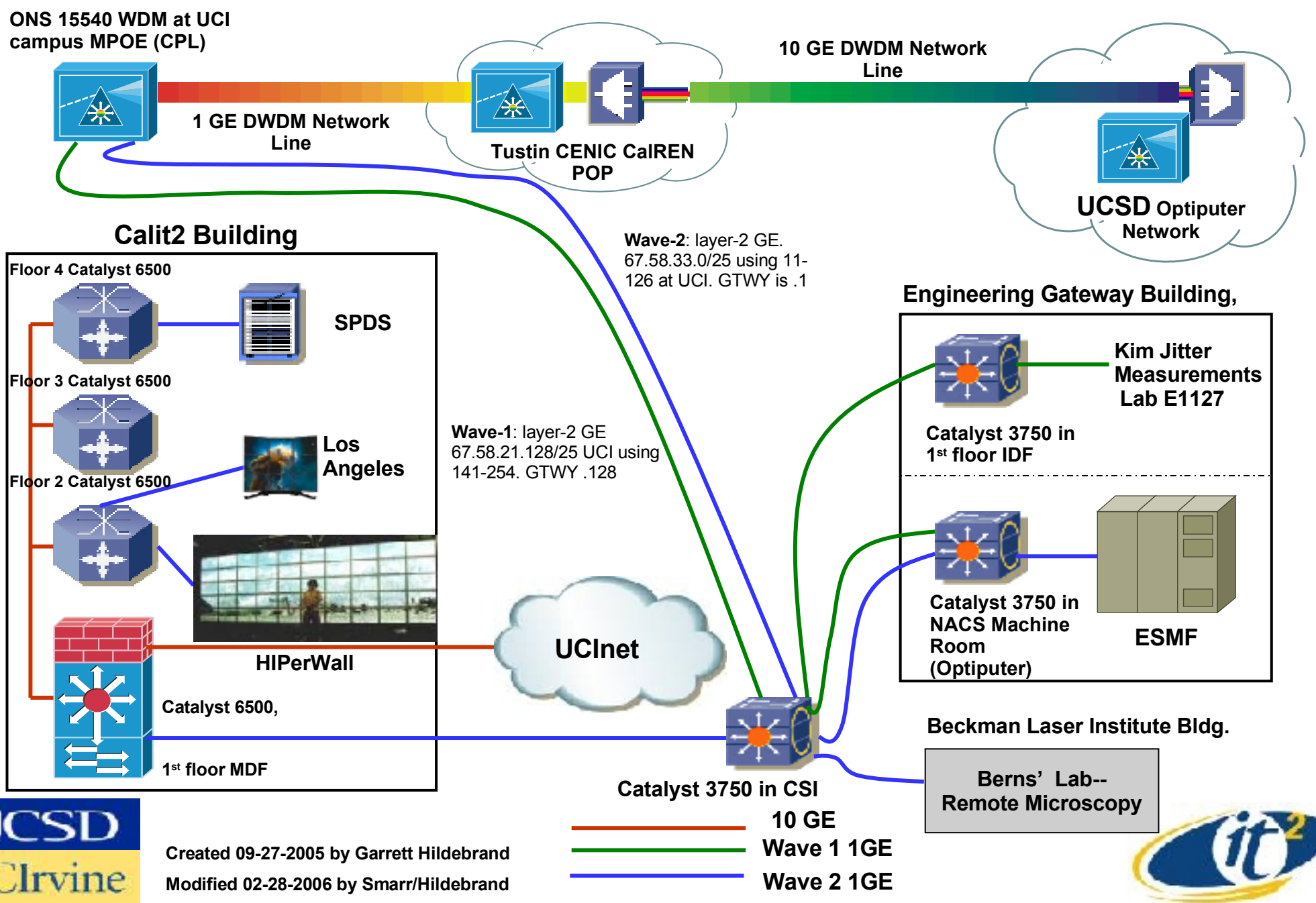


www.calit2.net

Preparing for a World in Which Distance is Eliminated…

UCSD
UCIrvine

UCI and UCSD Are Prototyping Gigabit Applications



UCSD UCIrvine

Created 09-27-2005 by Garrett Hildebrand

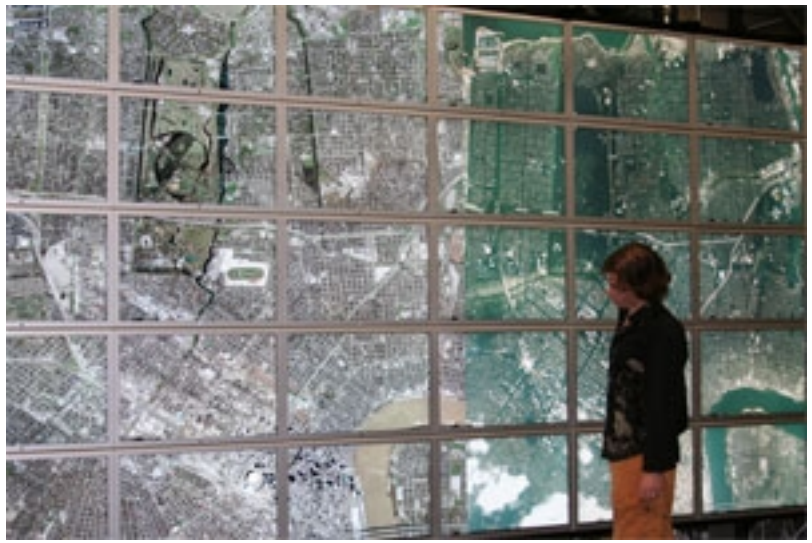
Modified 02-28-2006 by Smarr/Hildebrand

Nearly One Half Billion Pixels in Calit2 Extreme Visualization Project!

Connected at 2,000 Megabits/s!





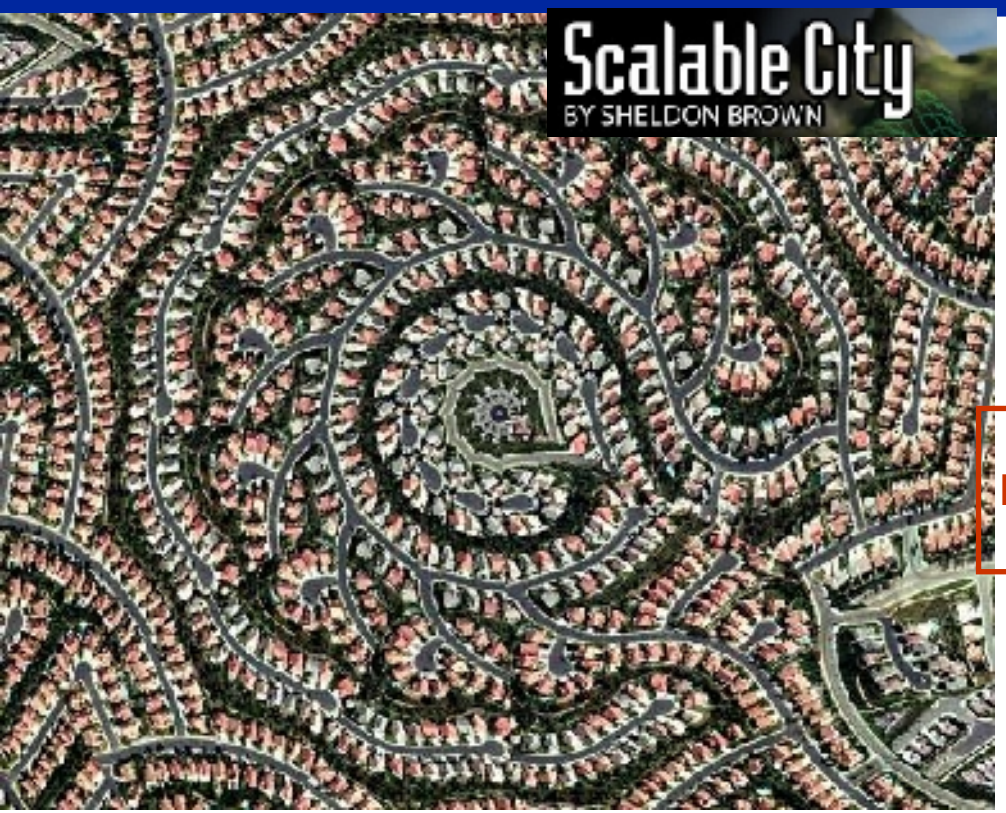


UCI HIPerWall Analyzing Pre- and Post- Katrina

UCSD
UCIrvine

Falko Kuester, UCSD; Steven Jenks, UCI

Calit2 Has Facilitated Deep Interactions With the Digital Arts on Both Campuses



Bill Tomlinson, Lynn Carpenter UCI "EcoRaft"



"Researchers Look to Create a Synthesis of Art and Science for the 21st Century"

By John Markoff
NYTimes November 5, 2005

Alex Dragulescu, CRCA

SPECFLIC 1.0 – A Speculative Distributed Social Cinema by Adrienne Jenik



Multipurpose Room—
A “Black Box” Theatre Space

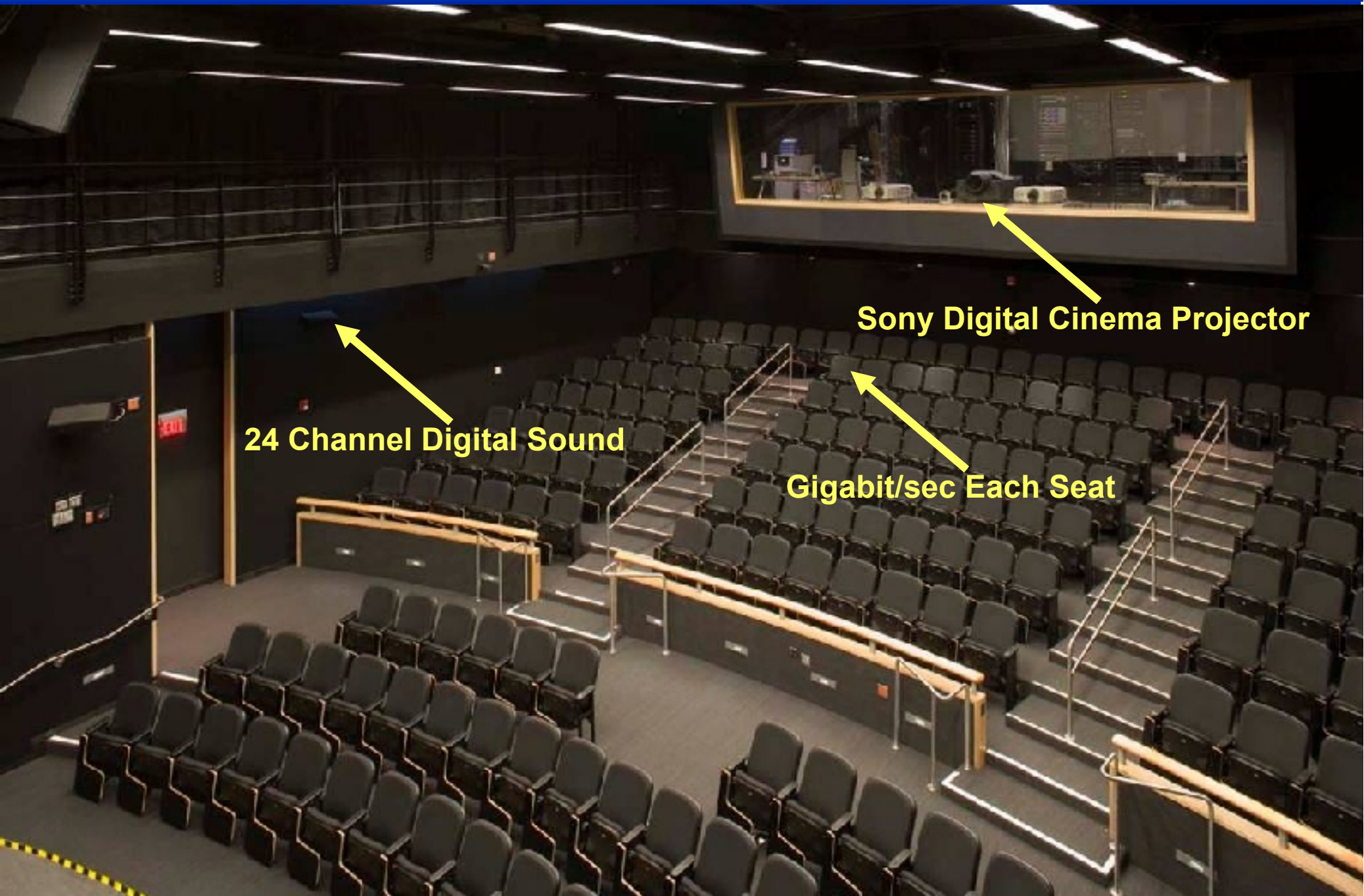


UCSD
UCIrvine

- 100-seat Reconfigurable Space
- 3D HD Projection

it²

Building a Global Collaboratorium



Borderless Collaboration Between Global University Research Centers at 10Gbps

Maxine Brown, Tom DeFanti, Co-Chairs

iGrid 2005

THE GLOBAL LAMBDA INTEGRATED FACILITY

www.igrid2005.org

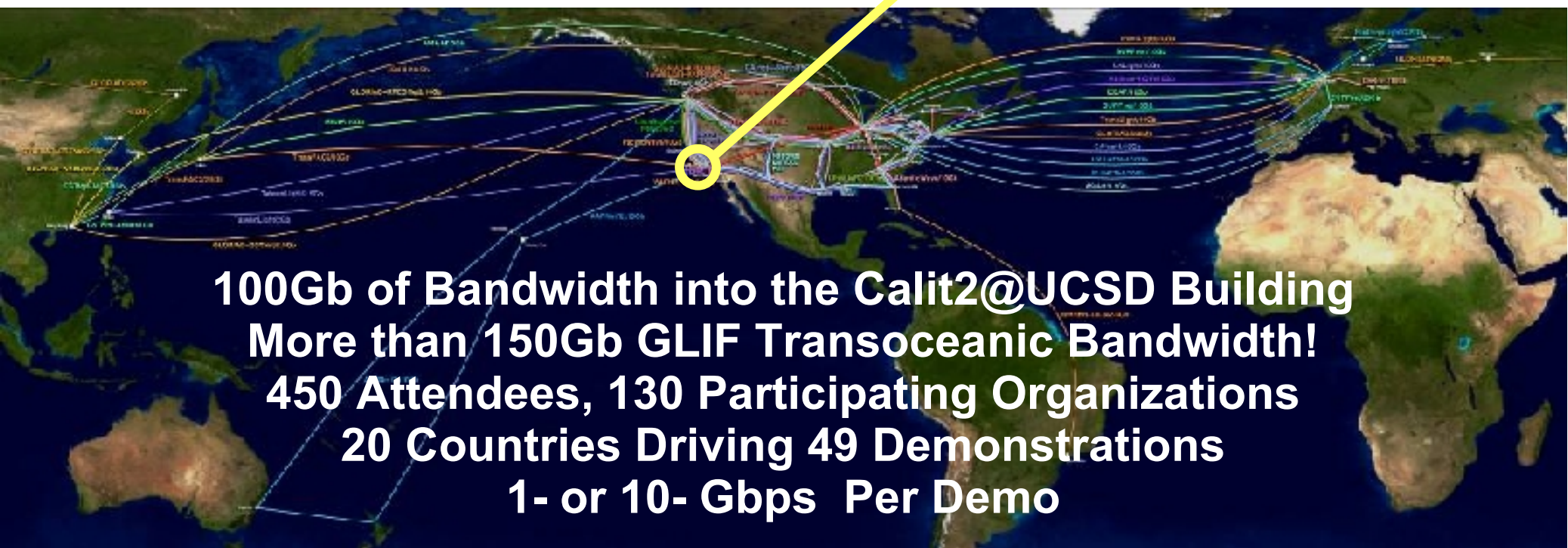


the UC Discovery Grant

September 26-30, 2005

Calit2 @ University of California, San Diego

California Institute for Telecommunications and Information Technology



100Gb of Bandwidth into the Calit2@UCSD Building

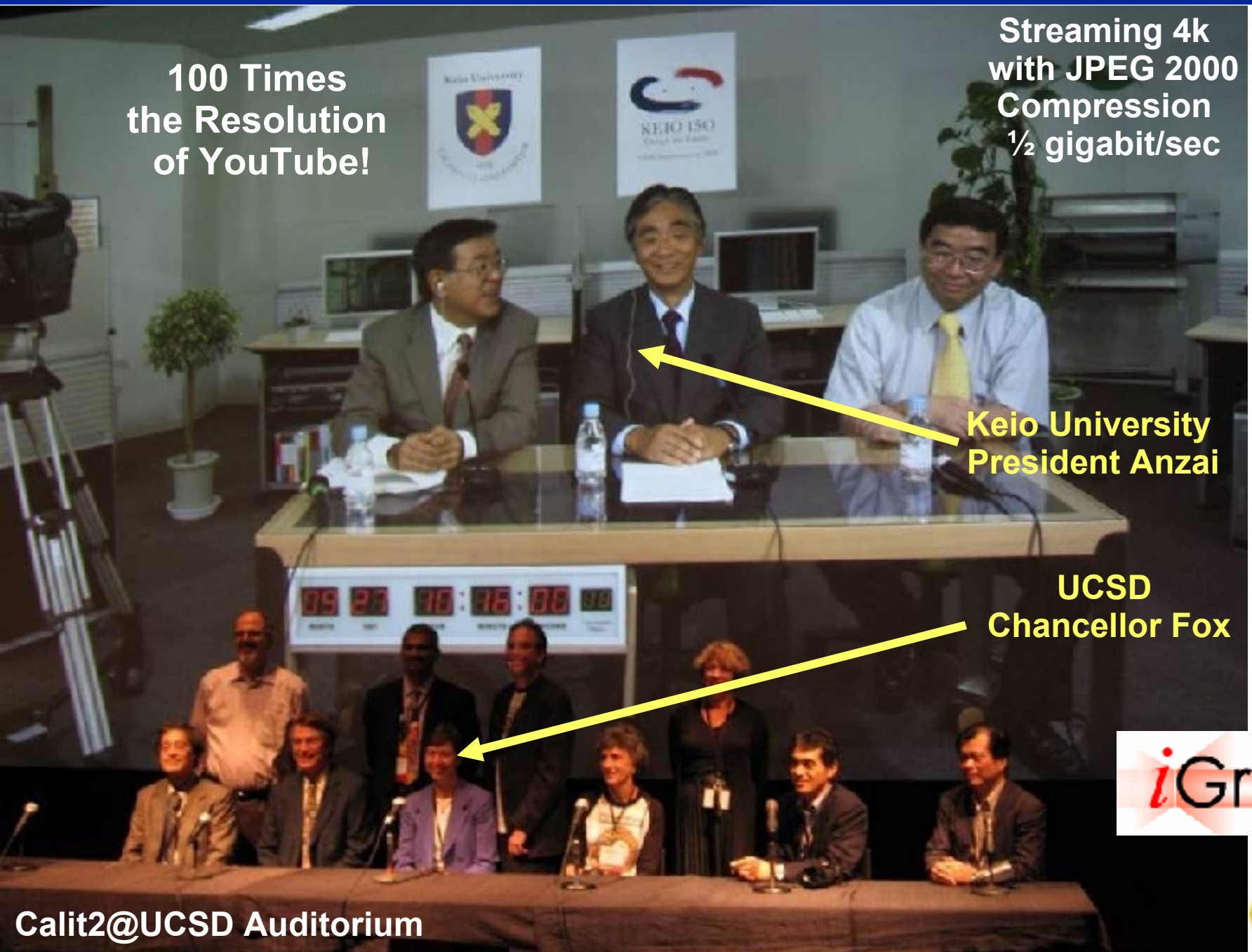
More than 150Gb GLIF Transoceanic Bandwidth!

450 Attendees, 130 Participating Organizations

20 Countries Driving 49 Demonstrations

1- or 10- Gbps Per Demo

First Trans-Pacific Super High Definition Telepresence Meeting Using Digital Cinema 4k Streams



CineGrid

Lays Technical Basis for Global Digital Cinema

Sony
NTT
SGI

iGrid 2005

it²

Interactive VR Streamed Live from Tokyo to Calit2 Over Dedicated GigE and Projected at 4k Resolution









Source: Toppan Printing

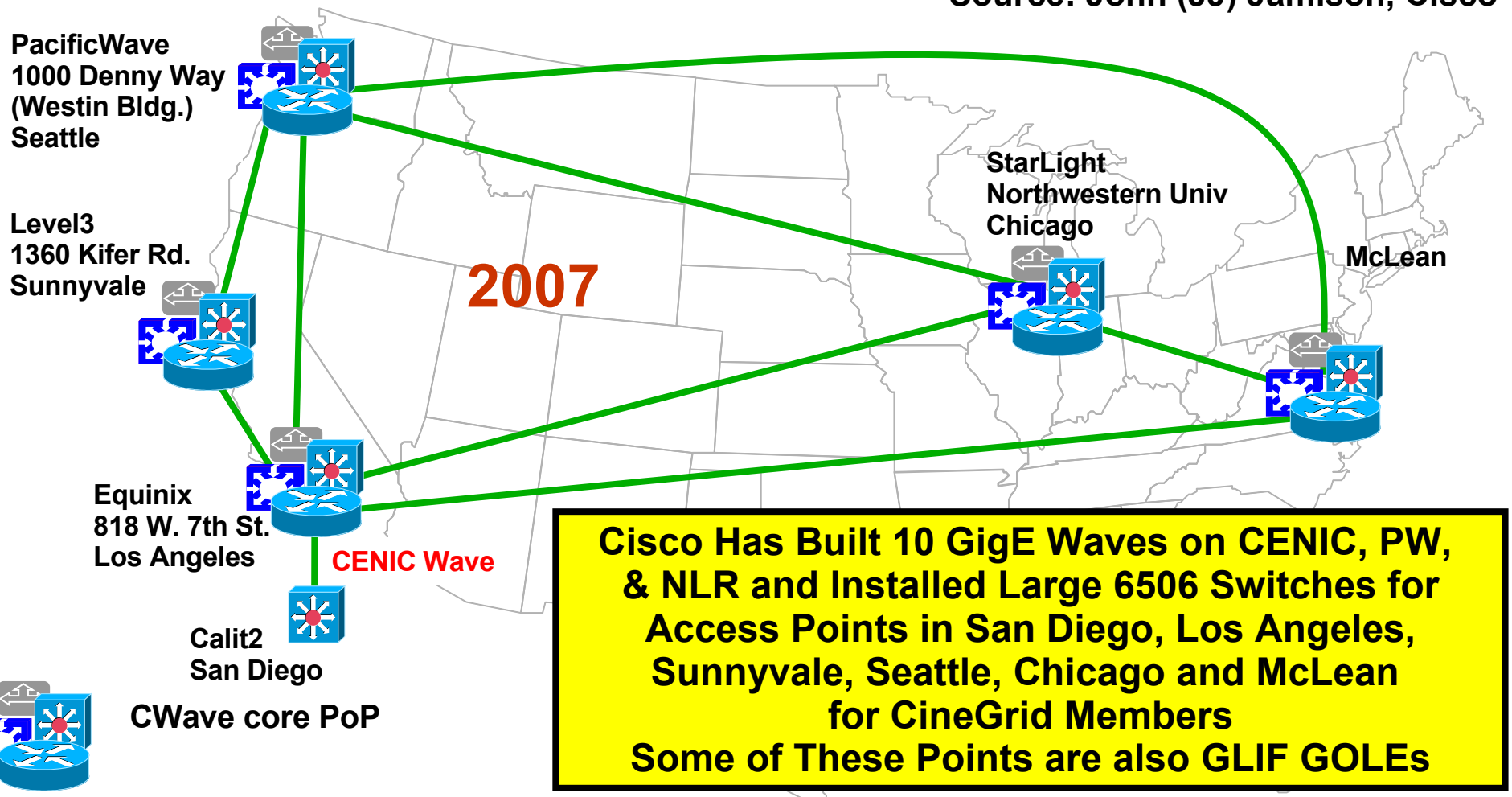
iGrid 2005 Kyoto Nijo Castle

UCSD UCIrvine

it²

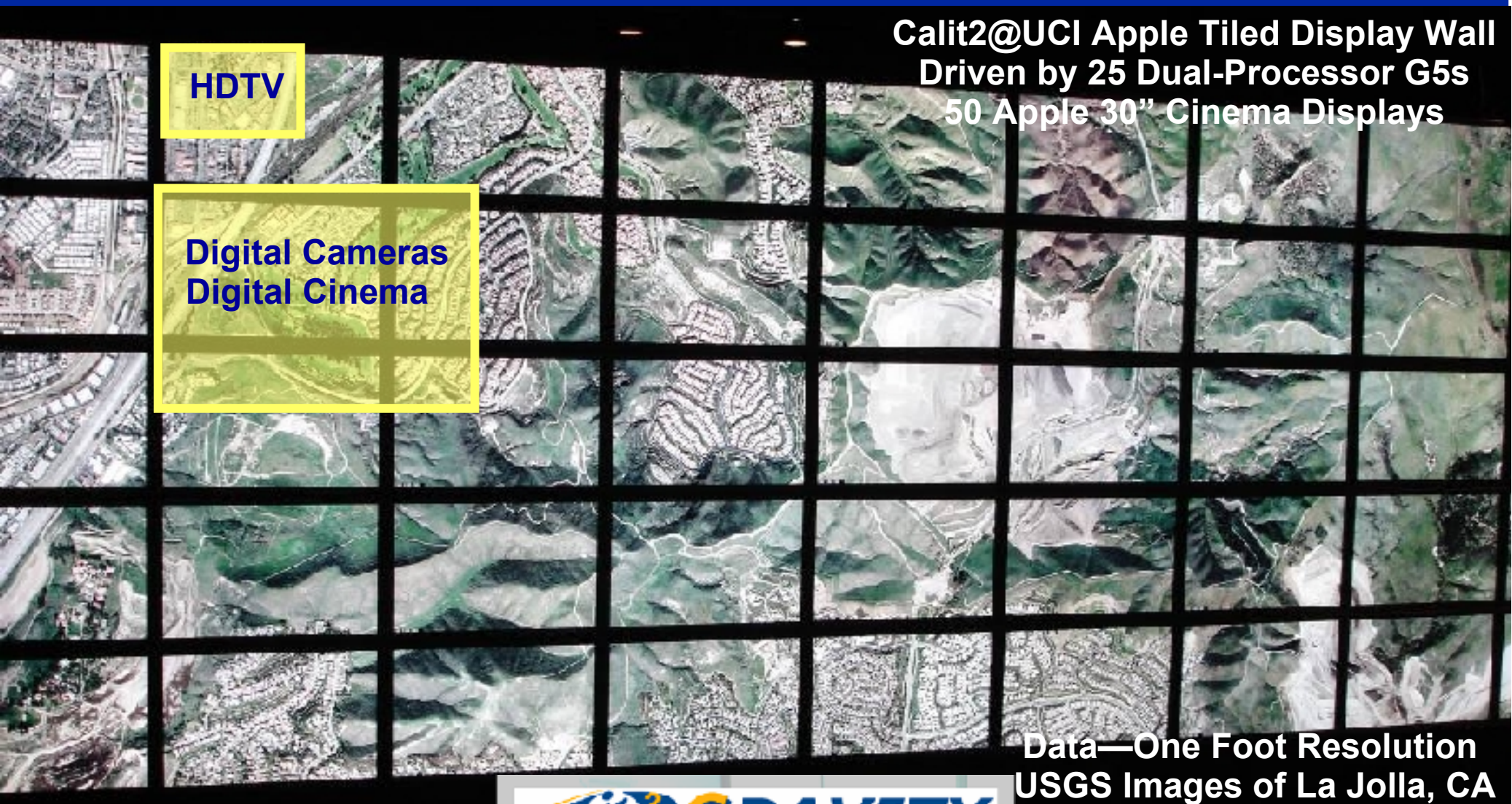
CineGrid: A New Cyberinfrastructure for High Resolution Media Streaming*

Source: John (JJ) Jamison, Cisco



Cisco Has Built 10 GigE Waves on CENIC, PW, & NLR and Installed Large 6506 Switches for Access Points in San Diego, Los Angeles, Sunnyvale, Seattle, Chicago and McLean for CineGrid Members
Some of These Points are also GLIF GOLEs

Beyond 4k –
From 8 Megapixels Towards a Billion Megapixels



Source: Falko Kuester, Calit2@UCI
NSF Infrastructure Grant

Multi-Gigapixel Images are Available from Film Scanners Today



UCSD
UCIrvine

The Gigapxl Project
http://gigapxl.org

it²

Large Image with Enormous Detail Require Interactive Ultra-Resolution Viewing Systems



The OptIPuter Project is Pursuing Obtaining some of these Images for 200M Pixel Walls

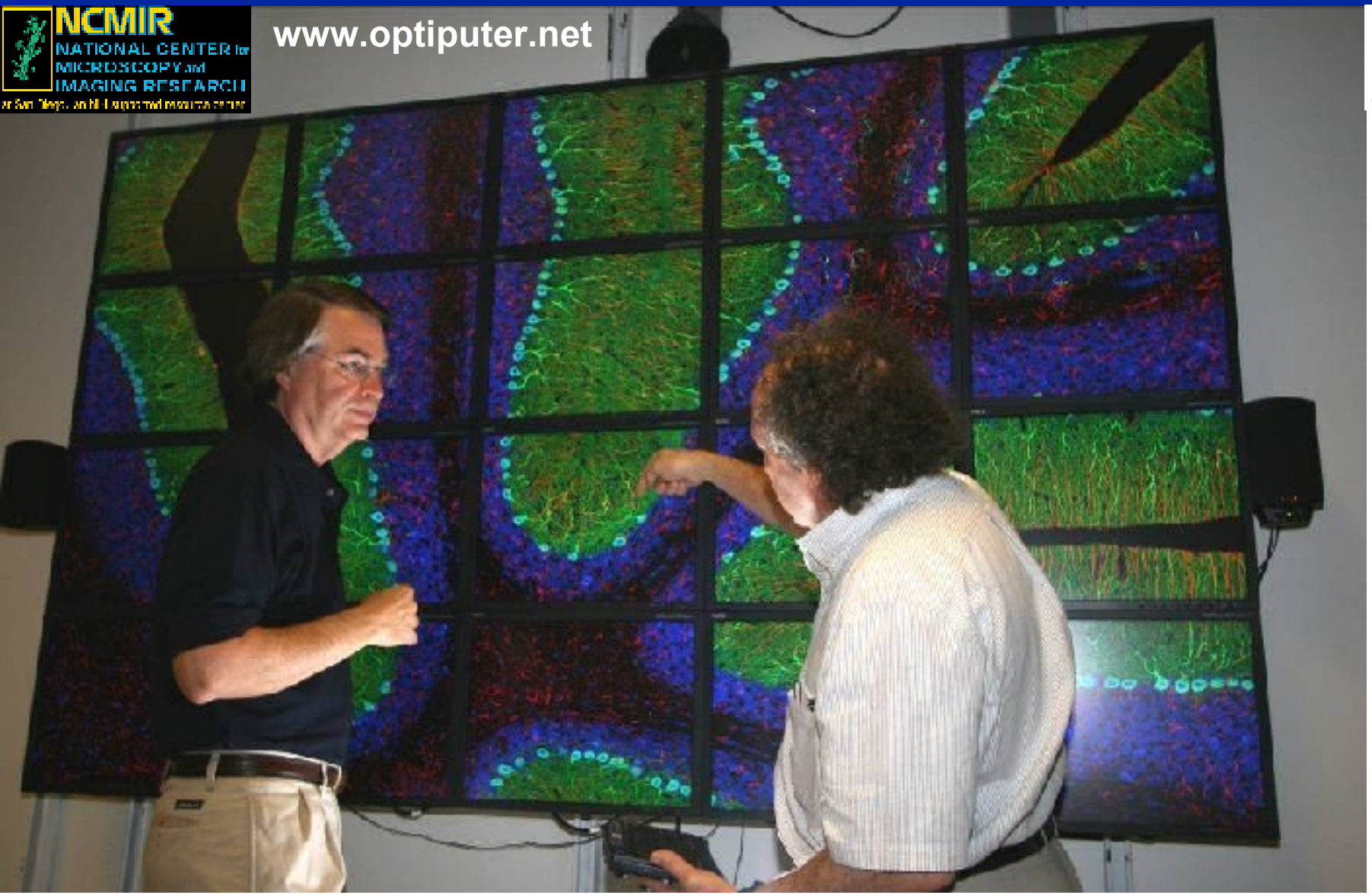
One Square Inch Shot From 100 Yards

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

NCMIR NATIONAL CENTER for MICROSCOPY and IMAGING RESEARCH

www.optiputer.net

OptIPuter



NSF

2002-2008

Picture Source: Mark Ellisman, David Lee, Jason Leigh

UCSD

UCIrvine

Calit2 (UCSD, UCI) and UIC Lead Campuses—Larry Smarr PI

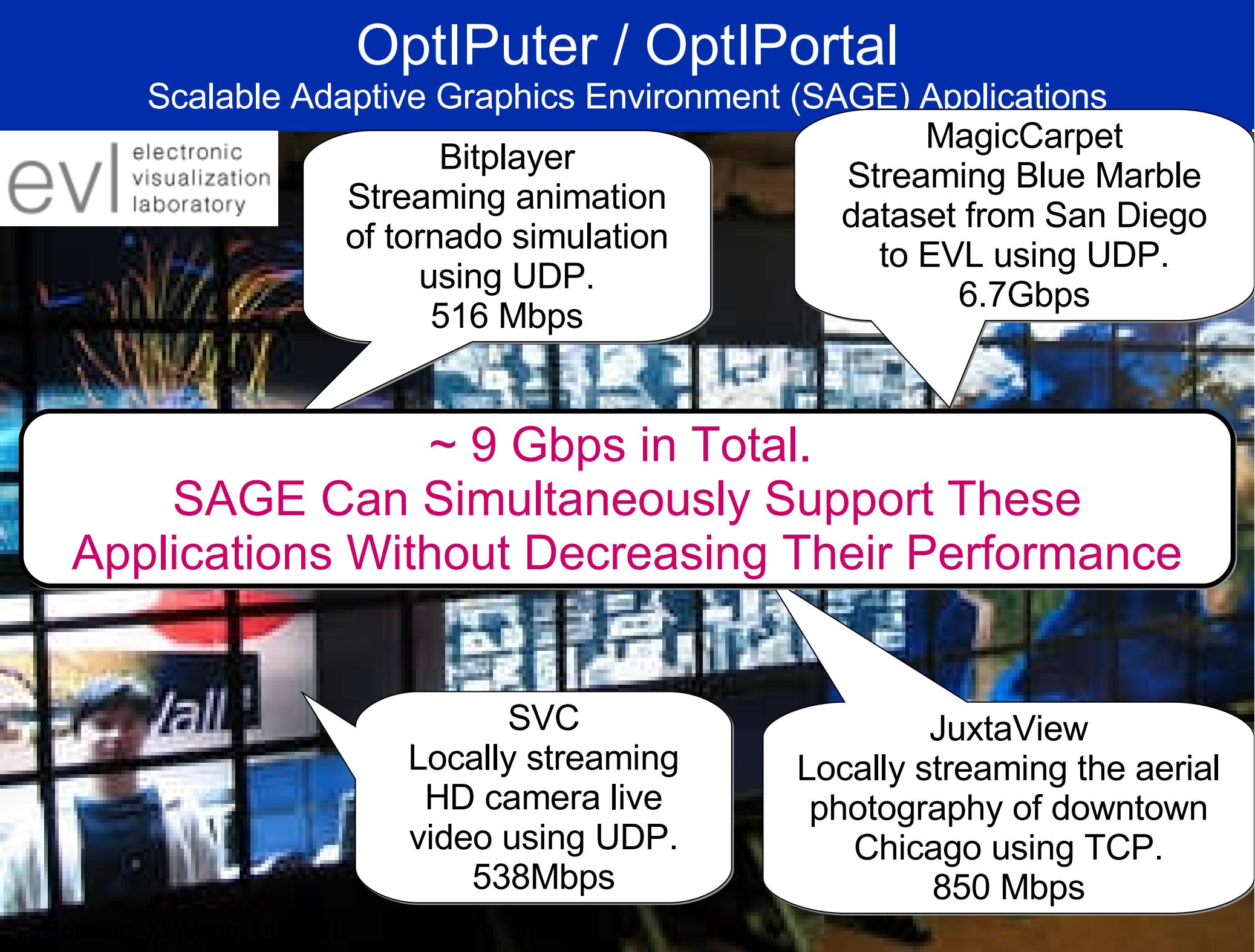
Univ. Partners: SDSC, USC, SDSU, NW, TA&M, UvA, SARA, KISTI, AIST

Industry: IBM, Sun, Telcordia, Chiaro, Calient, Glimmerglass, Lucent

it2

OptIPuter / OptIPortal

Scalable Adaptive Graphics Environment (SAGE) Applications



My OptIPortal™ – Affordable Termination Device for the OptIPuter Global Backplane

- 20 Dual CPU Nodes, 20 24” Monitors, ~$50,000
- 1/4 Teraflop, 5 Terabyte Storage, 45 Mega Pixels--Nice PC!
- Scalable Adaptive Graphics Environment (SAGE) Jason Leigh, EVL-UIC





UCSD UCIrvine

Powered by Rocks ROCKS

Source: Phil Papadopoulos SDSC, Calit2

it²

Calit2's Direct Access Core Architecture Has Created Next Generation Metagenomics Server

Sargasso Sea Data

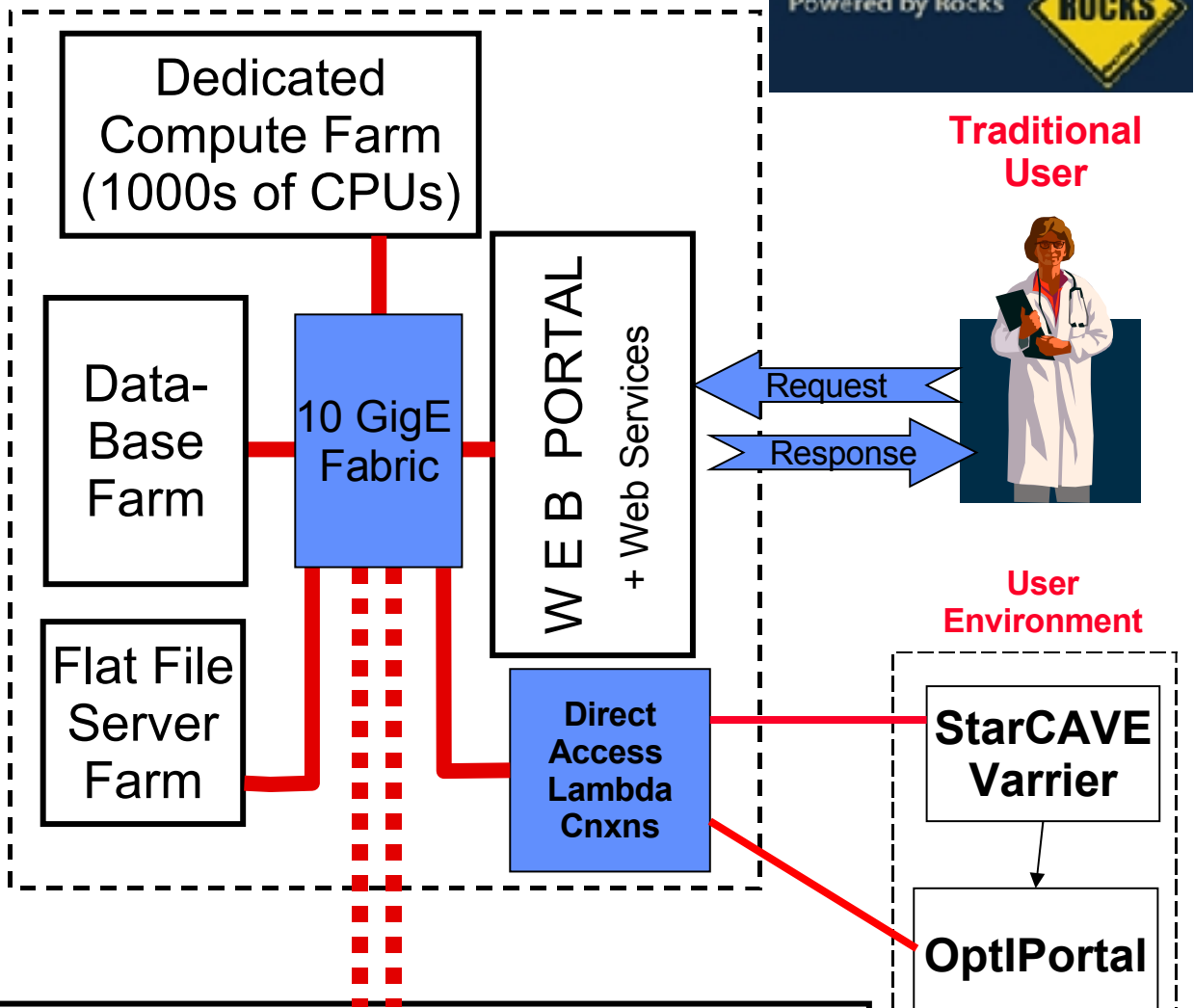
Sorcerer II Expedition (GOS)

JGI Community Sequencing Project

Moore Marine Microbial Project

NASA and NOAA Satellite Data

Community Microbial Metagenomics Data



Source: Phil Papadopoulos, SDSC, Calit2

Use of Tiled Display Wall OptIPortal to Interactively View Microbial Genome



camera

OptIPuter

Powered by Rocks ROCKS

Acidobacteria bacterium Ellin345
Soil Bacterium 5.6 Mb
Source: Raj Singh, UCSD

it2

Use of Tiled Display Wall OptIPortal to Interactively View Microbial Genome



camera Marine Microbial Ecology

OptIPuter

Powered by Rocks ROCKS

Source: Raj Singh, UCSD

it²

Use of Tiled Display Wall OptIPortal to Interactively View Microbial Genome



camera Marine Microbial Ecology

OptIPuter

Powered by Rocks ROCKS

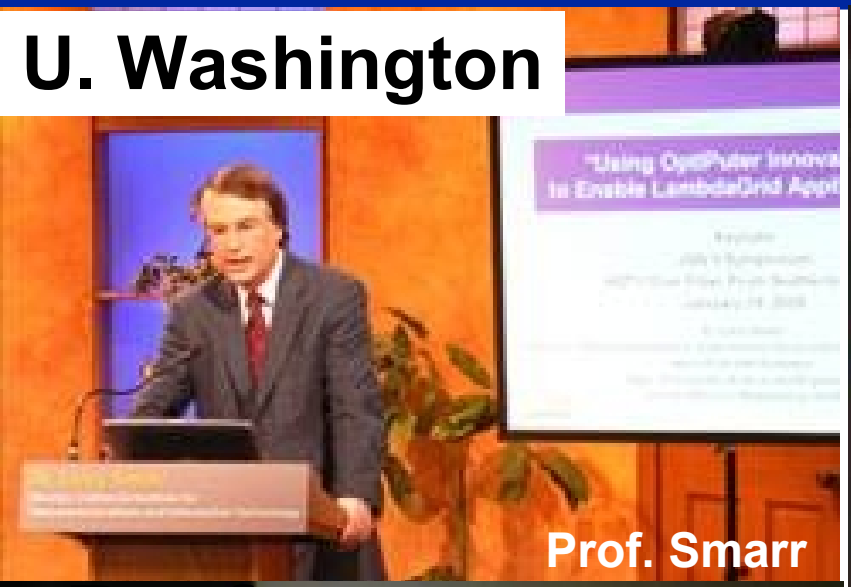
Source: Raj Singh, UCSD

it²

An Emerging High Performance Collaboratory for Microbial Metagenomics

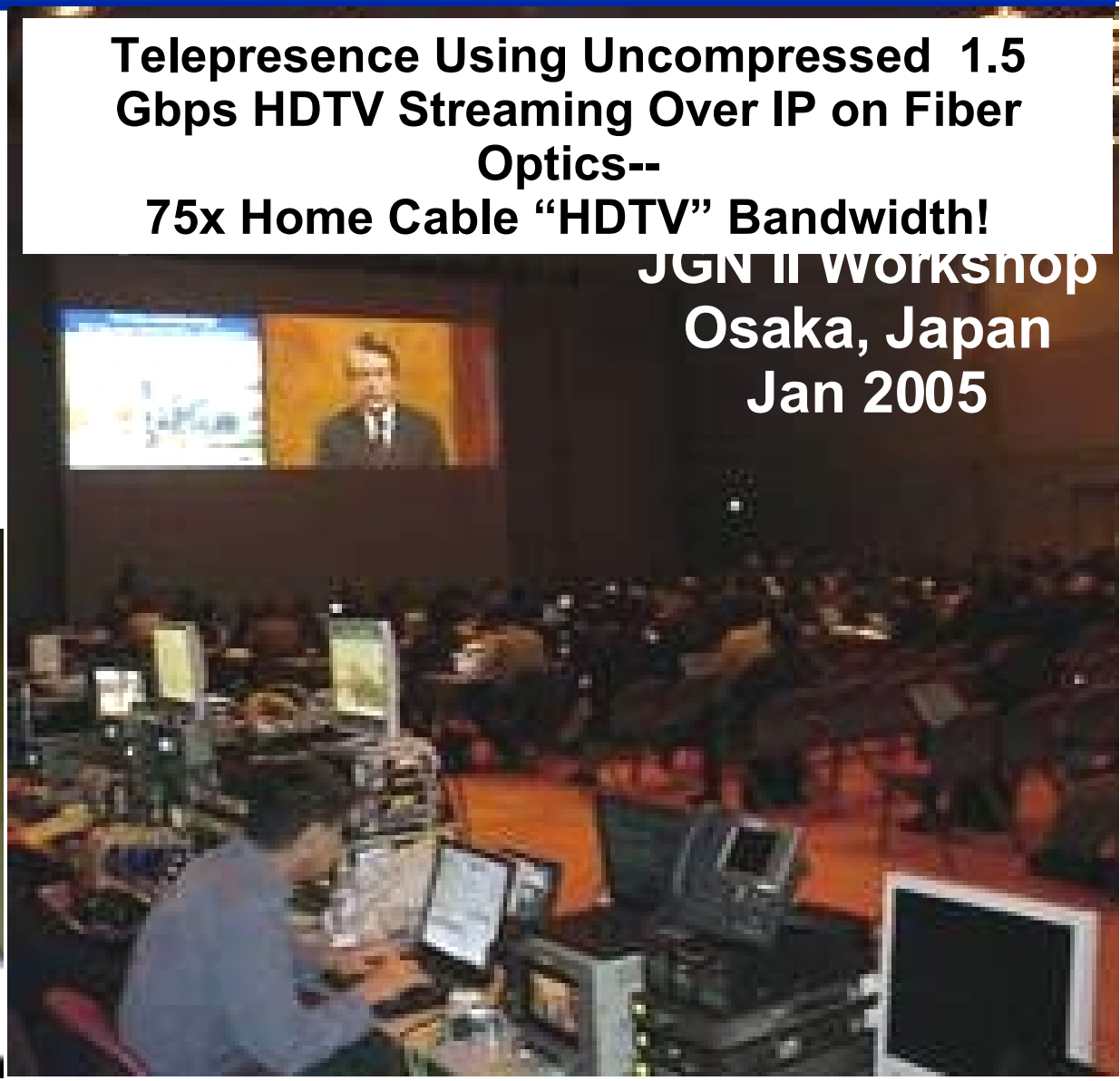


Multiple Gigabit HD Streams Over Lambdas Will Radically Transform Global Collaboration





Telepresence Using Uncompressed 1.5 Gbps HDTV Streaming Over IP on Fiber Optics--
75x Home Cable "HDTV" Bandwidth!



UCSD
UCIrvine

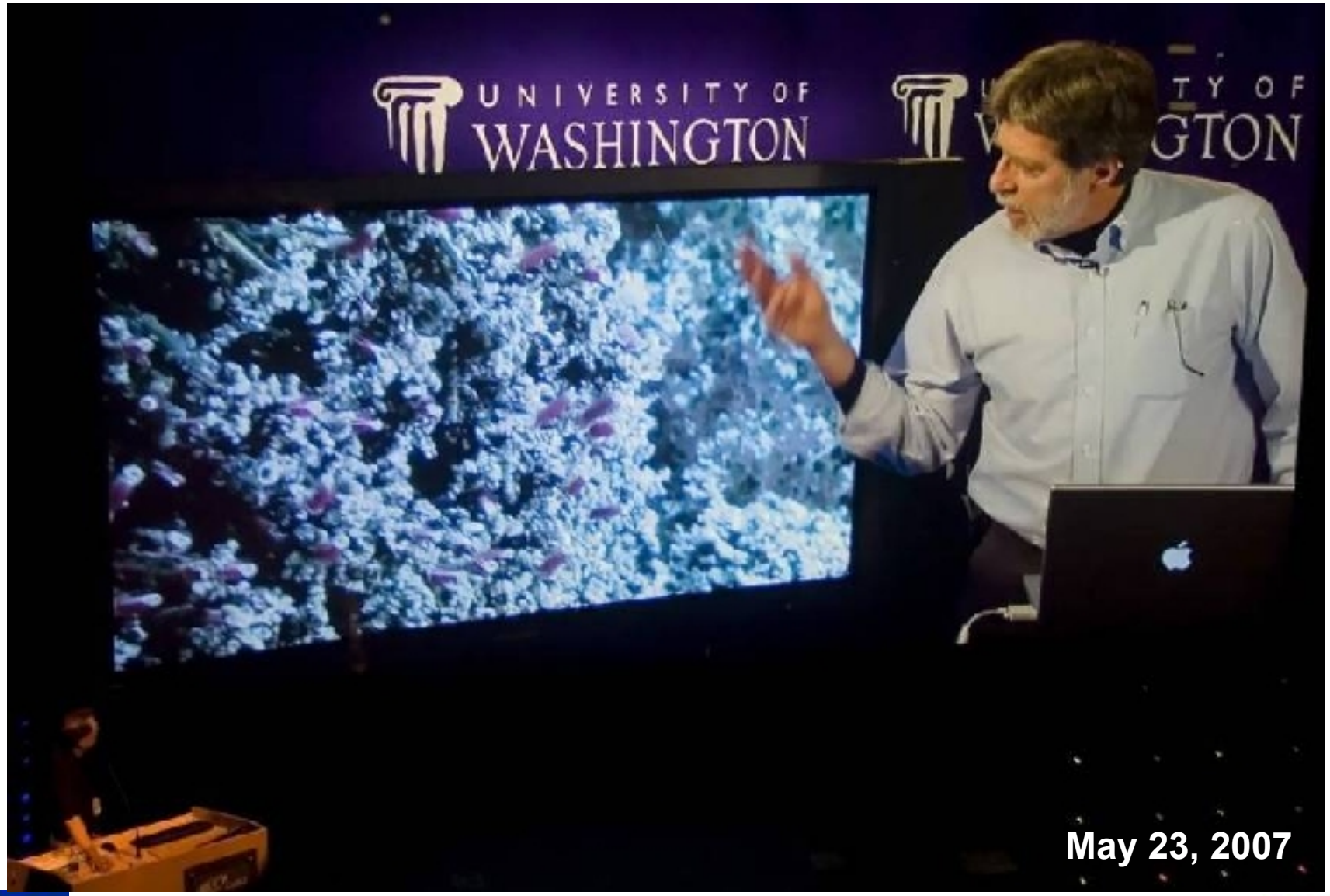
"I can see every hair on your head!"—Prof. Aoyama

Source: U Washington Research Channel

it²

e-Science Collaboratory Without Walls Enabled by Uncompressed HD Telepresence

1500 Mbits/sec Calit2 to UW Research Channel Over NLR



John Delaney, PI LOOKING, Neptune

Photo: Harry Ammons, SDSC

UCSD
UCIrvine

Goal for SC'07
iHDTV Integrated into OptIPortal

SC07 is the International Conference for High Performance Computing, Networking, Storage and Analysis

Moving from Compressed HD to Uncompressed iHDTV Reno to UW in Seattle



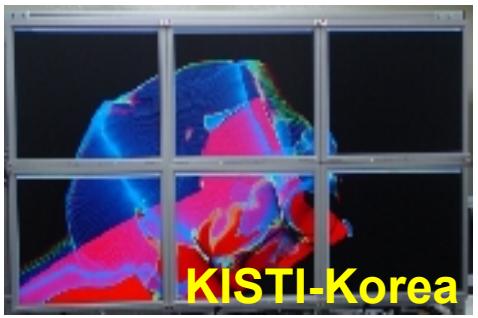


Source: Michael Wellings
Research Channel
Univ. Washington

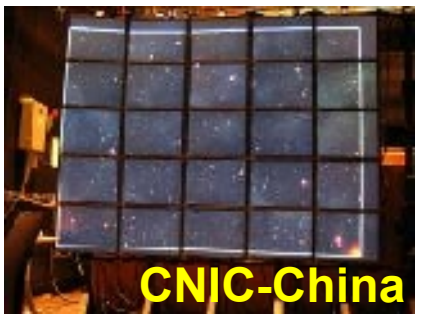
UCSD
UCIrvine

Rocks / SAGE OptIPortals Are Being Adopted Globally

























UCSD
UCIrvine

Powered by Rocks ROCKS

evl electronic visualization laboratory

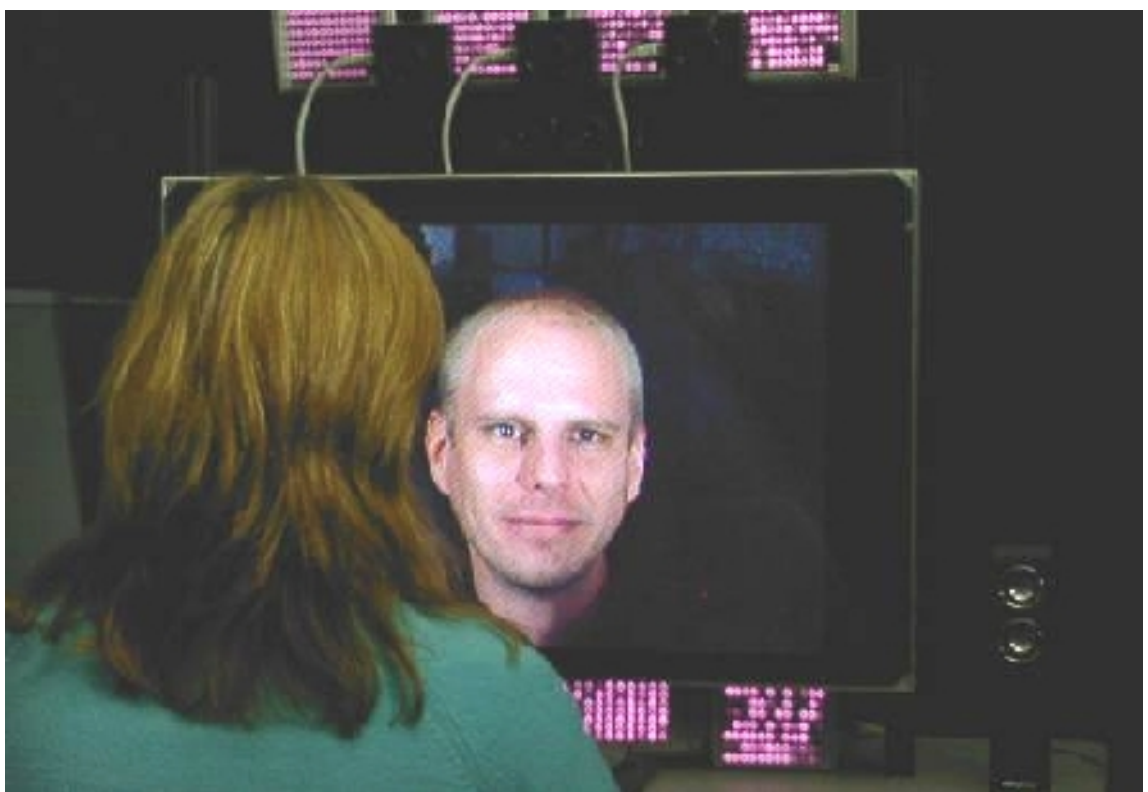
it2

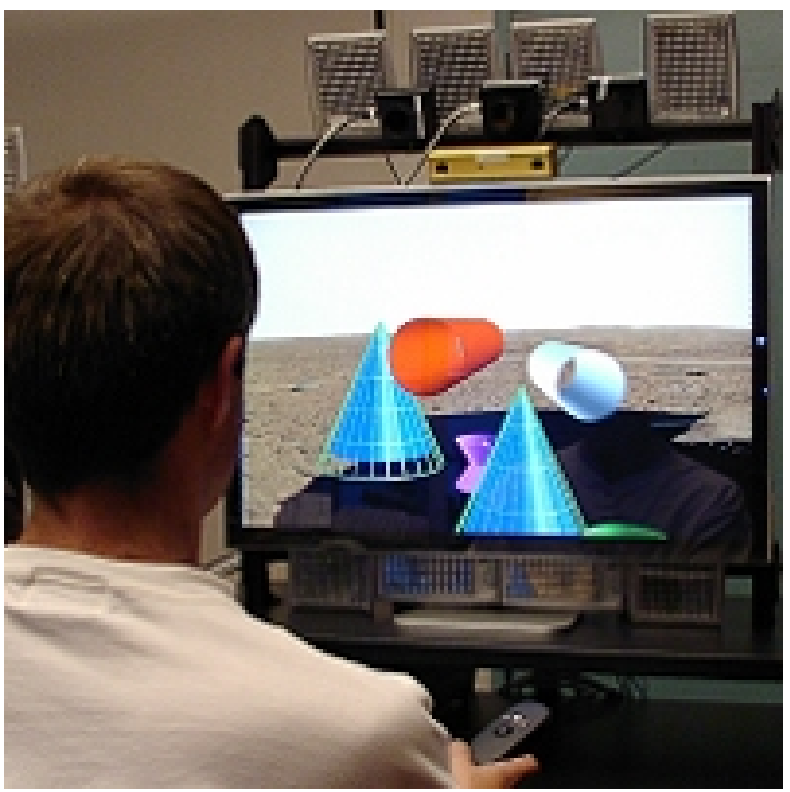
SAGE Global Visualcasting to Europe September 2007



3D Videophones Are Here!
The Personal Varrier Autostereo Display

- Varrier is a Head-Tracked Autostereo Virtual Reality Display
  - 30” LCD Widescreen Display with 2560x1600 Native Resolution
  - A Photographic Film Barrier Screen Affixed to a Glass Panel
- Cameras Track Face with Head Tracker to Locate Eyes
- The Display Eliminates the Need to Wear Special Glasses





UCSD
UCIrvine

Source: Daniel Sandin, Thomas DeFanti, Jinghua Ge, Javier Girado, Robert Kooima, Tom Peterka—EVL, UIC

it²

Calit2/EVL Varrier
60 Screen Stereo OptIPortal, no Glasses Needed



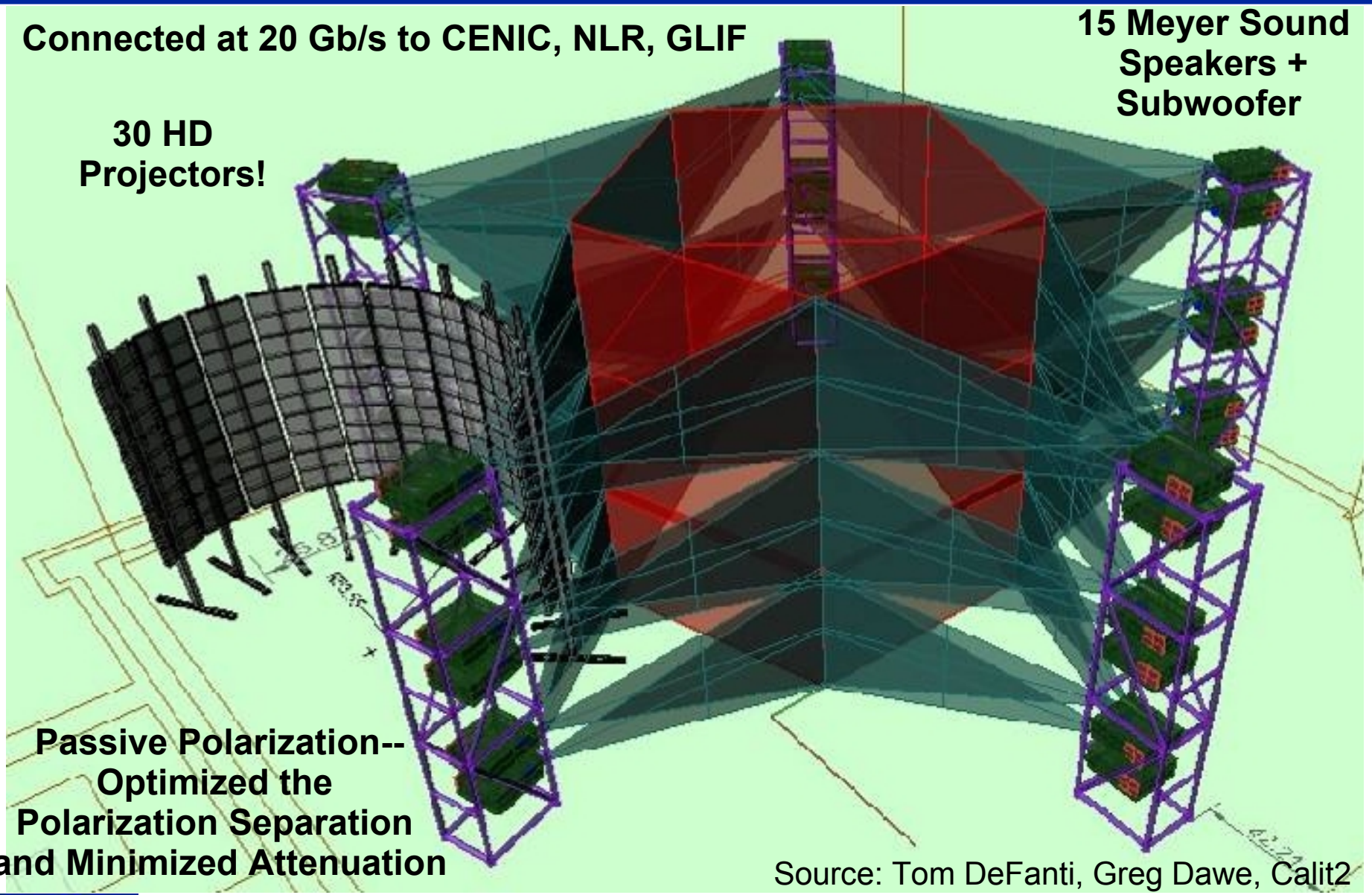
evl visualization laboratory

UCIrvine

Dan Sandin, Greg Dawe, Tom Peterka, Tom DeFanti, Jason Leigh, Jinghua Ge, Javier Girado, Bob Kooima, Todd Margolis, Lance Long, Alan Verlo, Maxine Brown, Jurgen Schulze, Qian Liu, Ian Kaufman, Bryan Glogowski

it2

3D OptIPortals: Calit2 StarCAVE and Varrier Alpha Tests of Telepresence "Holodecks"



Source: Tom DeFanti, Greg Dawe, Calit2

UCSD
UCIrvine

Cluster with 30 Nvidia 5600 cards-60 GB Texture Memory, Renders Images 3,200 Times the Speed of Single PC

StarCAVE Panoramas

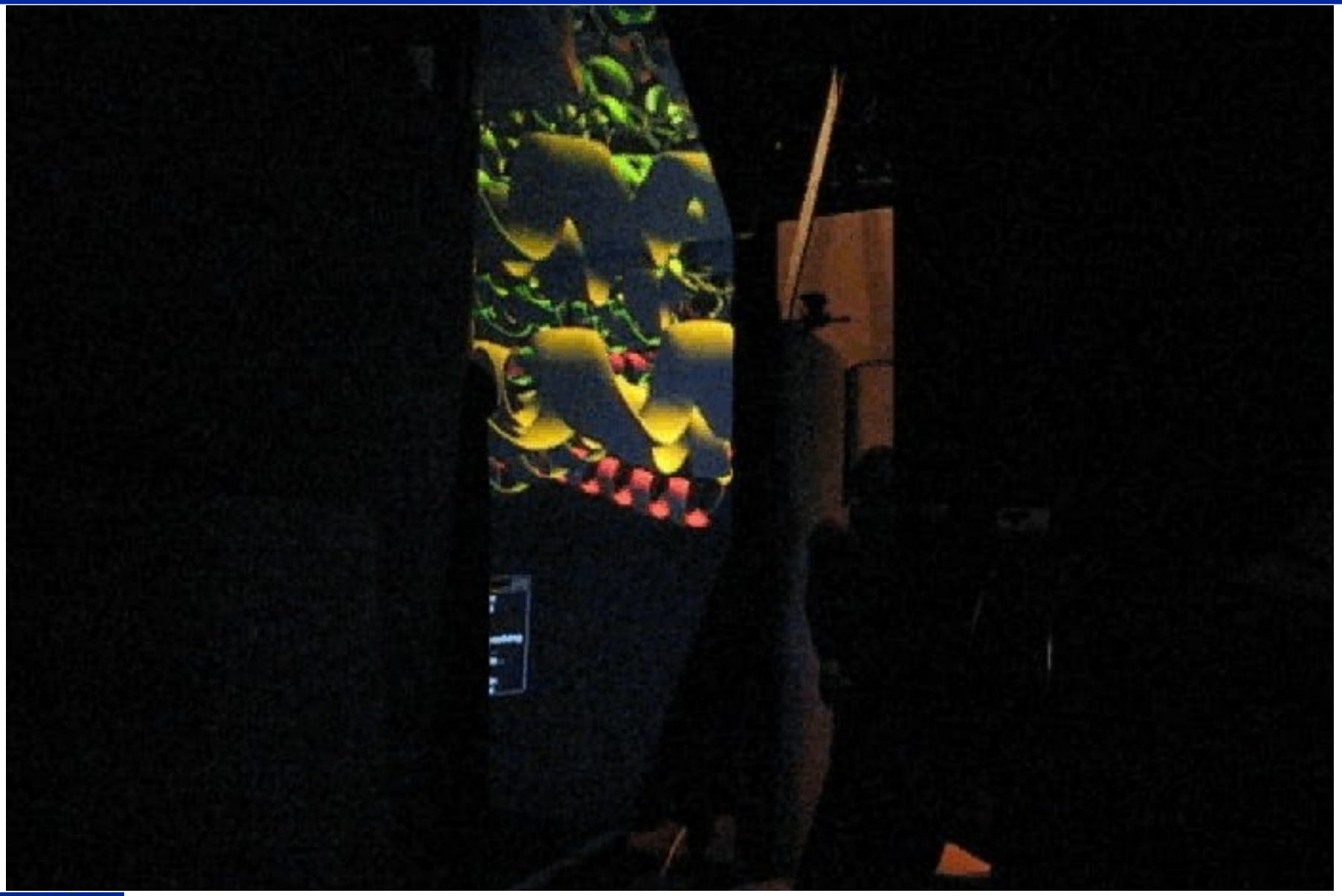


UCSD
UCIrvine

Source: Tom DeFanti, Jurgen Schulze, Bob Kooima, Calit2/EVL

it²

The StarCAVE as a “ Browser” for the Protein Data Bank



UCSD UCIrvine

Source: Tom DeFanti, Jurgen Schulze, Bob Kooima, Calit2/EVL

it²

EVL's Next-Generation Context Aware Virtual Environment (NG-CAVE)

