

AUSTRALIAN AMERICAN LEADERSHIP DIALOGUE

aarnet
Australia's Academic and Research Network

"Coupling Australia's Researchers to the Global Innovation Economy"

Second Lecture in the
Australian American Leadership Dialogue Scholar Tour
University of Western Australia
Perth, Australia
October 6, 2008

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

An innovation economy begins with the “pull toward the future” provided by a robust public research sector. While the shared Internet has been rapidly diminishing Australia’s “tyranny of distance,” the 21st Century global competition, driven by public research innovation, requires Australia to have high performance connectivity second to none for its researchers.

A major step toward this goal has been achieved during the last year through the Australian American Leadership Dialogue (AALD) Project Link, establishing a 1 Gigabit/sec dedicated end-to-end connection between a 100 megapixel OptIPortal at the University of Melbourne and Calit2@UC San Diego over AARNet, Australia's National Research and Education Network.

From October 2-17 Larry Smarr, as the 2008 Leadership Dialogue Scholar, is visiting Australian universities from Perth to Brisbane in order to oversee the launching of the next phase of the Leadership Dialogue’s Project Link—the linking of Australia’s major research intensive universities and the CSIRO to each other and to innovation centres around the world with AARNet’s new 10 Gbps access product.

At each university Dr. Smarr will facilitate discussions on what is needed in the local campus infrastructure to make this ultra-broadband available to data intensive researchers. With this unprecedented bandwidth, Australia will be able to join emerging global collaborative research—across disciplines as diverse as climate change, coral reefs, bush fires, biotechnology, and health care—bringing the best minds on the planet to bear on issues critical to Australia’s future.

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The 20 Year Pursuit of a Dream: Shrinking the Planet

"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

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SIGGRAPH 1989

NCSA™

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The OptIPuter Creates an OptIPlanet Collaboratory
Using High Performance Bandwidth, Resolution, and Video



Scalable Adaptive Graphics Environment (SAGE)

evl electronic visualization laboratory

NSF

Just Finished Sixth and Final Year

ROCKS

September 2007

Calit2 (UCSD, UCI), SDSC, and UIC Leads—Larry Smarr PI
Univ. Partners: NCSA, USC, SDSU, NW, TA&M, UvA, SARA, KISTI, AIST
Industry: IBM, Sun, Telcordia, Chiaro, Calient, Glimmerglass, Lucent

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OptIPuter Step I:
From Shared Internet to Dedicated Lightpaths

The Unrelenting Exponential Growth of Data Requires an Exponential Growth in Bandwidth

- **"US Bancorp backs up 100 TeraBytes of financial data every night – now."**
  - **David Grabski (VP Information Tech. US Bancorp), Qwest High Performance Networking Summit, Denver, CO. USA, June 2006**
- **"Each LHC experiment foresees a recorded raw data rate of 1 to several thousand TeraBytes/year"**
  - **Dr. Harvey Neuman (Cal Tech), Professor of Physics**
- **"The VLA facility is now able to generate 700 Gbps of astronomical data and the Extended VLA will reach 3200 Gigabits per second by 2009."**
  - **Dr. Steven Durand, National Radio Astronomy Observatory, e-VLBI Workshop, MIT Haystack Observatory, Sep 2006**
- **"The Global Information Grid will need to store and access millions of Terabytes of data on a realtime basis by 2010"**
  - **Dr. Henry Dardy (DOD), Optical Fiber Conference, Los Angeles, CA USA, Mar 2006**

OptIPuter

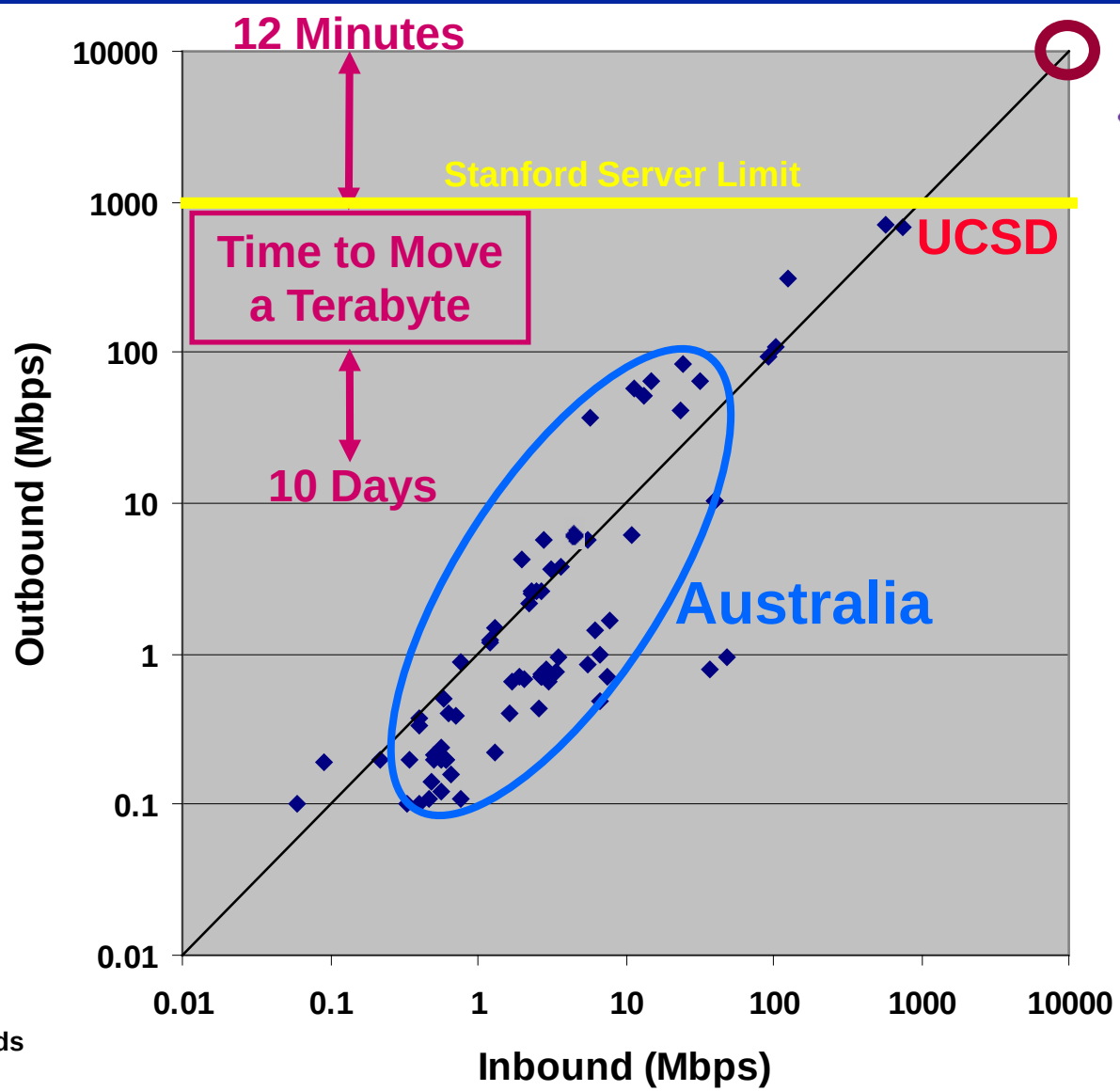
Source: Jerry Sobieski MAX / University of Maryland

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

Computers In:

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



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100-1000x 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/

OptIPuter

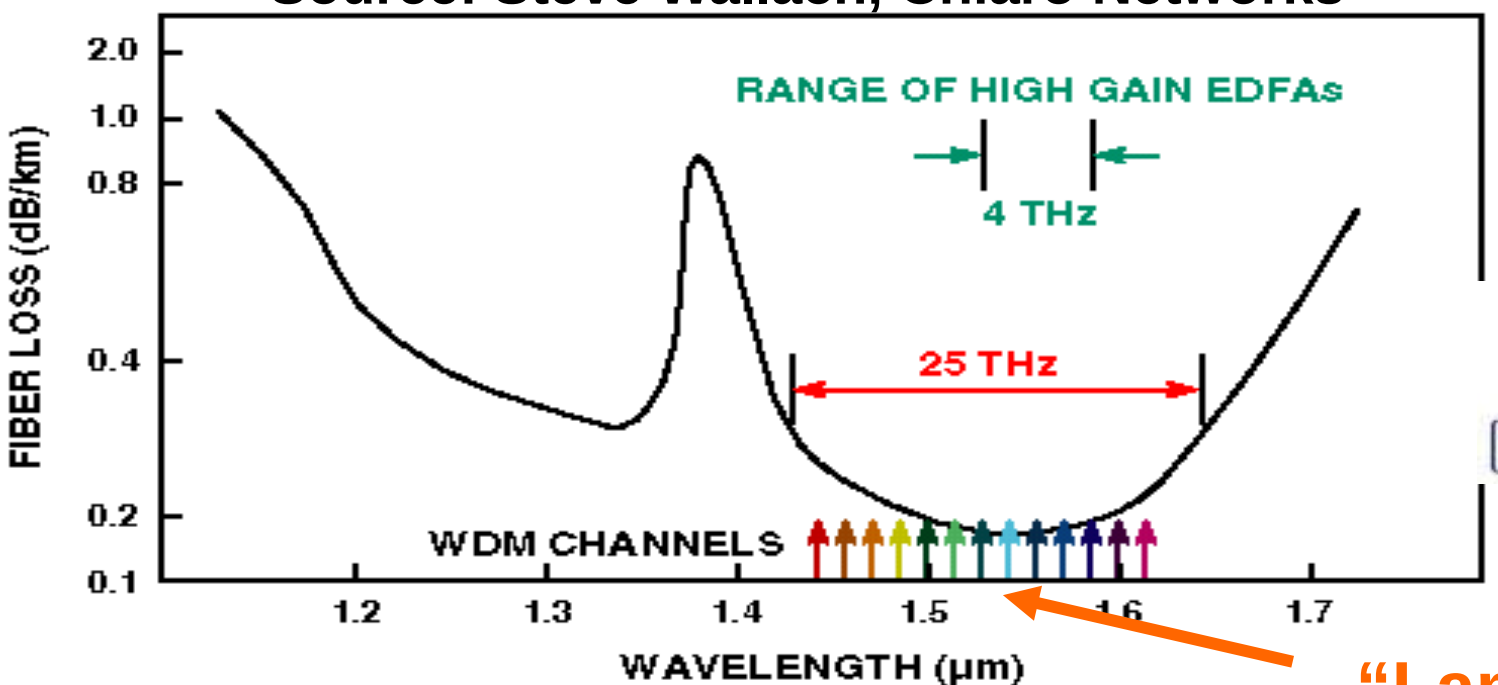
it²

Dedicated Optical Channels Makes High Performance Cyberinfrastructure Possible

WAVELENGTH DIVISION MULTIPLEXING (WDM)

- EXPLOITS
  - ENORMOUS BANDWIDTH OF SILICA FIBER
  - HIGH-GAIN WIDEBAND OPTICAL AMPLIFIERS

Source: Steve Wallach, Chiaro Networks



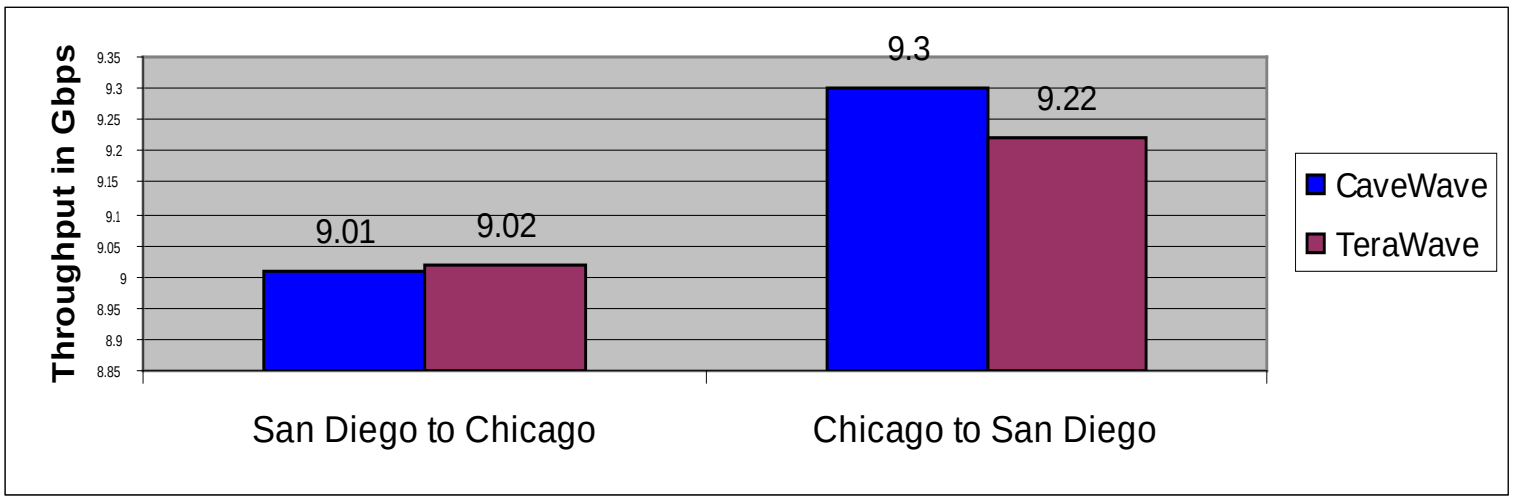
CHIARO

"Lambdas"

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9Gbps Out of 10Gbps Disk-to-Disk Performance Using LambdaStream between EVL and Calit2



CAVEWave:
20 senders to 20 receivers (point to point)

Effective Throughput = **9.01** Gbps
(San Diego to Chicago)
450.5 Mbps disk to disk transfer per stream

Effective Throughput = **9.30** Gbps
(Chicago to San Diego)
465 Mbps disk to disk transfer per stream

TeraGrid:
20 senders to 20 receivers (point to point)

Effective Throughput = **9.02** Gbps
(San Diego to Chicago)
451 Mbps disk to disk transfer per stream

Effective Throughput = **9.22** Gbps
(Chicago to San Diego)
461 Mbps disk to disk transfer per stream

Dataset: 220GB Satellite Imagery of Chicago courtesy USGS.
Each file is 5000 x 5000 RGB image with a size of 75MB i.e ~ 3000 files

Source: Venkatram Vishwanath, UIC EVL

Investing to Keep Illinois as the Hub of the Nation's Infrastructure

Illinois has always served as a crossroads.

And for two centuries our location has helped make Illinois rich, as goods and ideas have moved faster and faster.

First by water.

Then by rail.

Today by air.

For each, in its time, Illinois was a dominant hub.

But the new medium is neither water, nor steel nor air.

It's information.

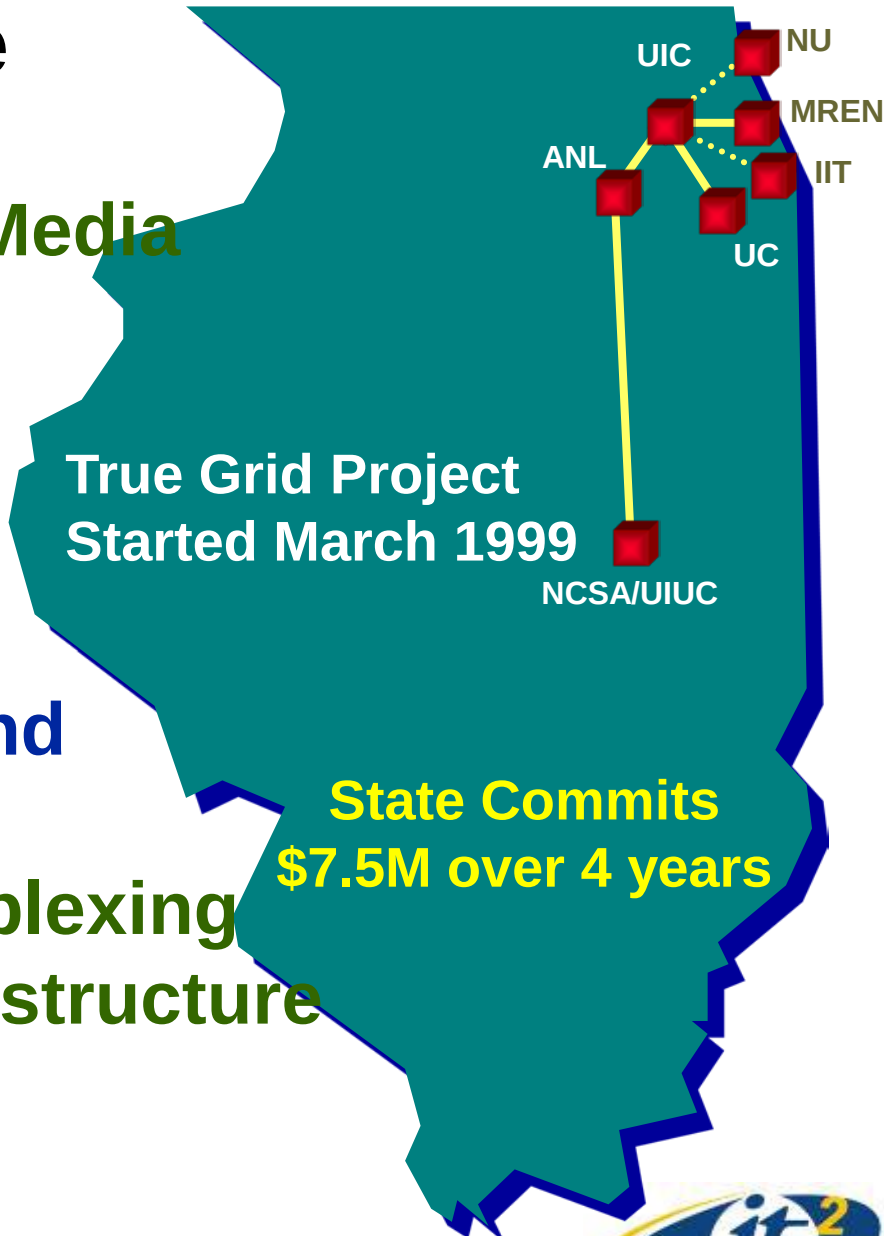
---Governor Ryan, 1999 Budget Address

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Illinois Seized National Optical Networking Leadership with I-WIRE Infrastructure Investment

- **State-Funded Infrastructure**
  - **Application Driven**
    - **High Definition Streaming Media**
      - Telepresence and Media
    - **Computational Grids**
      - Cloud Computing
    - **Data Grids**
      - Search & Information Analysis
  - **EmergingTech Proving Ground**
    - **Optical Switching**
    - **Dense Wave Division Multiplexing**
    - **Advanced Middleware Infrastructure**
    - **Wireless Extensions**

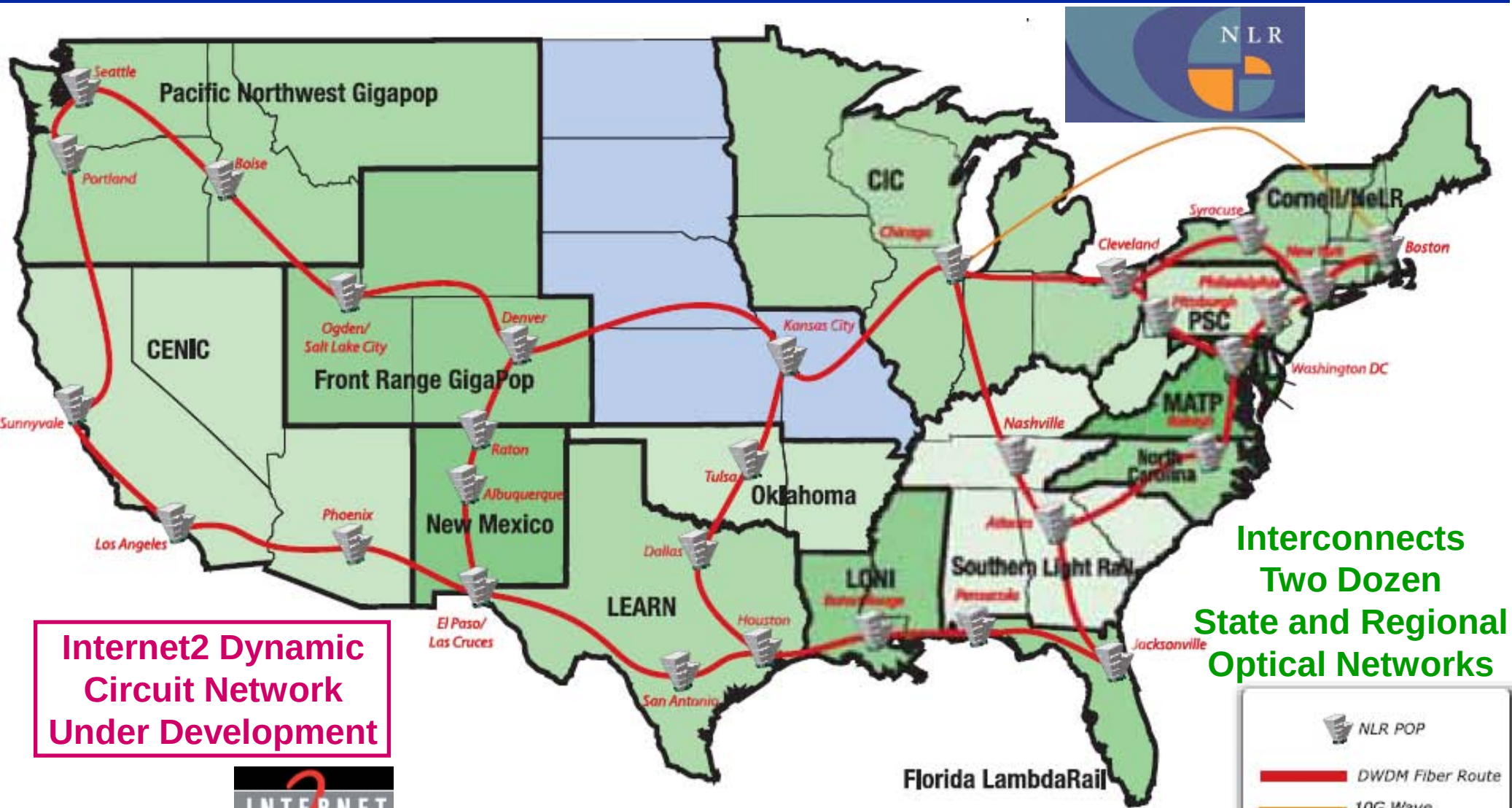


OptIPuter

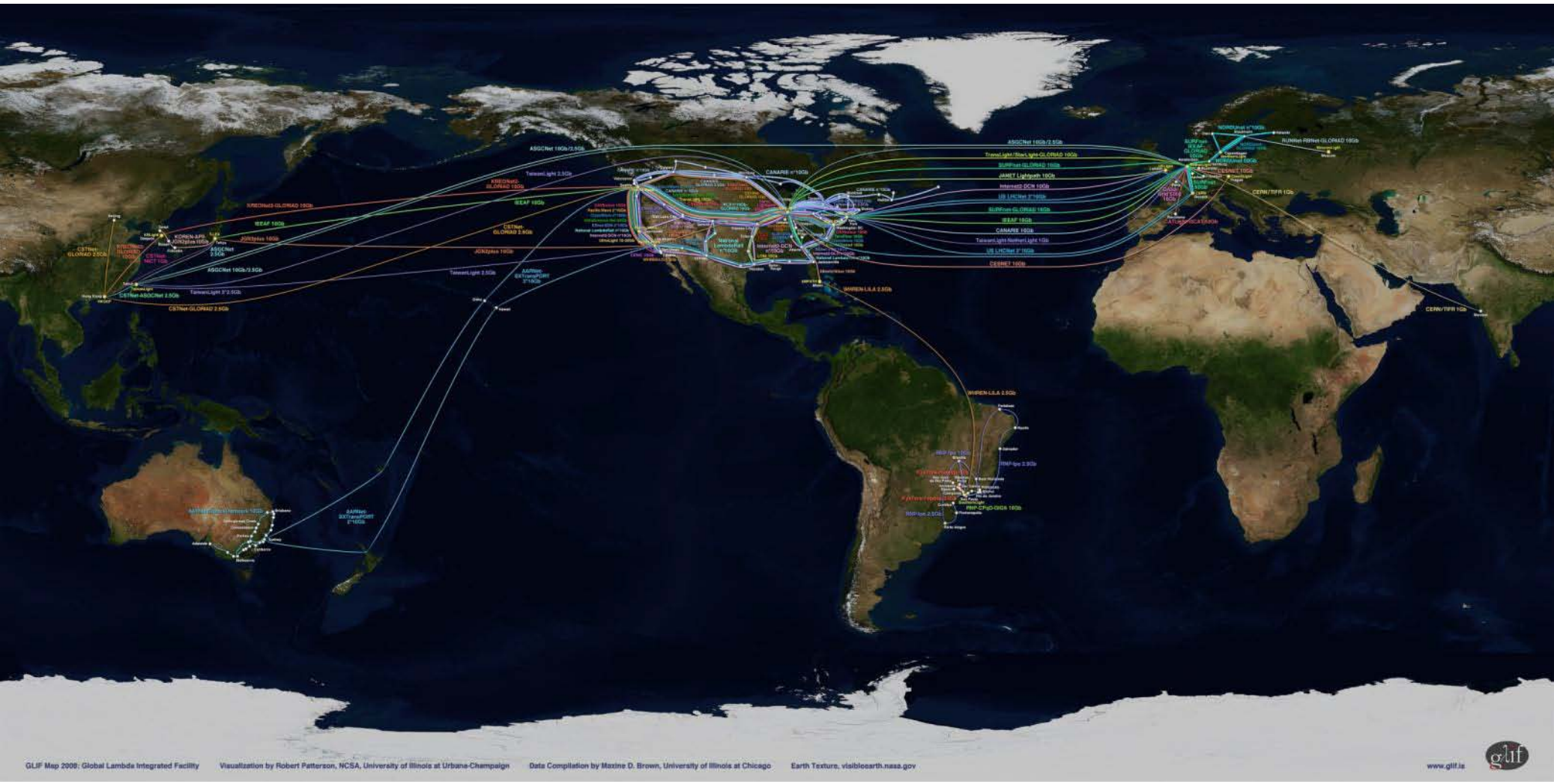
Source: Charlie Catlett, ANL

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Dedicated 10Gbps Lightpaths Tie Together State and Regional Fiber Infrastructure



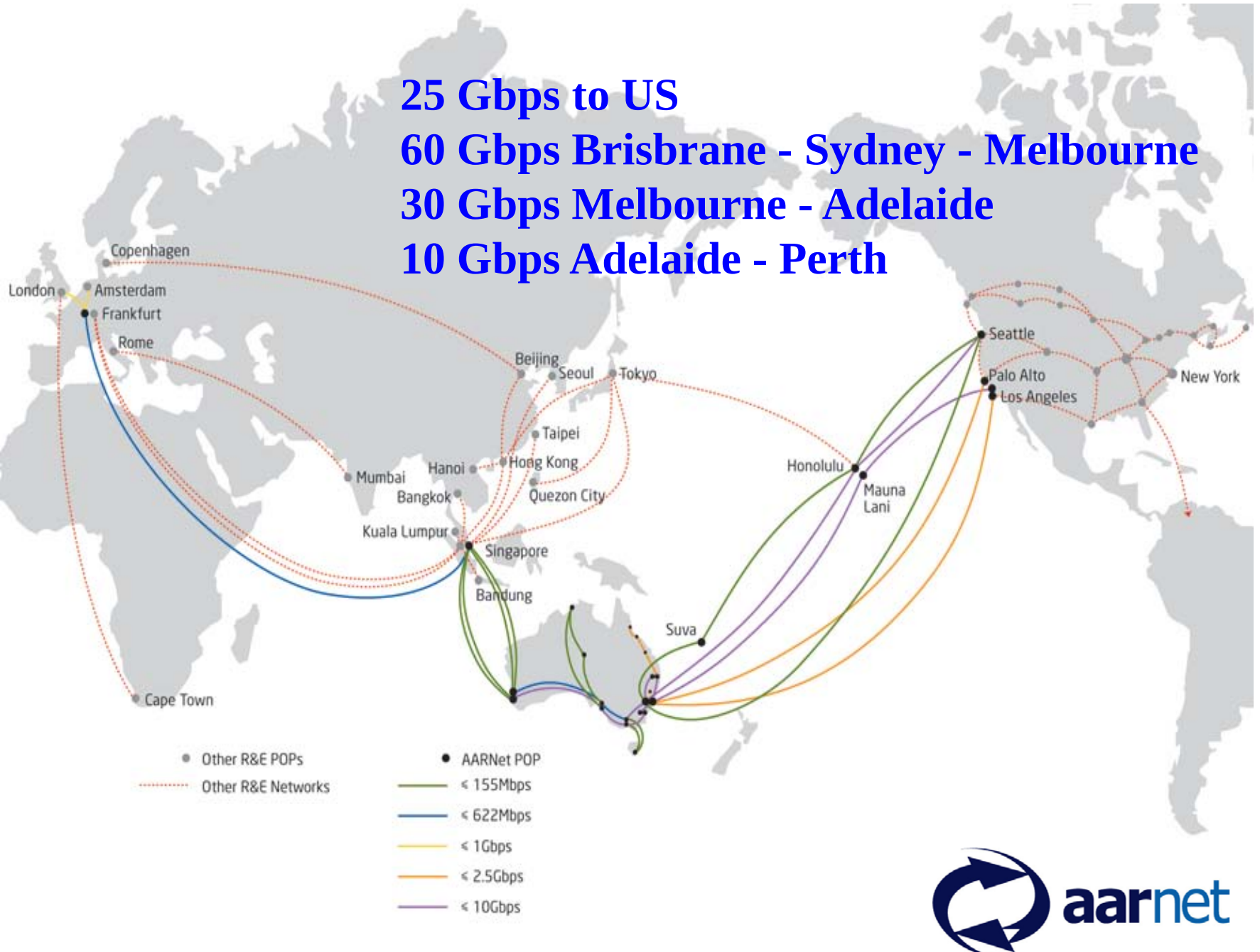
Global Lambda Integrated Facility
1 to 10G Dedicated Lambda Infrastructure



Interconnects Global
Public Research Innovation Centers

Source: Maxine Brown, UIC and Robert Patterson, NCSA

AARNet Provides the National and Global Bandwidth Required Between Campuses



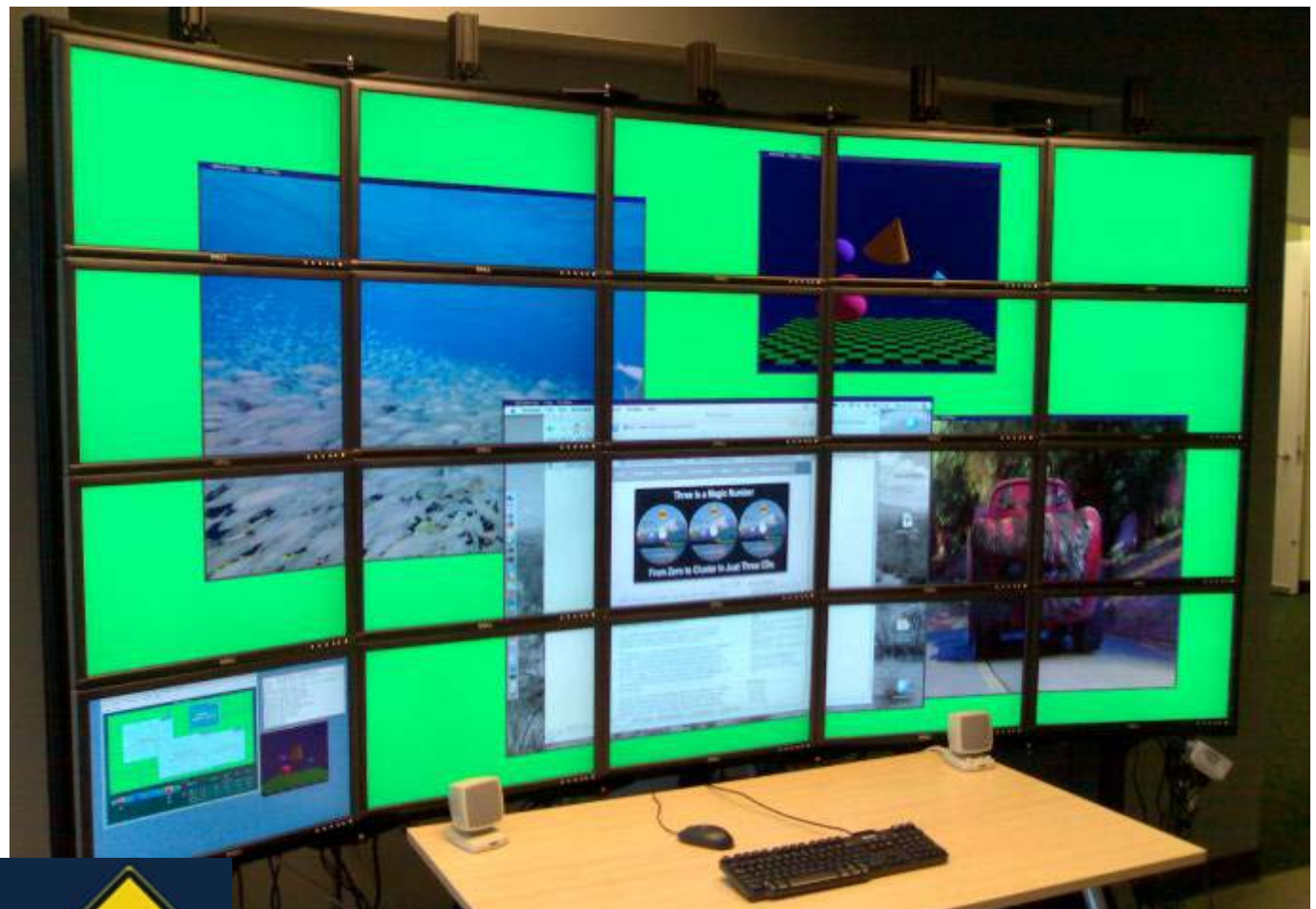
OptIPuter Step II:
From User Analysis on PCs to OptIPortals

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

evl electronic visualization laboratory





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Powered by Rocks ROCKS

Source: Phil Papadopoulos SDSC, Calit2

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On-Line Resources
Help You Build Your Own OptIPuter

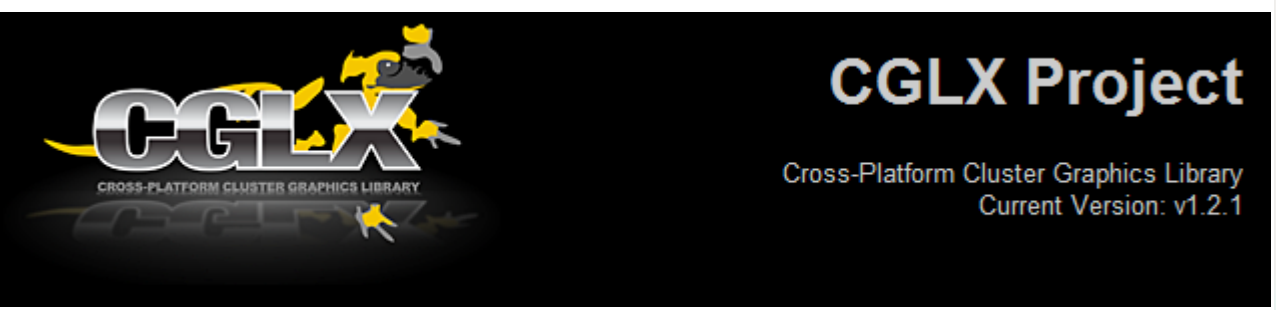
www.optiputer.net

http://wiki.optiputer.net/optiportal



www.evl.uic.edu/cavern/sage





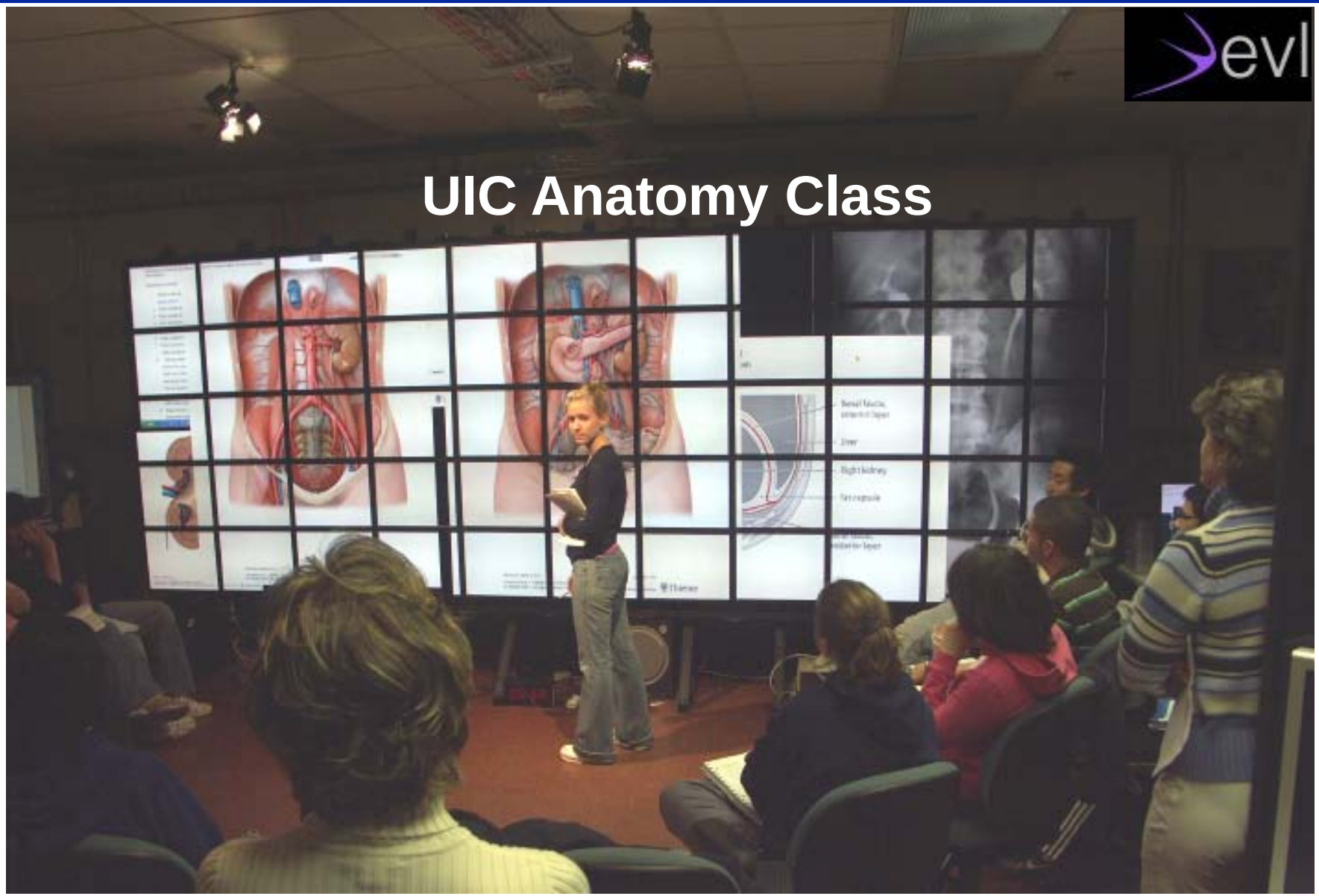
http://vis.ucsd.edu/~cglx/



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Students Learn Case Studies in the Context of Diverse Medical Evidence



CoreWall:
Use of OptIPortal in Geosciences

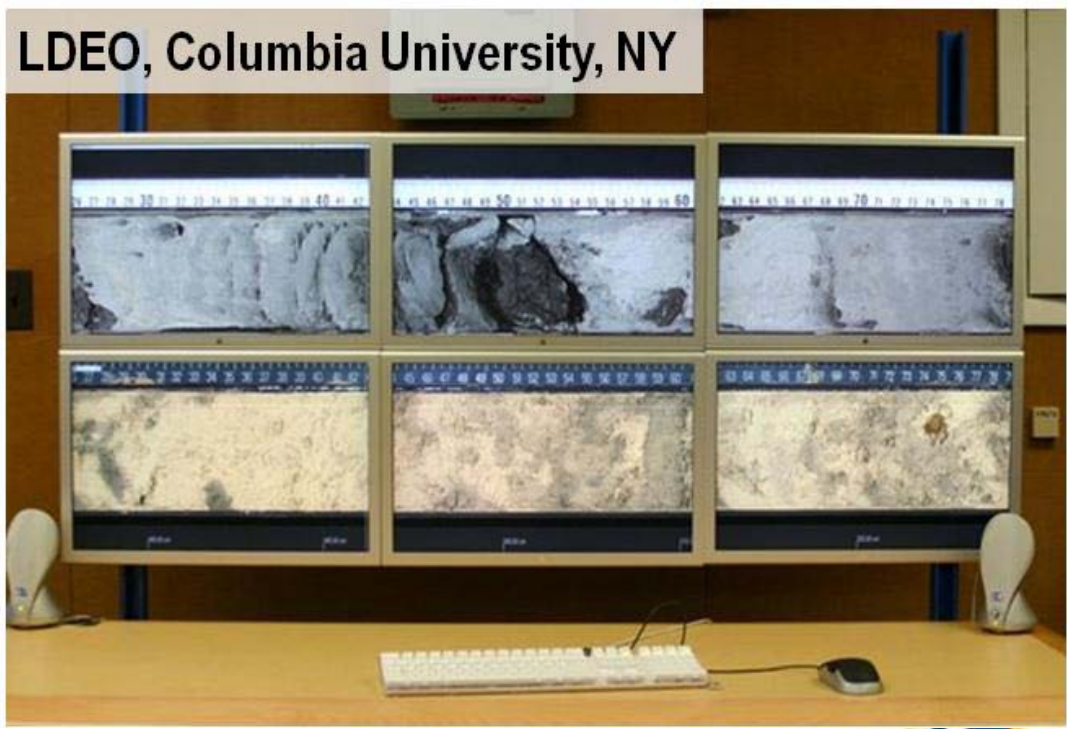
Using High Resolution Core Images to Study Paleogeology, Learning about the History of The Planet to Better Understand Causes of Global Warming

5 Deployed In Antarctica
www.corewall.org



After





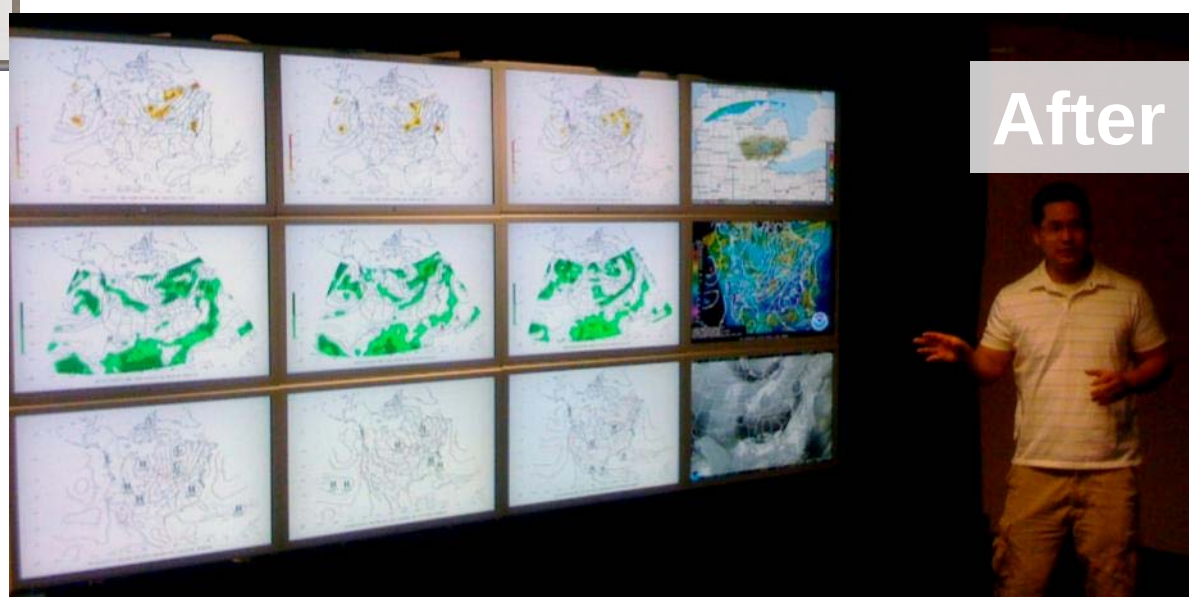
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Group Analysis of Global Change Supercomputer Simulations



**Latest Atmospheric Data is Displayed for Classes, Research Meetings, and Lunch Gatherings-
A Truly Communal Wall**

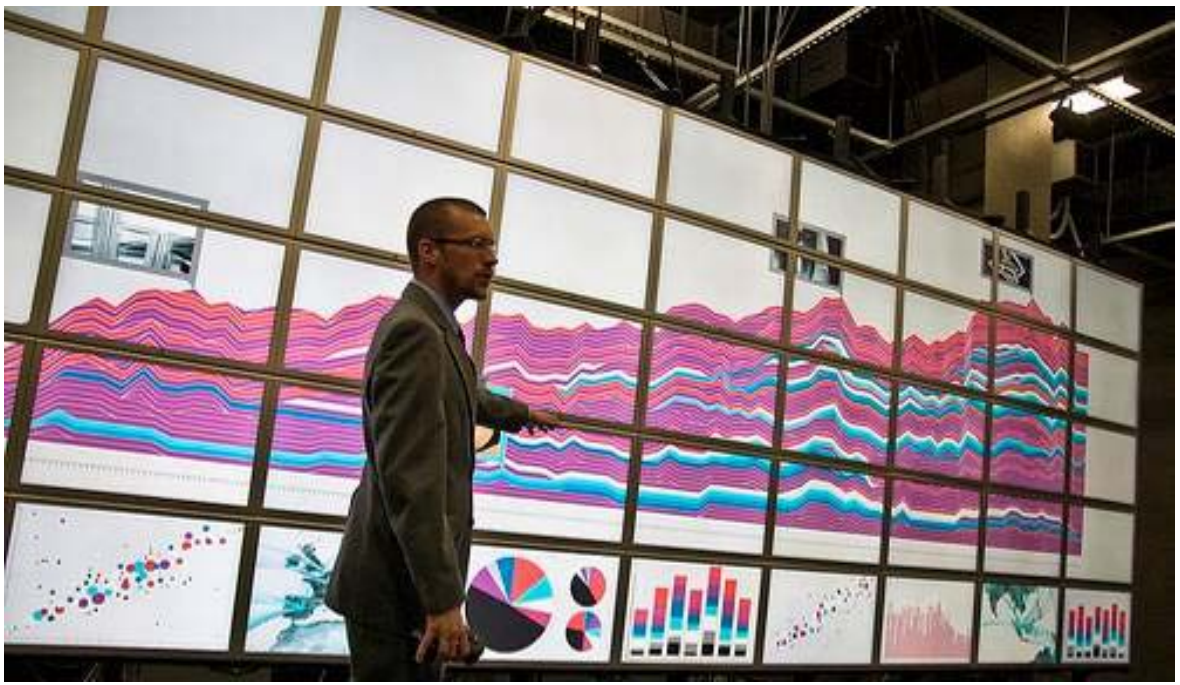


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**Source: U of Michigan
Atmospheric Sciences Department**

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Using HIPerWall OptIPortals for Humanities and Social Sciences



Calit2@UCI
200 Mpixel
HIPerWall



Software Studies Initiative, Calti2@UCSD

Interface Designs for Cultural Analytics Research Environment

Jeremy Douglass (top) & Lev Manovich (bottom)

Second Annual Meeting of the Humanities, Arts, Science, and Technology Advanced Collaboratory (HASTAC II)
UC Irvine May 23, 2008

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OptIPuter Step III:
From YouTube to Digital Cinema Streaming Video

AARNet Pioneered Uncompressed HD VTC with UWashington Research Channel--Supercomputing 2004







Canberra

Pittsburgh

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e-Science Collaboratory Without Walls
Enabled by iHDTV Uncompressed HD Telepresence

1500 Mbits/sec Calit2 to UW Research Channel Over NLR



John Delaney, PI LOOKING, Neptune

Photo: Harry Ammons, SDSC

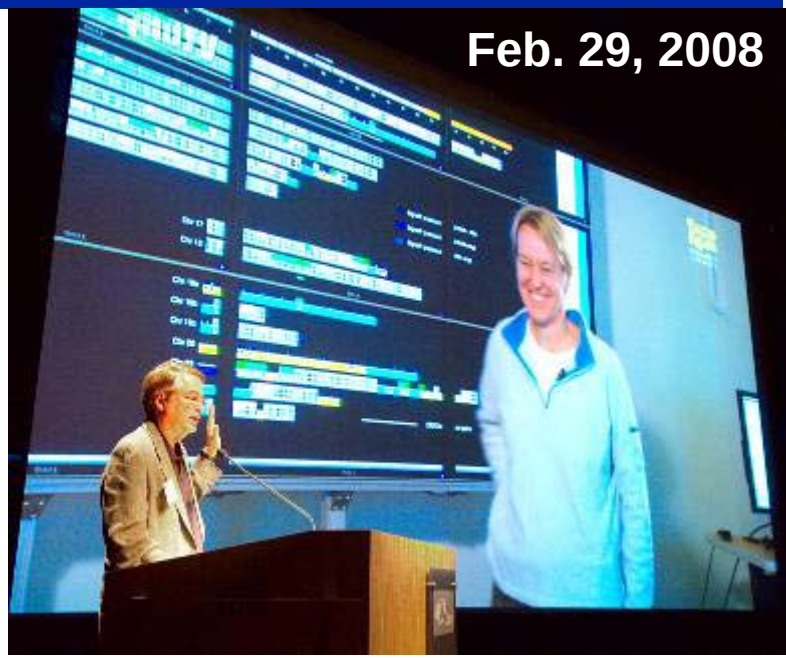
OptIPlanet Collaboratory Persistent Infrastructure Between Calit2 and U Washington



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Ginger Armbrust's Diatoms: Micrographs, Chromosomes, Genetic Assembly

ROCKS



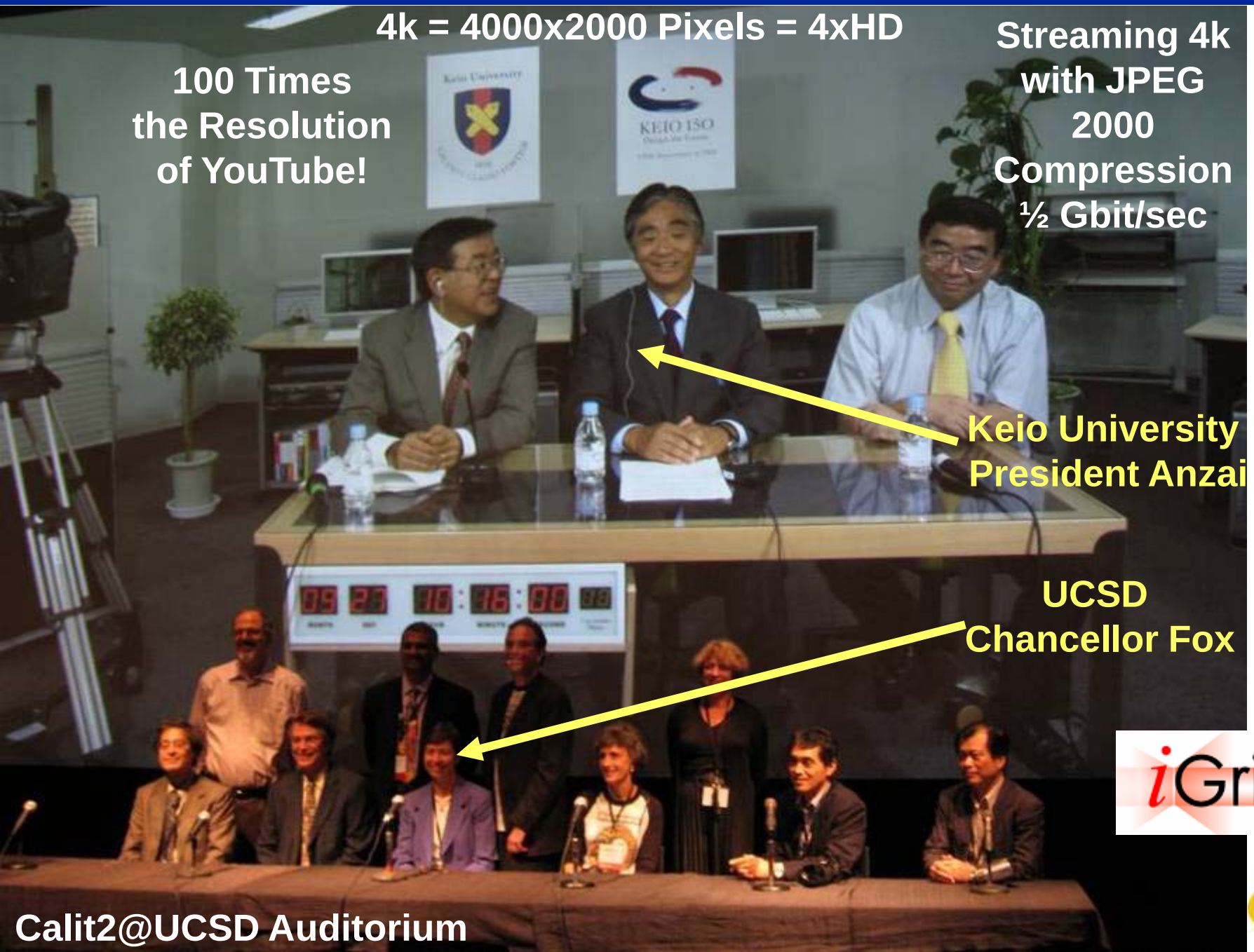




UW's Research Channel
Michael Wellings

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Telepresence Meeting
Using Digital Cinema 4k Streams



CineGrid

Lays Technical Basis for Global Digital Cinema

Sony
NTT
SGI

iGrid 2005

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HD Talk to Monash University from Calit2



OptIPuter Step IV:
Integration of Lightpaths, OptIPortals, and Streaming Media

The Calit2 OptIPortals at UCSD and UCI Are Now a Gbit/s HD Collaboratory

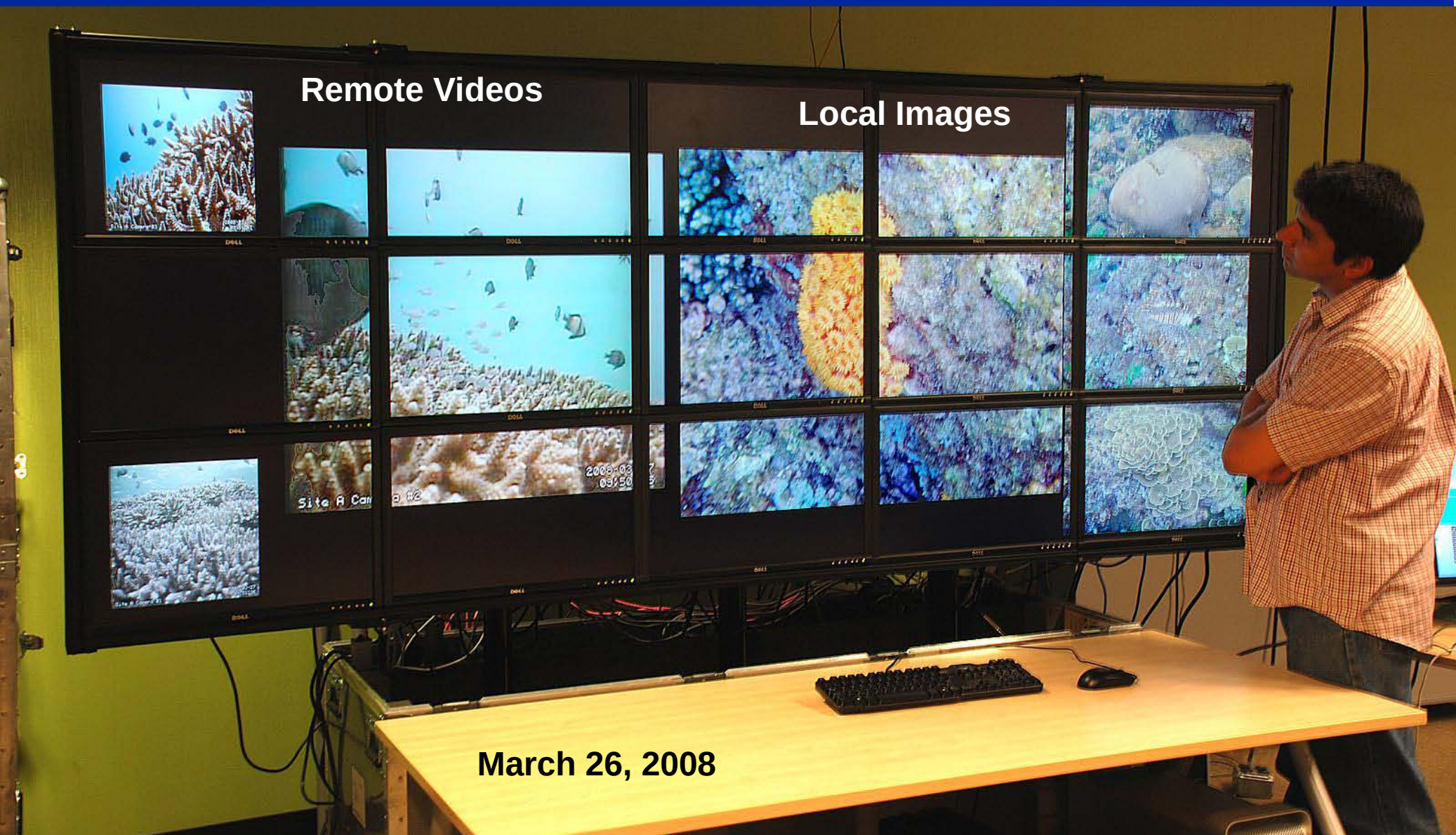


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UCSD cluster: 15 x Quad core Dell XPS with Dual nVIDIA 5600s
UCI cluster: 25 x Dual Core Apple G5

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New Year's Challenge: Streaming Underwater Video From Taiwan's Kenting Reef to Calit2's OptIPortal



Empowering the Scientific Community with Streaming Data Middleware

UCSD: Rajvikram Singh, Sameer Tilak, Jurgen Schulze, Tony Fountain, Peter Arzberger
NCHC : Ebbe Strandell, Sun-In Lin, Yao-Tsung Wang, Fang-Pang Lin

EVL's SAGE OptIPortal VisualCasting Multi-Site OptIPuter Collaboratory

CENIC CalREN-XD Workshop Sept. 15, 2008



At Supercomputing 2008 Austin, Texas November, 2008 SC08 Bandwidth Challenge Entry

On site:	Remote:
SARA (Amsterdam)	U of Michigan
GIST / KISTI (Korea)	UIC/EVL
Osaka Univ. (Japan)	U of Queensland
Masaryk Univ. (CZ), Calit2	Russian Academy of Science

Requires 10 Gbps Lightpath to Each Site

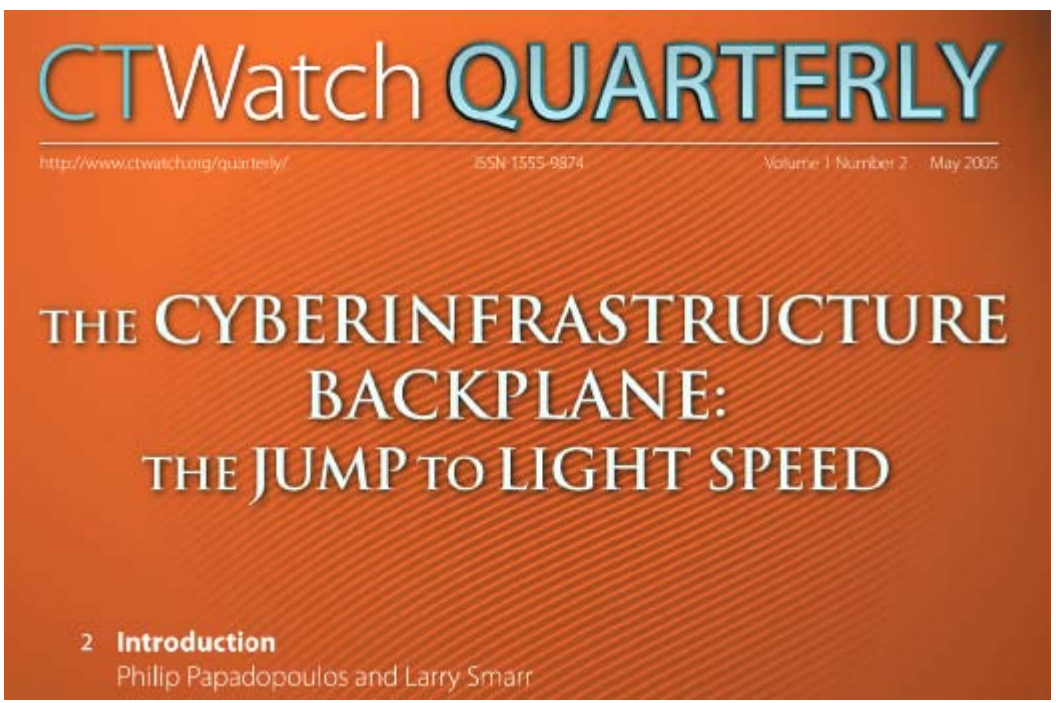
Source: Jason Leigh, Luc Renambot, EVL, UI Chicago

OptIPuter Step V:
The Campus Last Mile

How Do You Get From Your Lab to the Regional Optical Networks?

"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."

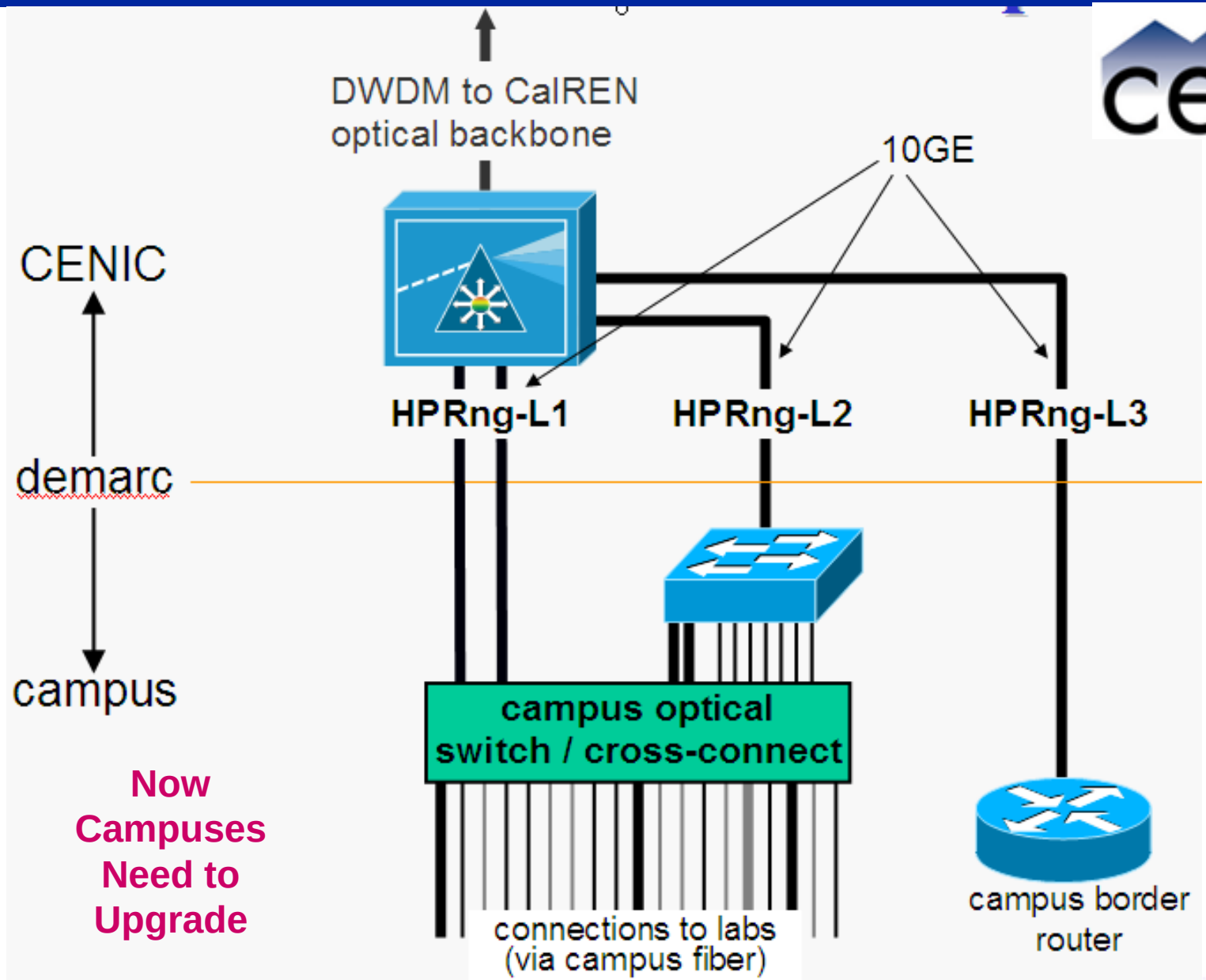
-- Arden Bement, the director of the National Science Foundation



www.ctwatch.org

CENIC's New "Hybrid Network" - Traditional Routed IP and the New Switched Ethernet and Optical Services

~ $14M Invested in Upgrade



Now Campuses Need to Upgrade

Source: Jim Dolgonas, CENIC

AARNet 10Gbps Access Product is Here!!!

- **HD and Other High Bandwidth Applications Combined with "Big Research" Pushing Large Data Sets Means 1 Gbps is No Longer Adequate for All Users**
- **AARNet Helps Connect Campus Users or Remote Instruments**
- **Will Permit Researchers to Exchange Large Amounts of Data within Australia, and Internationally via SXTransPORT**

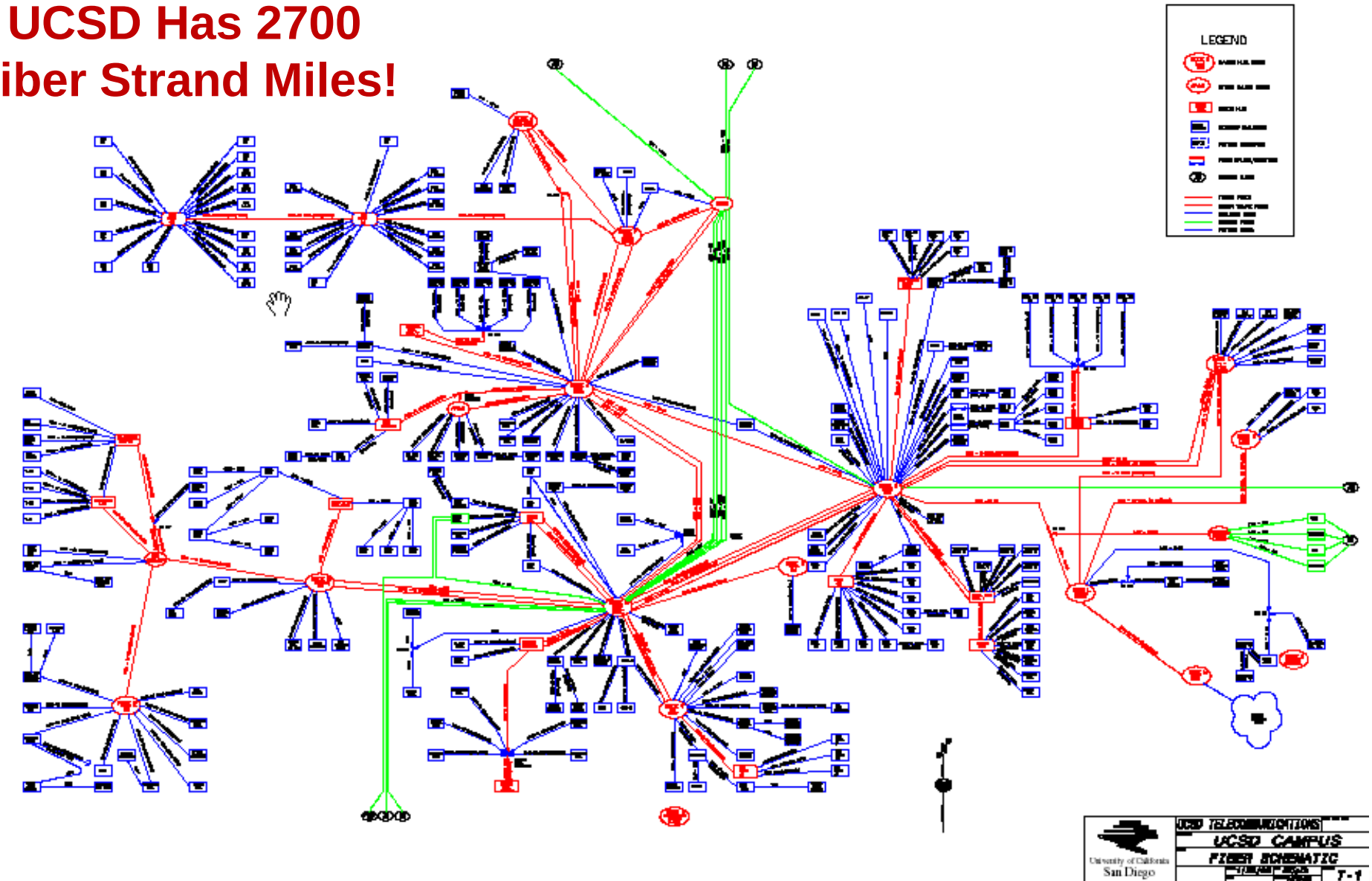




Slide From Chris Hancock, CEO AARNet

To Continually Improve a Campus Dark Fiber Network—Install New Conduit As Part of all New Construction!

UCSD Has 2700 Fiber Strand Miles!



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The "Golden Spike" UCSD Experimental Optical Core: Ready to Couple Users to CENIC L1, L2, L3 Services



Goals by 2008:

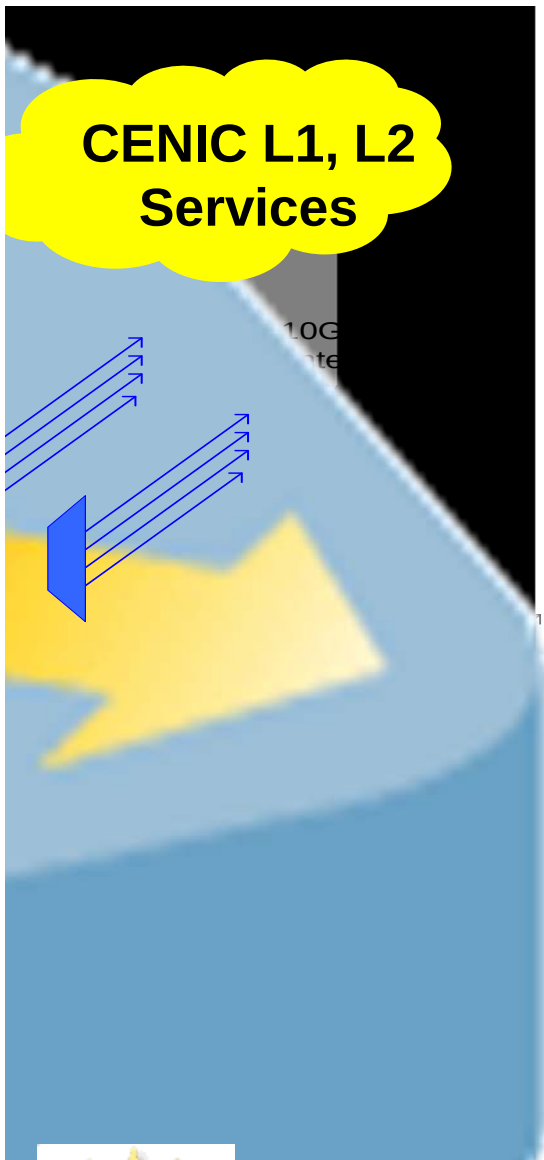
>= 60 endpoints at 10 GigE

>= 30 Packet switched

>= 30 Switched wavelengths

>= 400 Connected endpoints

Approximately 0.5 Tbps Arrive at the "Optical" Center of Hybrid Campus Switch



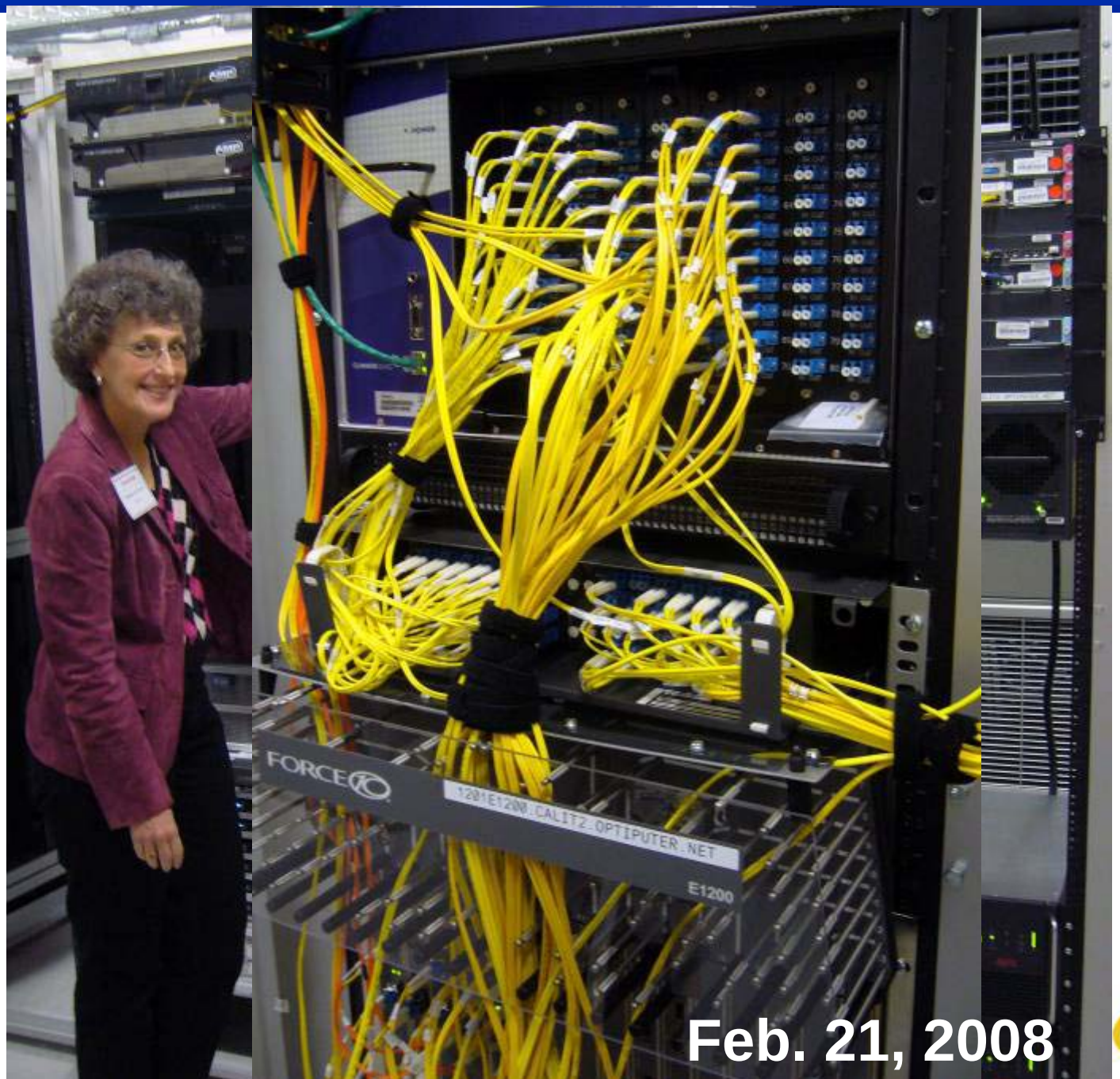
Funded by NSF MRI Grant

OptIPuter SDSC

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

NSF it2

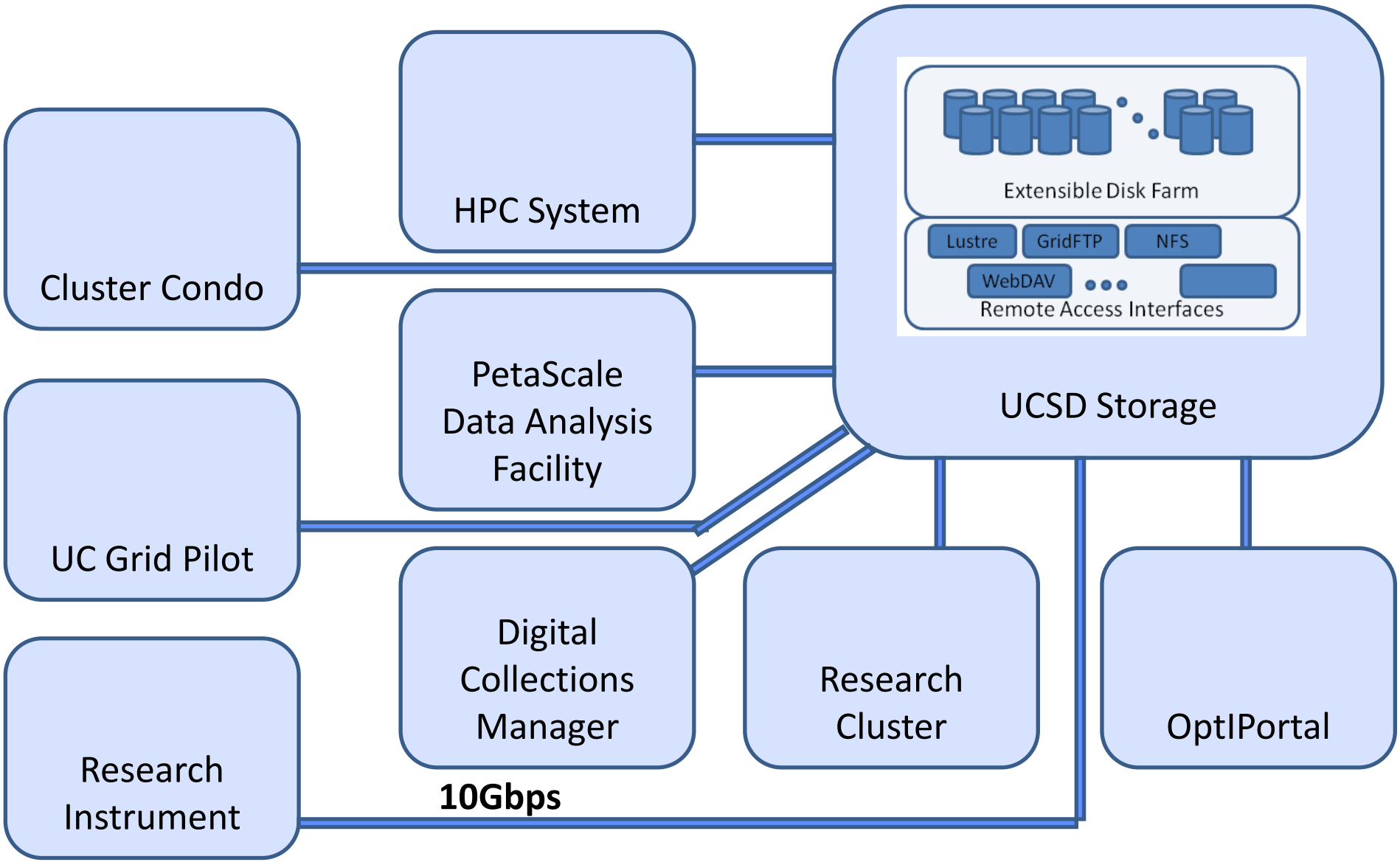
Calit2 Sunlight Optical Exchange Contains Quartzite



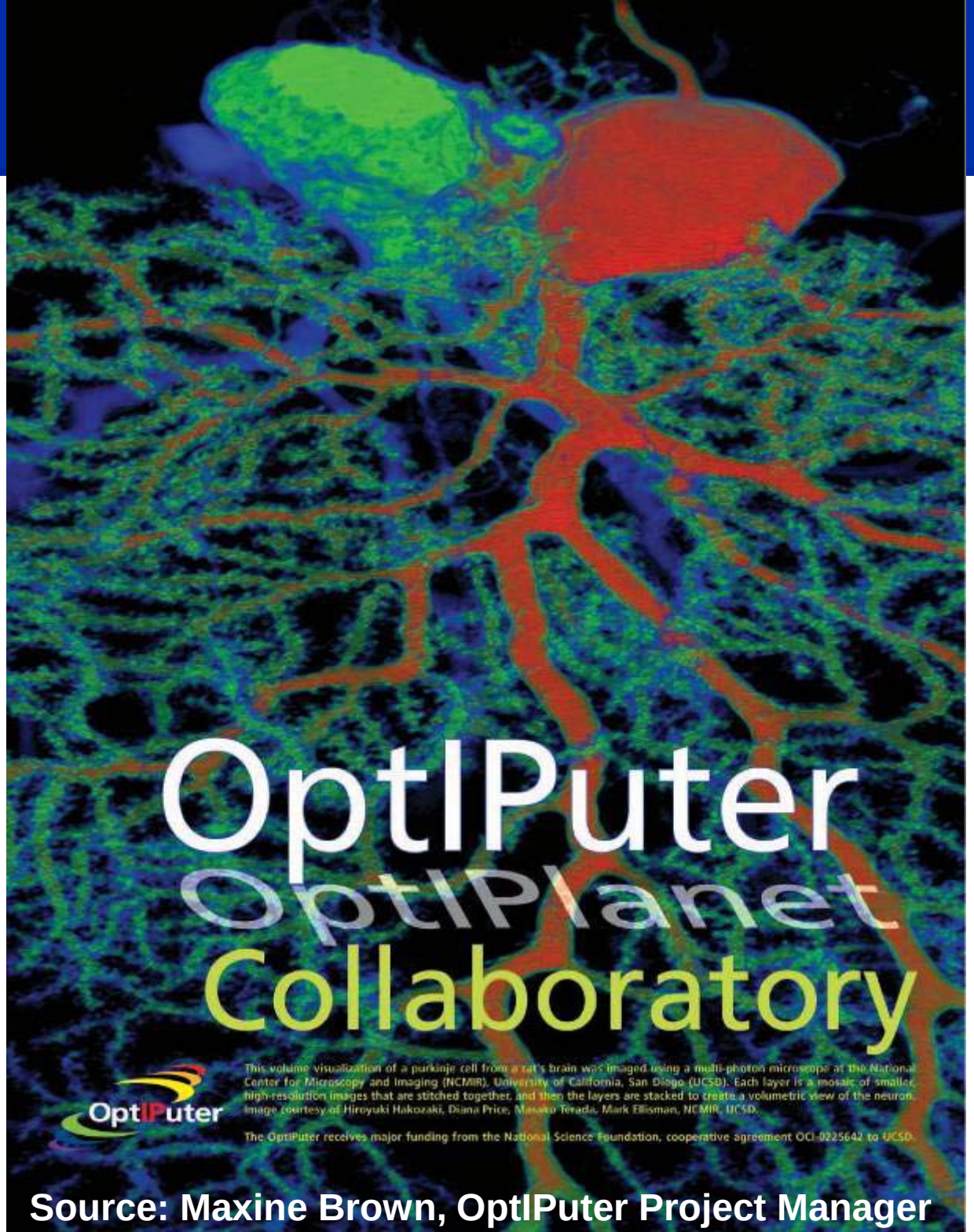
Maxine Brown, UIC OptIPuter Project Manager

Feb. 21, 2008

Use Campus Investment in Fiber and Networks to Physically Connect Campus Resources



Source:Phil Papadopoulos, SDSC/Calit2

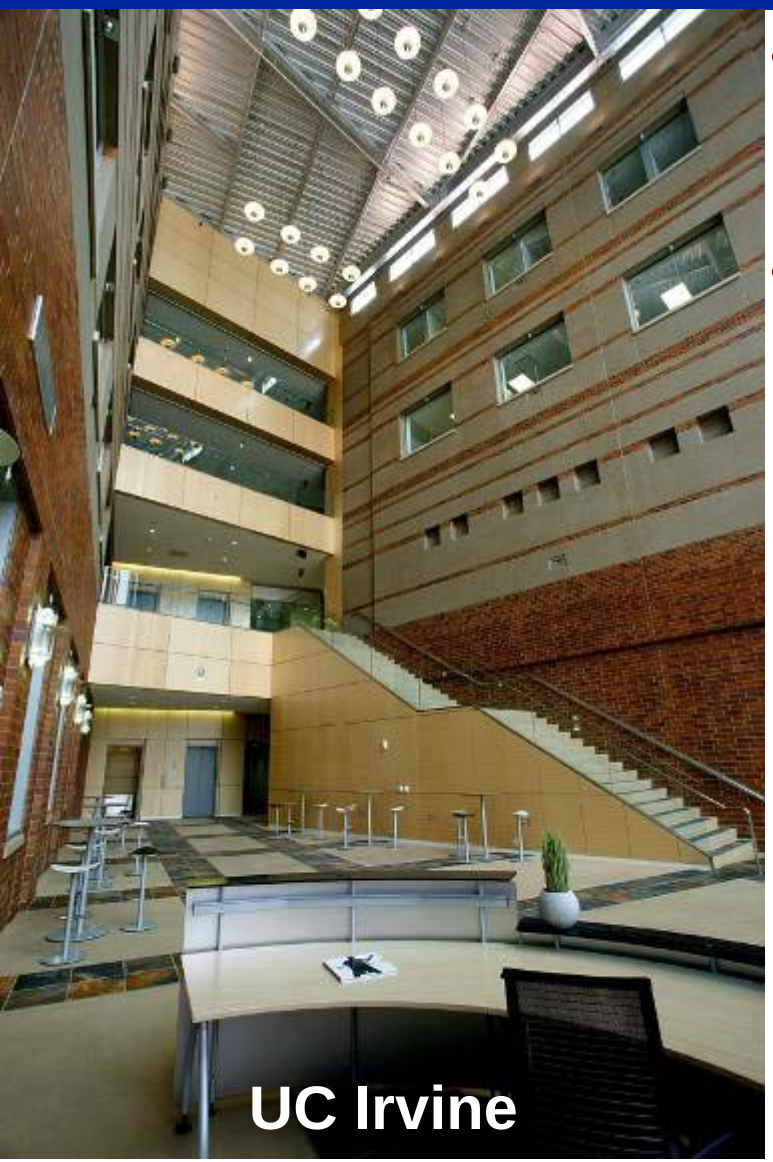


Source: Maxine Brown, OptIPuter Project Manager

Green Initiative:

Can Optical Fiber Replace Airline Travel for Continuing Collaborations ?

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…

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Discovering New Applications and Services Enabled by 1-10 Gbps Lambdas

Maxine Brown, Tom DeFanti, Co-Chairs

iGrid 2005

www.igrid2005.org

THE GLOBAL LAMBDA INTEGRATED FACILITY

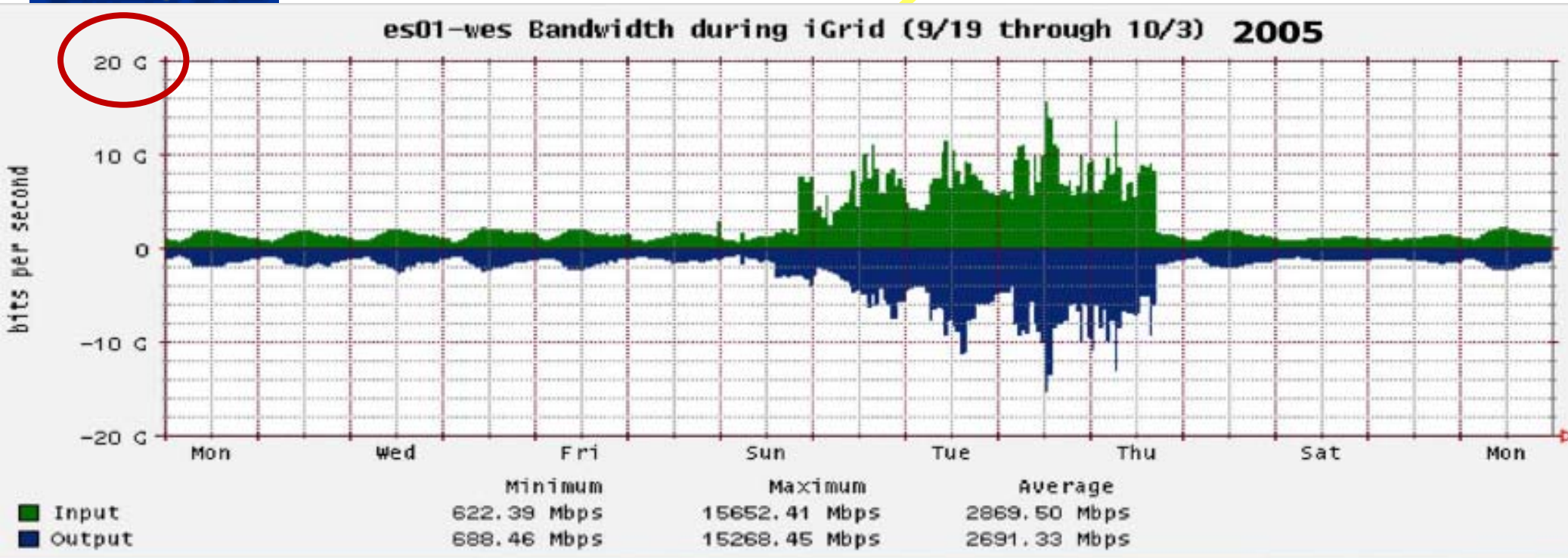


September 26-30, 2005

Calit2 @ University of California, San Diego

California Institute for Telecommunications and Information Technology

the UC Discovery Grant



The Large Hadron Collider Uses a Global Fiber Infrastructure To Connect Its Users

CERN Unveils Global Grid For Particle Physics Research

The network can pull in the IT power of more than 140 computer centers in 33 countries to crunch an expected 15 million GB of data every year.

By Antone Gonsalves
InformationWeek
October 3, 2008 04:57 PM

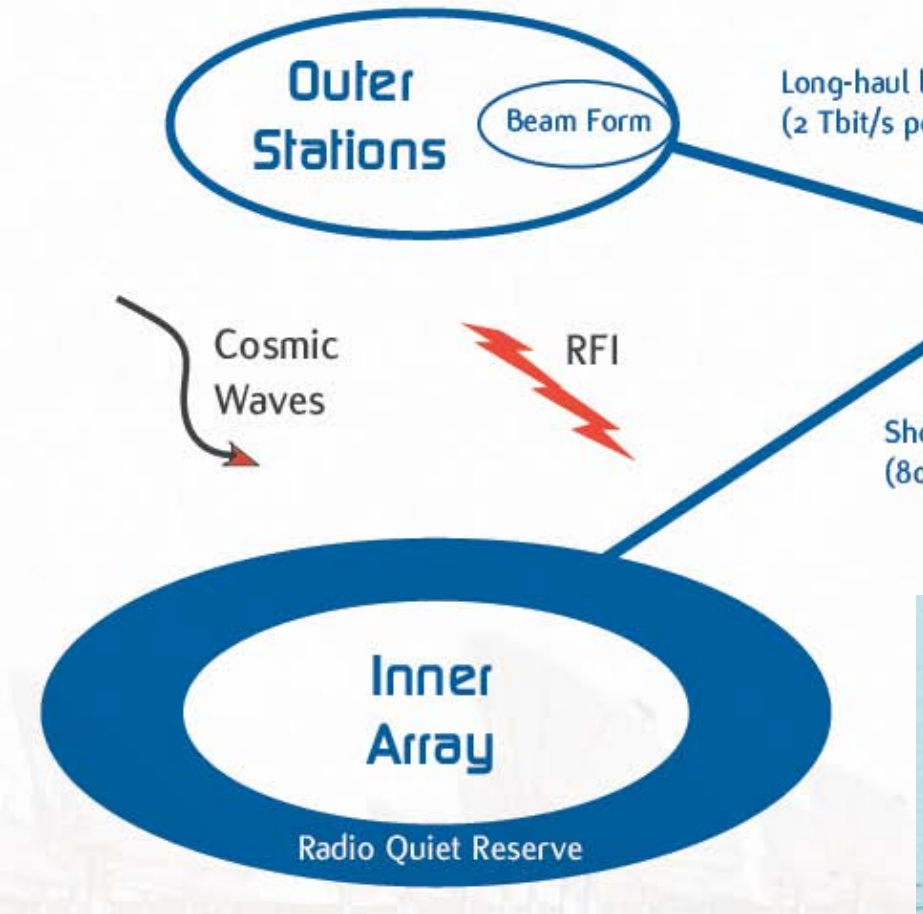
- **The grid relies on optical fiber networks to distribute data from CERN to 11 major computer centers in Europe, North America, and Asia**
- **The grid is capable of routinely processing 250,000 jobs a day**
- **The data flow will be ~6 Gigabits/sec or 15 million gigabytes a year for 10 to 15 years**

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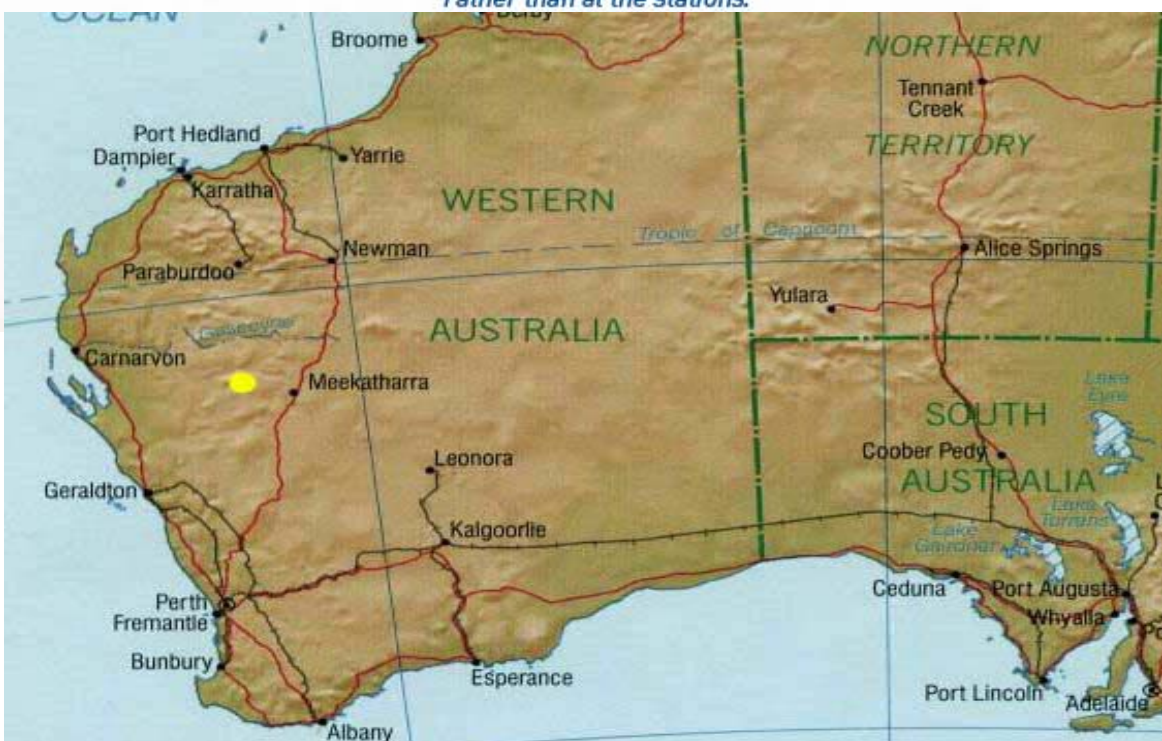
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Next Great Planetary Instrument: The Square Kilometer Array Requires Dedicated Fiber

www.skatelescope.org



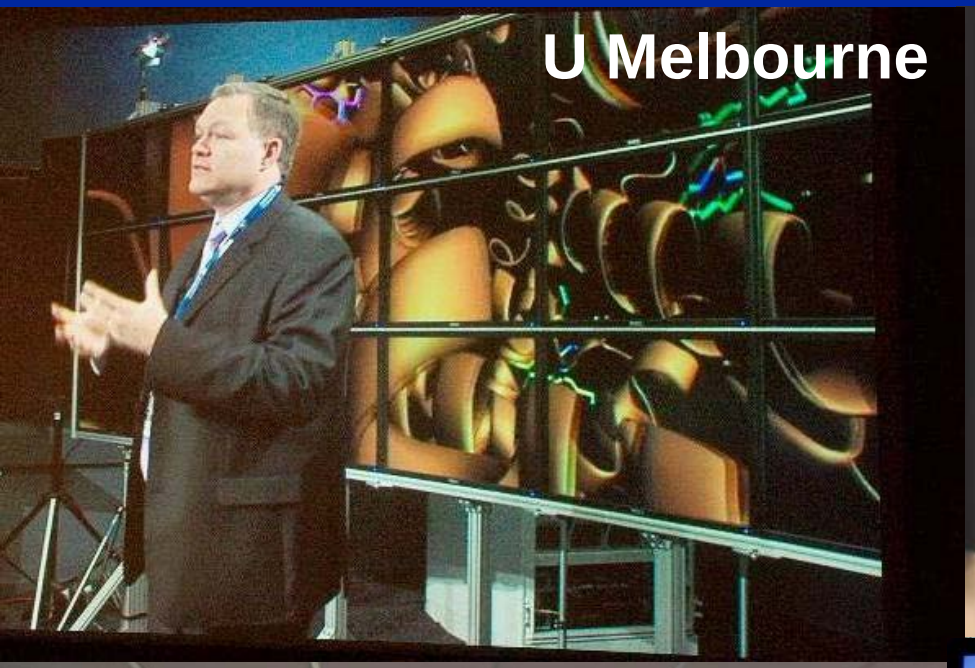
Schematic of SKA signal flow. Advances in signal transport technology may later allow more signals to be processed at the core, rather than at the stations.



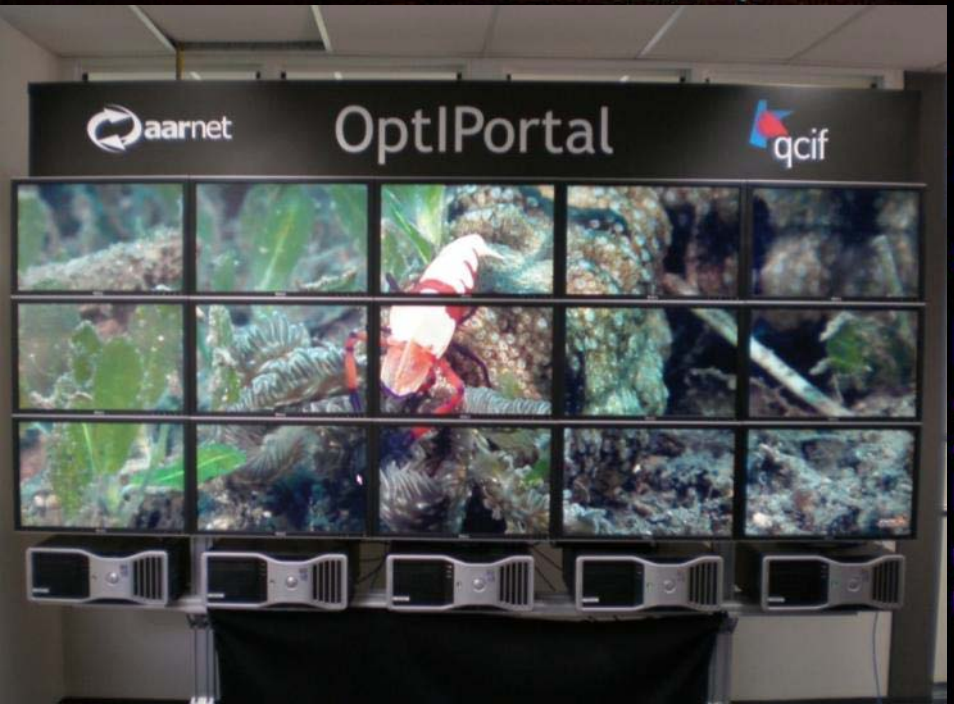
Transfers Of 1 TByte Images World-wide Will Be Needed Every Minute!

OptIPuter

OptIPortals
Are Being Adopted Globally









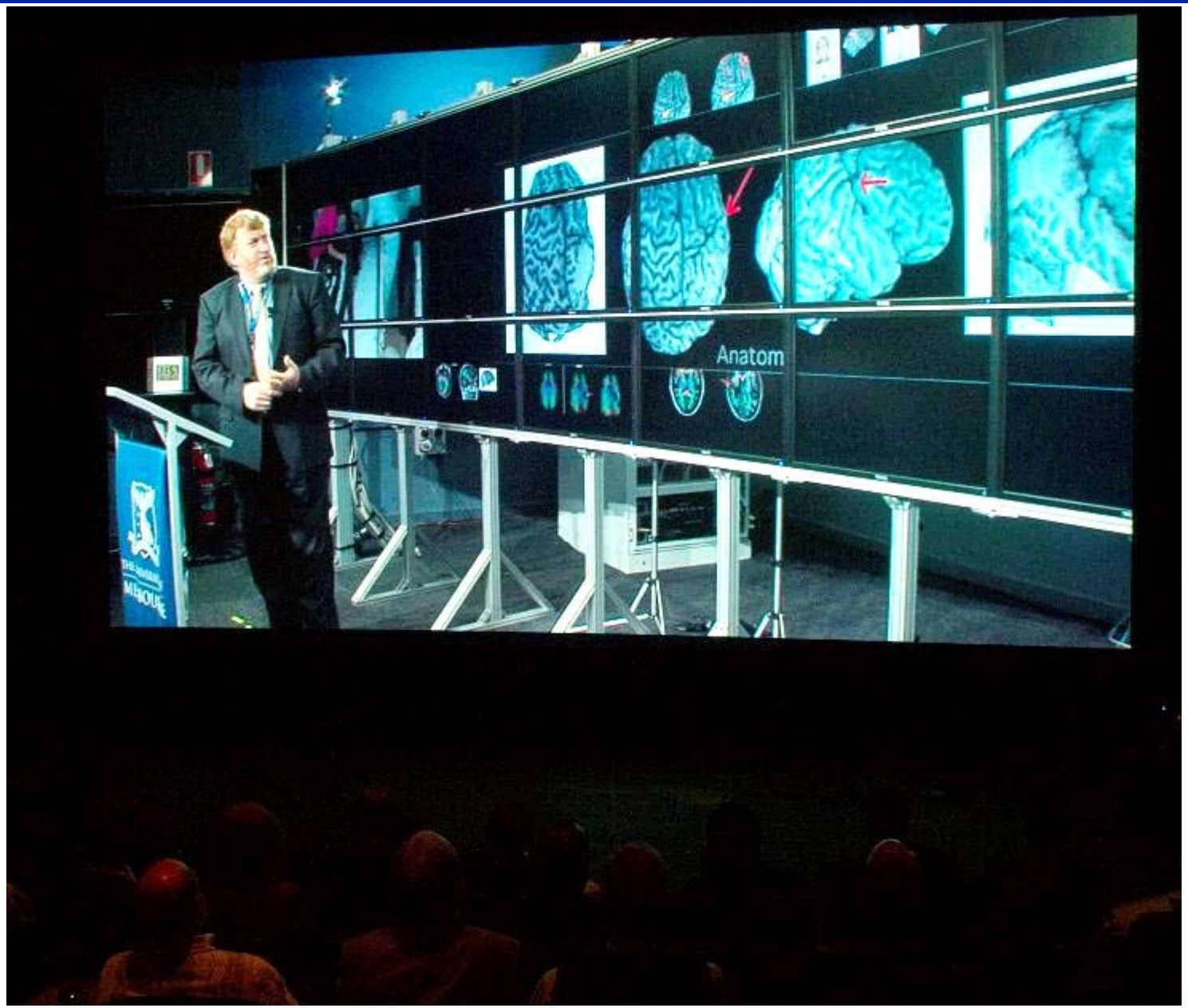
“Using the Link to Build the Link”
Calit2 and Univ. Melbourne Technology Teams



No Calit2 Person Physically Flew to Australia to Bring This Up!

www.calit2.net/newsroom/release.php?id=1219

UM Professor Graeme Jackson Planning Brain Surgery for Severe Epilepsy



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www.calit2.net/newsroom/release.php?id=1219

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Victoria Premier and Australian Deputy Prime Minister Asking Questions



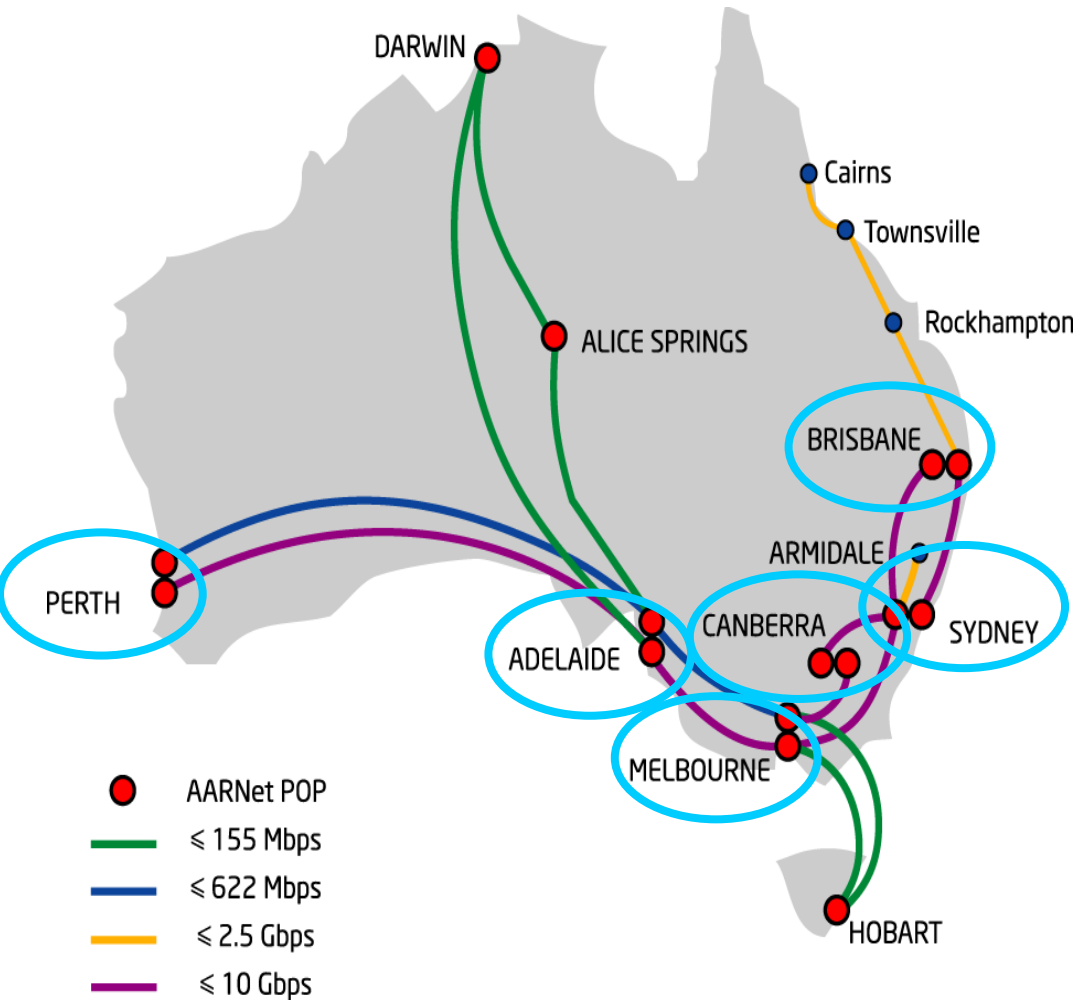
www.calit2.net/newsroom/release.php?id=1219

University of Melbourne Vice Chancellor Glyn Davis in Calit2 Replies to Question from Australia



Smarr American Australian Leadership Dialogue OptIPlanet Collaboratory Lecture Tour October 2008

AARNet National Network



- Oct 2—University of Adelaide
- Oct 6—Univ of Western Australia
- Oct 8—Monash Univ.; Swinburne Univ.
- Oct 9—Univ. of Melbourne
- Oct 10—Univ. of Queensland
- Oct 13—Univ. of Technology Sydney
- Oct 14—Univ. of New South Wales
- Oct 15—ANU; AARNet; Leadership Dialogue Scholar Oration, Canberra
- Oct 16—CSIRO, Canberra
- Oct 16—Sydney Univ.

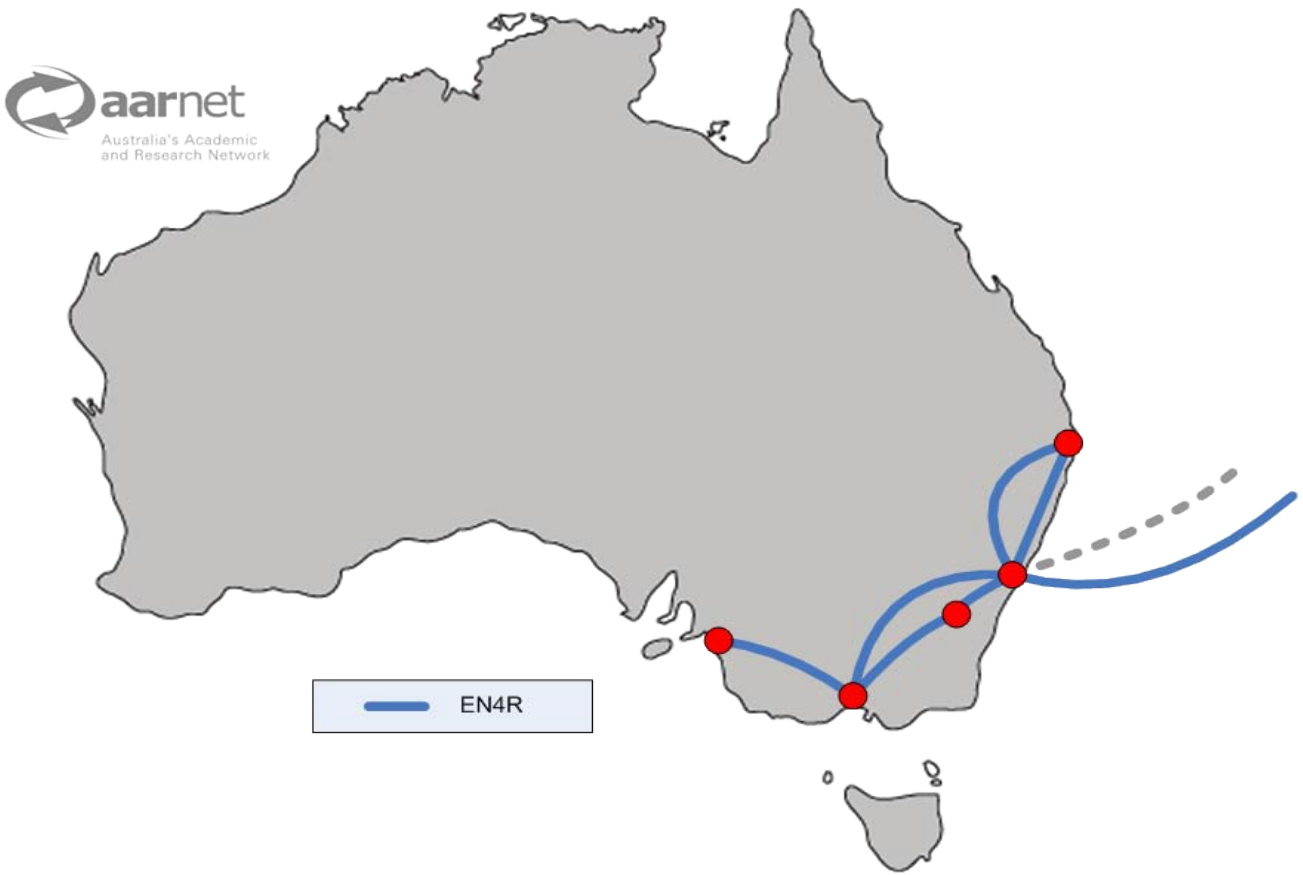
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AUSTRALIAN AMERICAN LEADERSHIP DIALOGUE

aarnet Australia's Academic and Research Network

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AARNet's "EN4R" – Experimental Network For Researchers

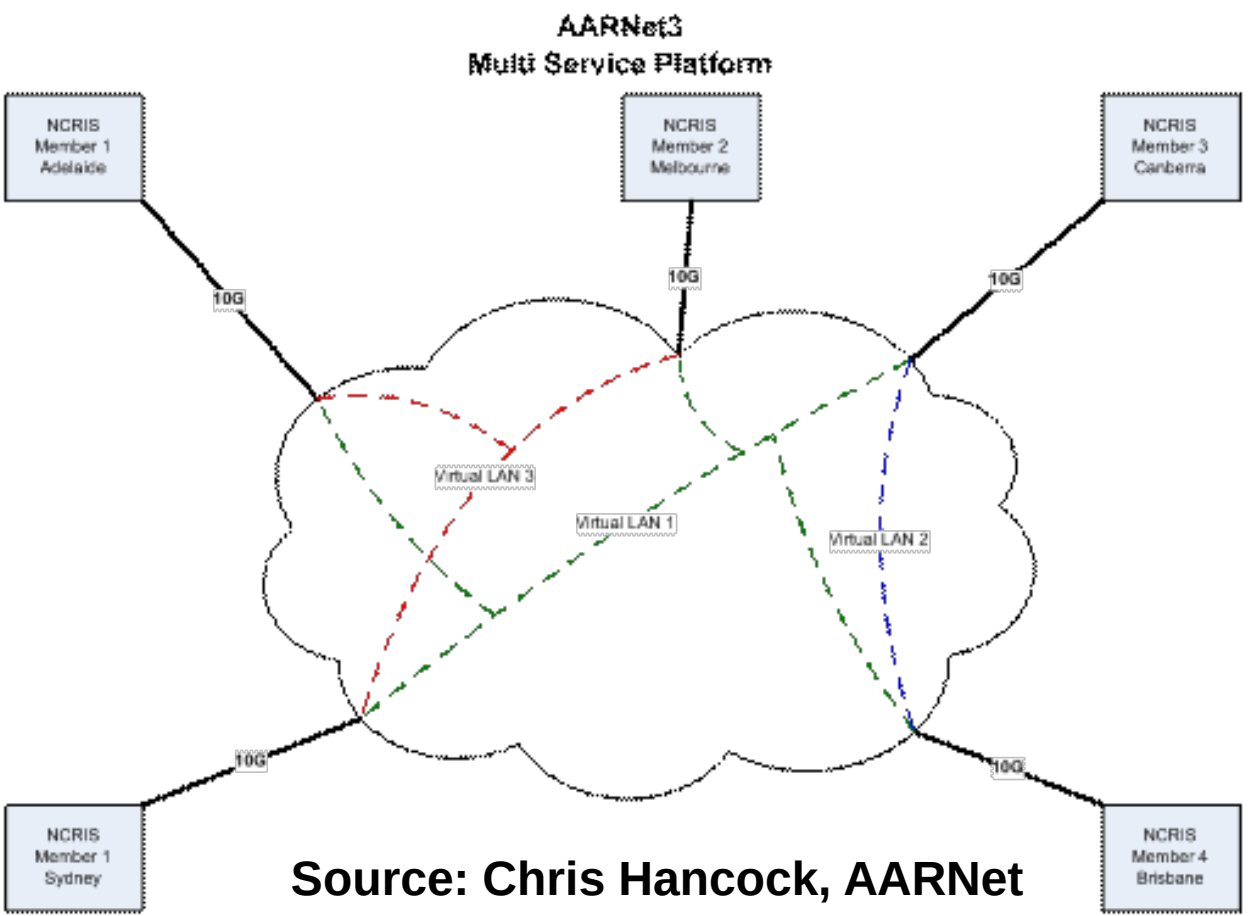


- For Researchers
- Free Access for up to 12 months
- 2 Circuits Reserved for EN4R on Each Optical Backbone Segment
- Access to North America via. SXTransPORT

Source: Chris Hancock, AARNet

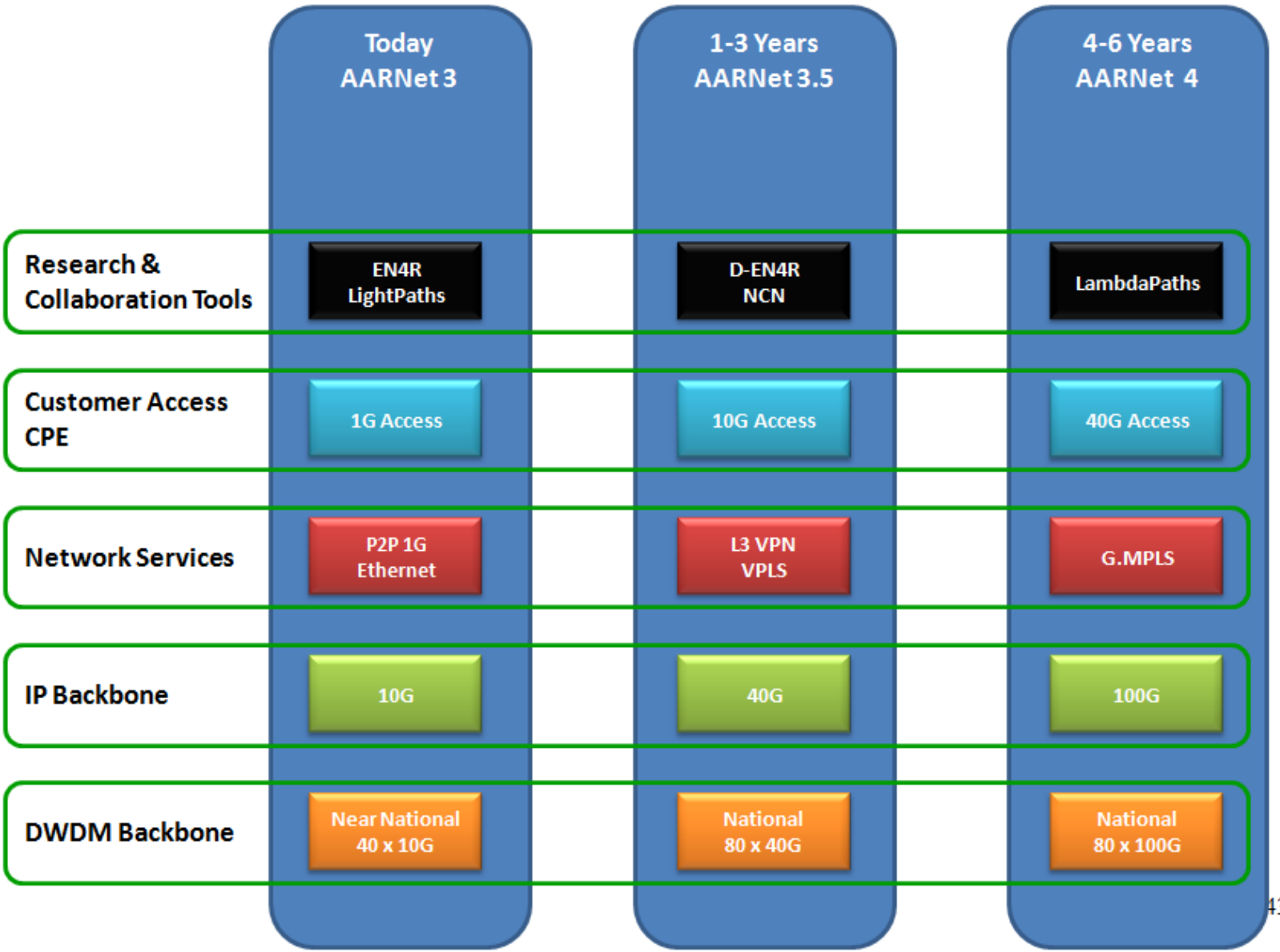
"NCN" - National Collaborative Network - Driving National Collaborative Research Infrastructure Strategy

- **Point to Point or Multipoint National Ethernet service**
- **Allows Researchers to Collaborate at Layer 2**
  - **For Use with Applications that Don't Tolerate IP Networks (e-VLBI)**
  - **Assists in Mitigating Firewalling and Security Concerns**
- ***Ready for service by Q4'08***



Source: Chris Hancock, AARNet

AARNet's Roadmap Towards 2012



Source: Chris Hancock, AARNet

Minimum Requirement for Australian Researchers to Join the Global Optical Research Platform

- **All Data-Intensive Australian:**
  - **Researchers**
  - **Scientific Instruments**
  - **Data Repositories**
- **Should Have Best-of-Breed End-End Connectivity**
- **Today, that means 10Gbps Lightpaths**

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The Public Research Sector Must Control its Own Fiber Infrastructure -- Lease Fiber Where You Can, Dig If You Must



“To ensure a competitive economy for the 21st century, the Australian Government should set a goal of making Australia the pre-eminent location to attract the best researchers and be a preferred partner for international research institutions, businesses and national governments.”

