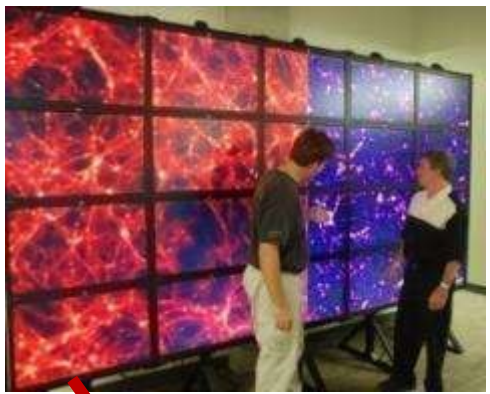
High Performance Cyberinfrastructure is Needed to Enable Data-Intensive Science and Engineering

Remote Luncheon Presentation from Calit2@UCSD
National Science Board
Expert Panel Discussion on Data Policies
National Science Foundation
Arlington, Virginia
March 28, 2011

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
Follow me on Twitter: lsmarr

Academic Research Data-Intensive Cyberinfrastructure: A 10Gbps "End-to-End" Lightpath Cloud

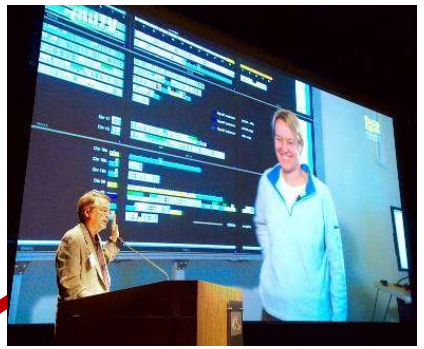


End User
OptIPortal





Local or Remote
Instruments



HD/4k Live Video

HPC

TeraGrid





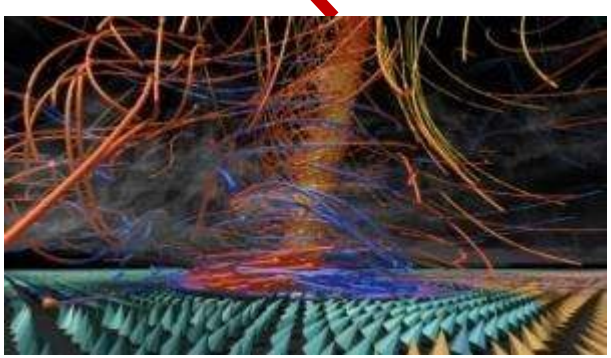
10G
Lightpaths

Campus
Optical Switch

amazon
web services



Data Repositories & Clusters

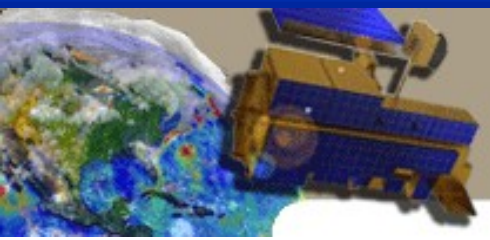


HD/4k Video Repositories

OptIPuter

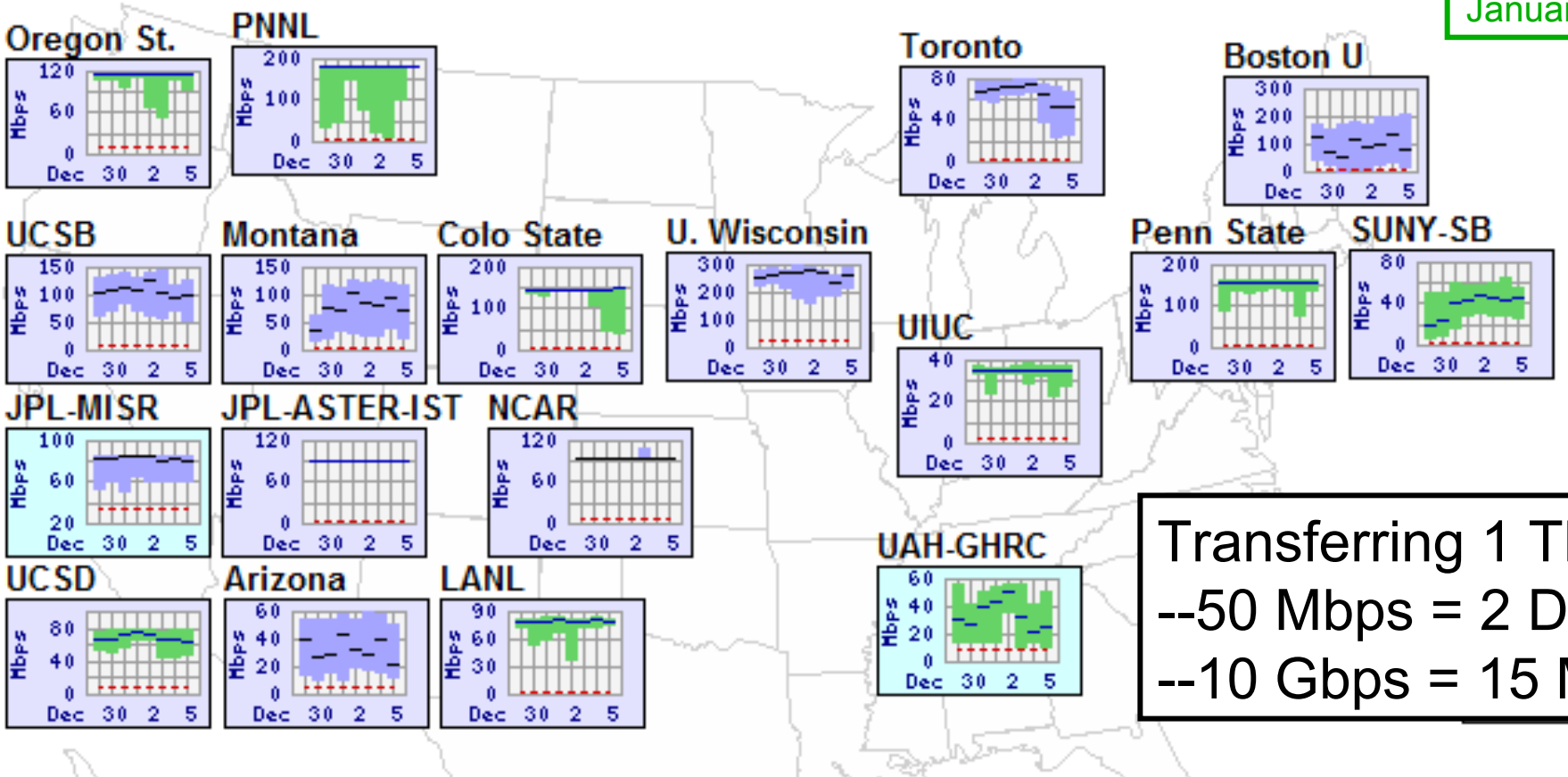
it²

Large Data Challenge: Average Throughput to End User on Shared Internet is ~50-100 Mbps



ENSIGHT Active Testing TERRA Destinations

Tested January 2011



Transferring 1 TB:
--50 Mbps = 2 Days
--10 Gbps = 15 Minutes

http://ensight.eos.nasa.gov/Missions/terra/index.shtml

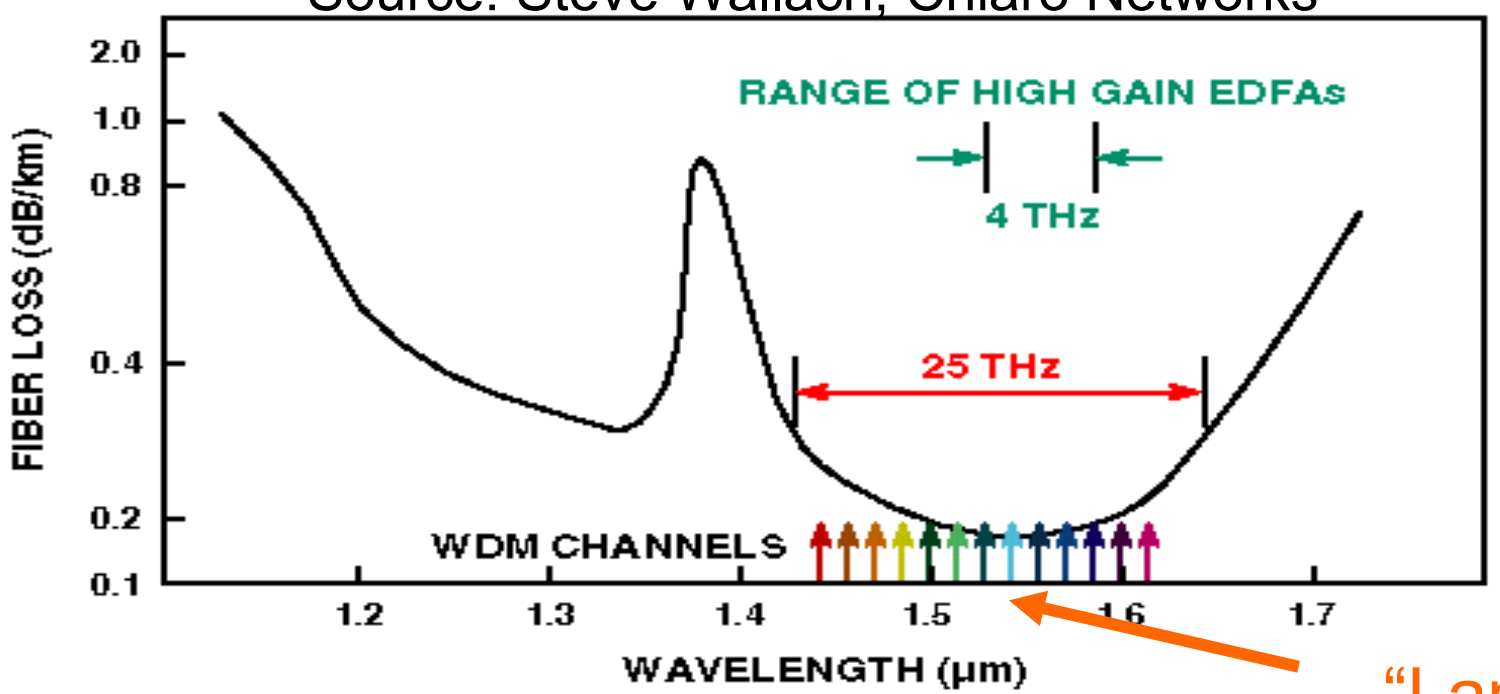
OptIPuter Solution:
Give Dedicated Optical Channels to Data-Intensive Users

WAVELENGTH DIVISION MULTIPLEXING (WDM)

10 Gbps per User ~ 100x
Shared Internet Throughput

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

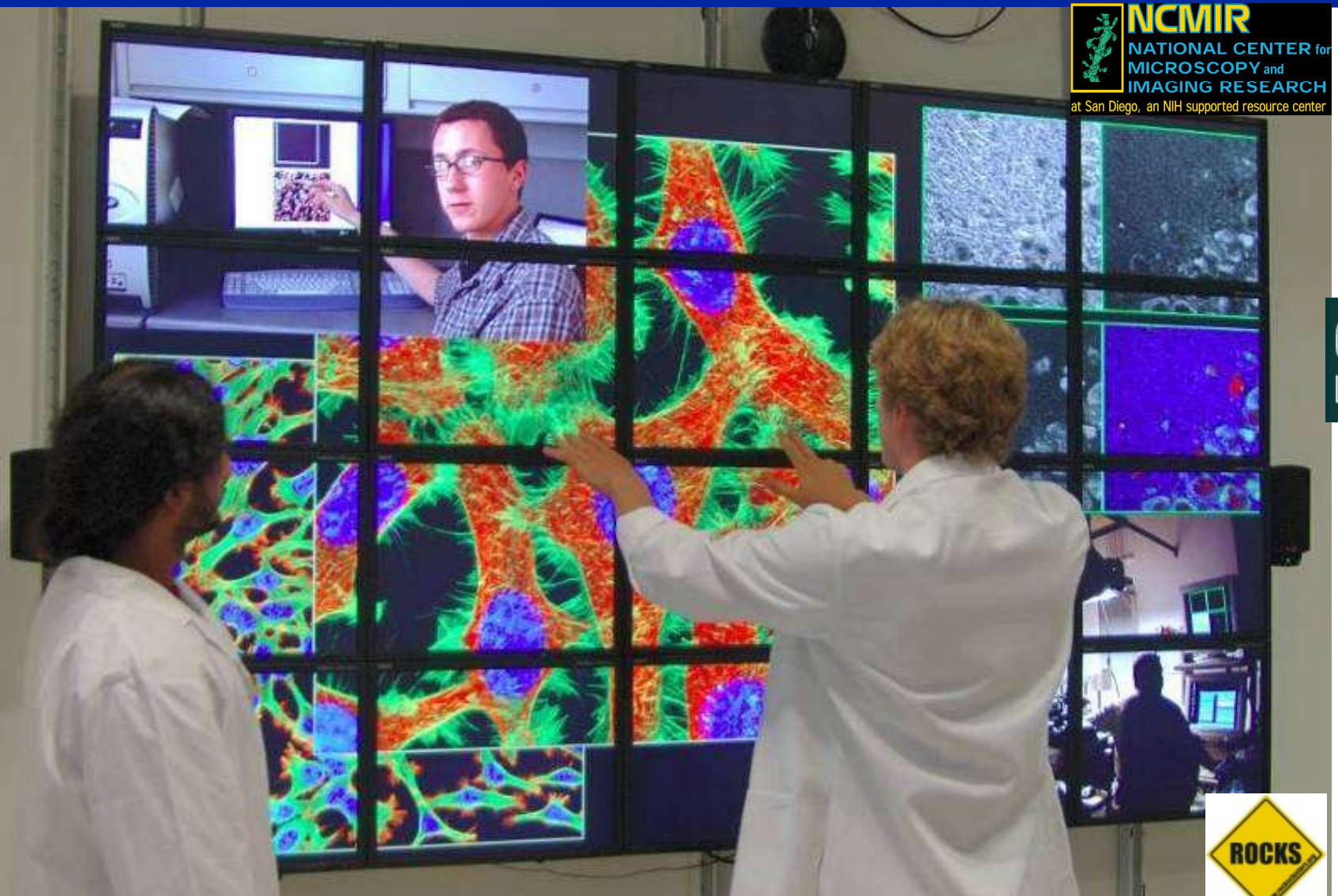
Source: Steve Wallach, Chiaro Networks



"Lambdas"

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

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



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

Scalable Adaptive Graphics Environment (SAGE)

SAGE

evl electronic visualization laboratory

NSF

ROCKS

Picture Source: Mark Ellisman, David Lee, Jason Leigh

OptIPuter

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

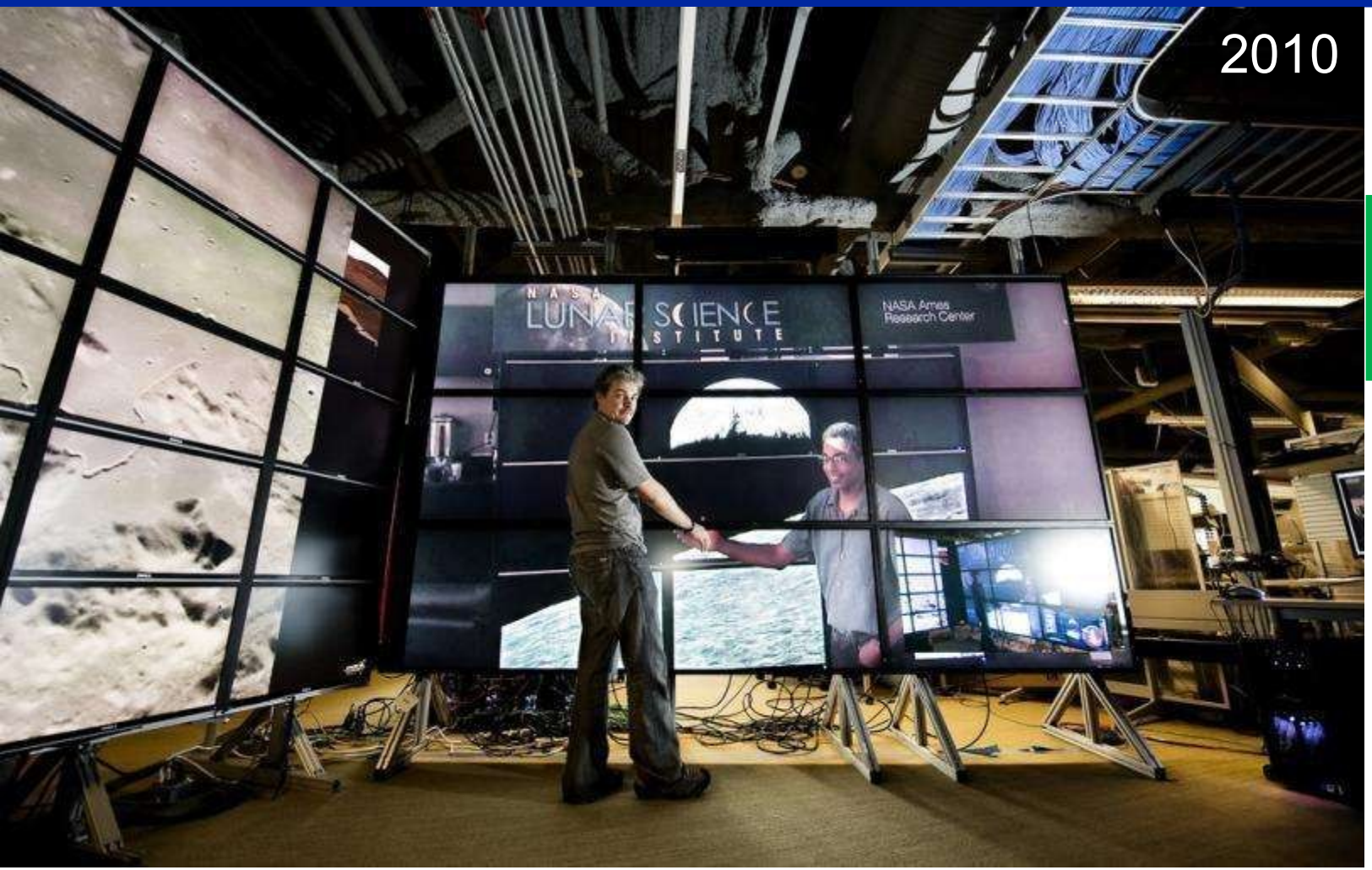
it2

The Latest OptIPuter Innovation: Quickly Deployable Nearly Seamless OptIPortables



45 minute setup, 15 minute tear-down with two people (possible with one)

High Definition Video Connected OptIPortals: Virtual Working Spaces for Data Intensive Research



NASA Supports Two Virtual Institutes

CGLX

LifeSize HD

Calit2@UCSD 10Gbps Link to
NASA Ames Lunar Science Institute, Mountain View, CA

OptIPuter

Source: Falko Kuester, Kai Doerr Calit2;
Michael Sims, Larry Edwards, Estelle Dodson NASA

it²

End-to-End 10Gbps Lambda Workflow: OptIPortal to Remote Supercomputers & Visualization Servers

Source: Mike Norman, Rick Wagner, SDSC

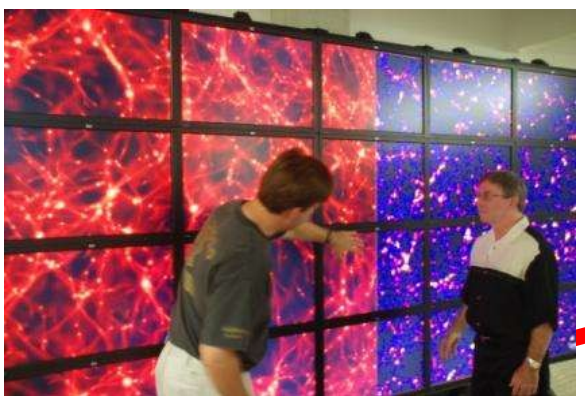
Project Stargate

Argonne NL

DOE Eureka
100 Dual Quad Core Xeon Servers
200 NVIDIA Quadro FX GPUs in 50 Quadro Plex S4 1U enclosures
3.2 TB RAM



SDSC

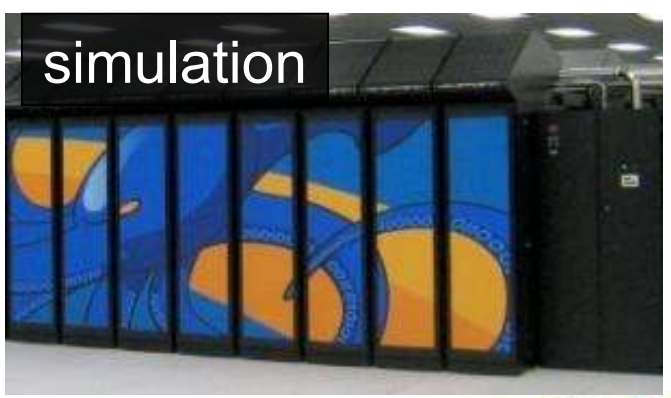


ESnet
10 Gb/s fiber optic network

NICS
ORNL

Calit2/SDSC OptIPortal1
20 30" (2560 x 1600 pixel) LCD panels
10 NVIDIA Quadro FX 4600 graphics cards > 80 megapixels
10 Gb/s network throughout

NSF TeraGrid Kraken
Cray XT5
8,256 Compute Nodes
99,072 Compute Cores
129 TB RAM

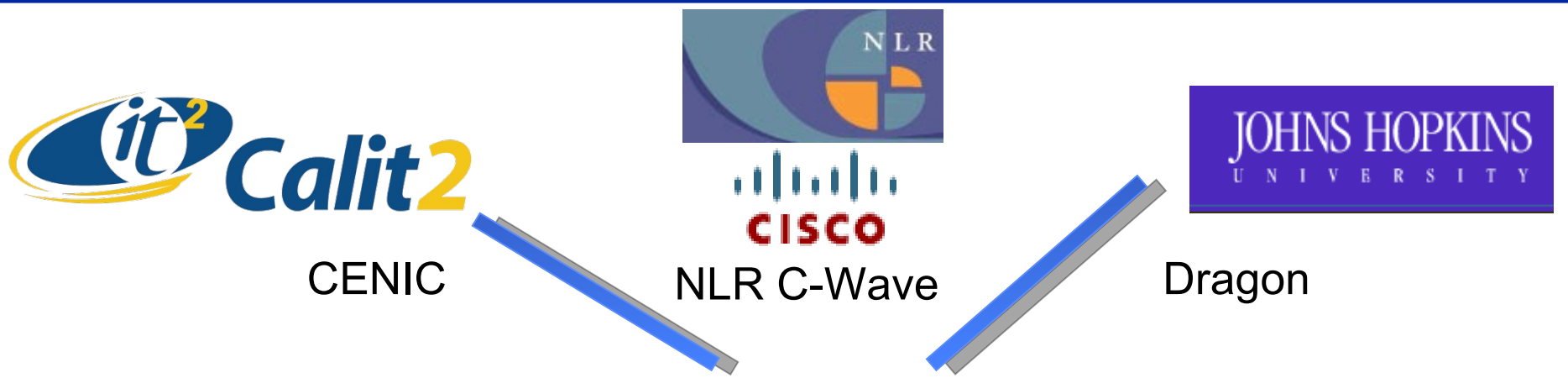


SDSC

*ANL * Calit2 * LBNL * NICS * ORNL * SDSC

it²

Open Cloud OptIPuter Testbed--Manage and Compute Large Datasets Over 10Gbps Lambdas



STARLIGHT℠
The Optical STAR TAP™

MREN

UIC

- **9 Racks**
- **500 Nodes**
- **1000+ Cores**
- **10+ Gb/s Now**
- **Upgrading Portions to 100 Gb/s in 2010/2011**

Open Source SW

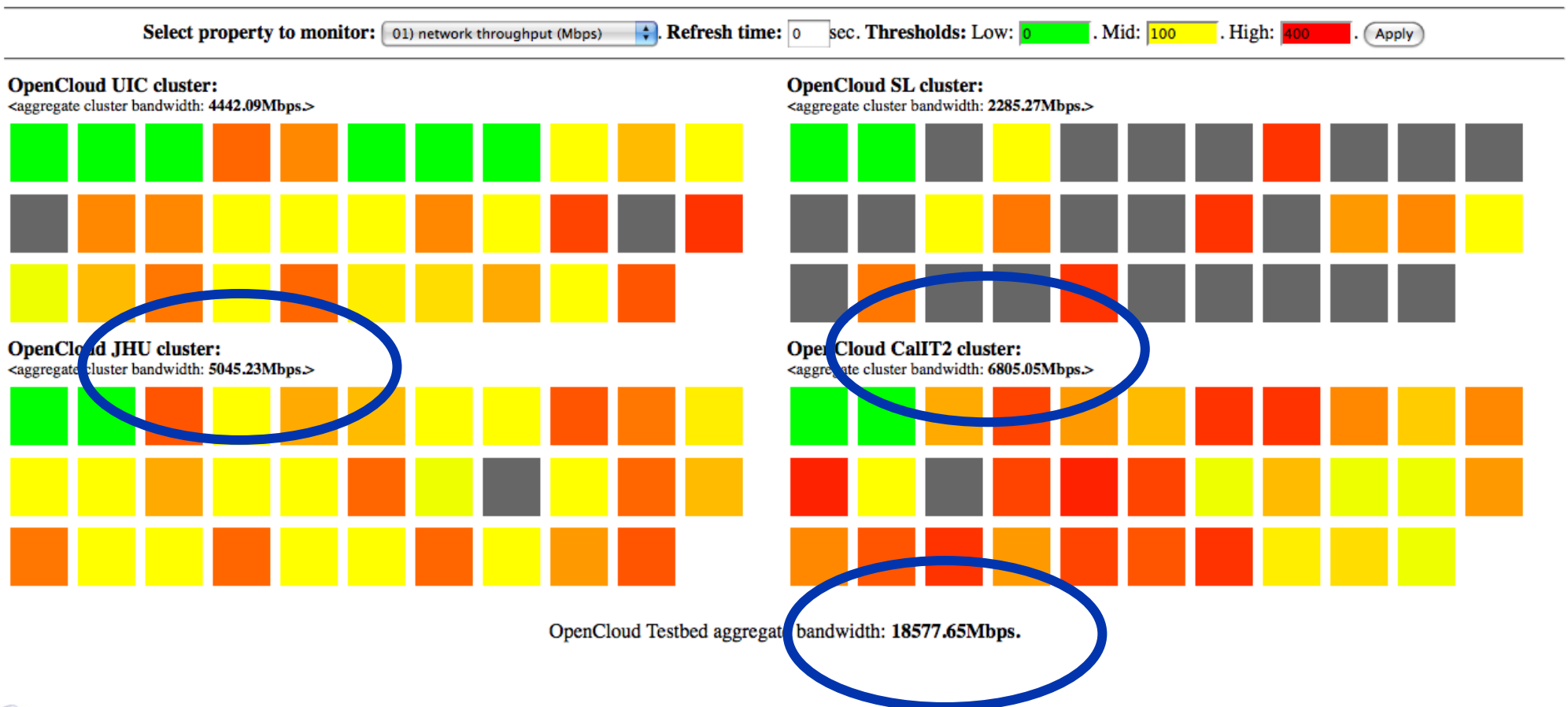
- Hadoop
- Sector/Sphere
- Nebula
- Thrift, GPB
- Eucalyptus
- Benchmarks

Open Cloud Consortium

Source: Robert Grossman, UChicago

Terasort on Open Cloud Testbed Sustains >5 Gbps--Only 5% Distance Penalty!

Sorting 10 Billion Records (1.2 TB) at 4 Sites (120 Nodes)



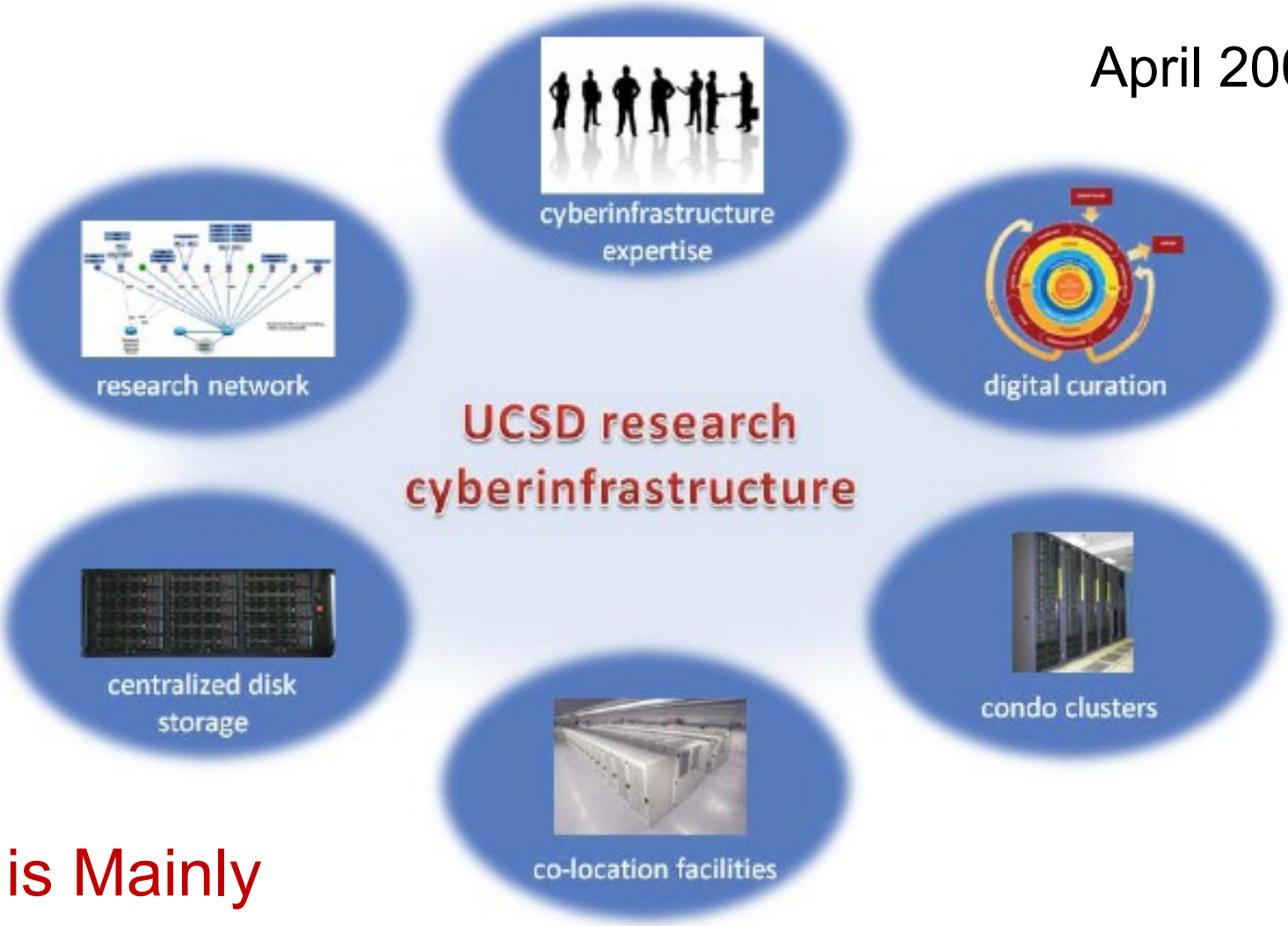
Source: Robert Grossman, UChicago

"Blueprint for the Digital University"--Report of the UCSD Research Cyberinfrastructure Design Team

- **Focus on Data-Intensive Cyberinfrastructure**

April 2009

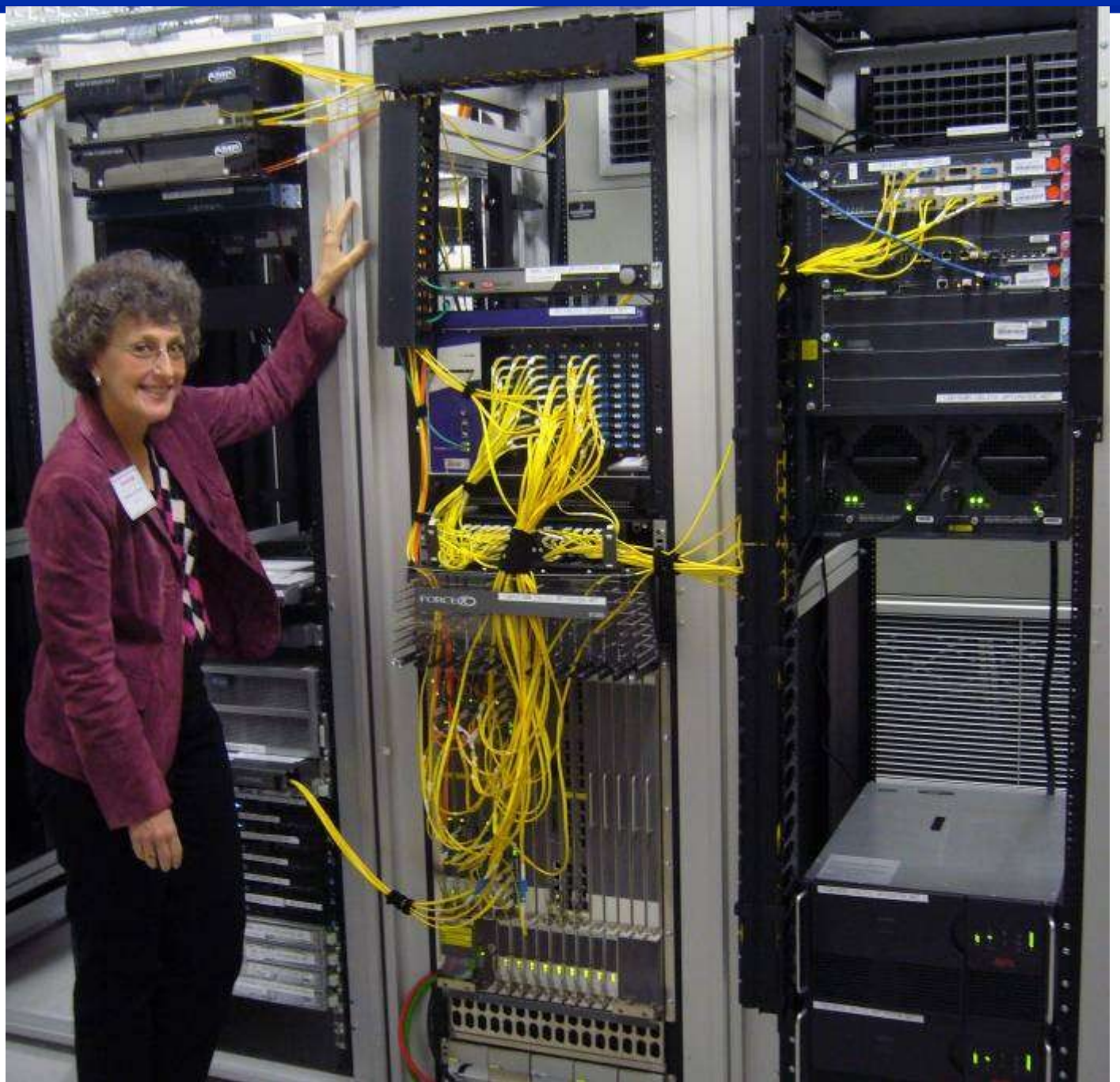
No Data Bottlenecks--Design for Gigabit/s Data Flows



Bottleneck is Mainly On Campuses

research.ucsd.edu/documents/rcidt/RCIDTReportFinal2009.pdf

Calit2 Sunlight Campus Optical Exchange -- Built on NSF Quartzite MRI Grant

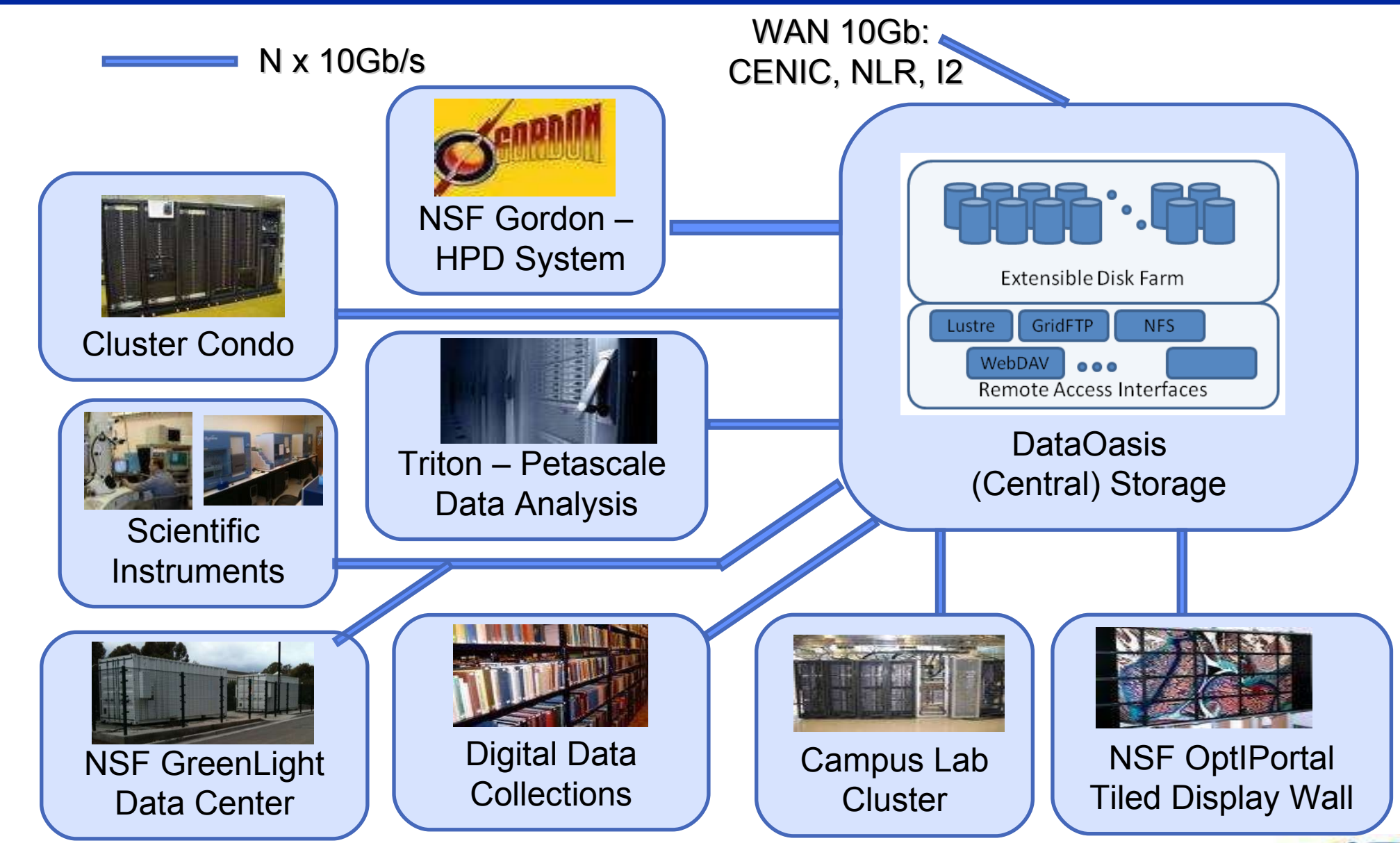


Maxine Brown, EVL, UIC - OptIPuter Project Manager

~60 10Gbps Lambdas Arrive at Calit2's SunLight. Switching is a Hybrid of: Packet, Lambda, Circuit

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

UCSD Campus Investment in Fiber Enables Consolidation of Energy Efficient Computing & Storage



Source: Philip Papadopoulos, SDSC, UCSD

Moving to Shared Campus Data Storage & Analysis: SDSC Triton Resource & Calit2 GreenLight

http://tritonresource.sdsc.edu

Source: Philip Papadopoulos, SDSC, UCSD

SDSC Large Memory Nodes
- 256/512 GB/sys
- 8TB Total
- 128 GB/sec
- ~ 9 TF



x28



x256

SDSC Shared Resource Cluster
- 24 GB/Node
- 6TB Total
- 256 GB/sec
- ~ 20 TF

ROCKS



SDSC Data Oasis Large Scale Storage
- 2 PB
- 50 GB/sec
- 3000 – 6000 disks
- Phase 0: 1/3 PB, 8GB/s



UCSD Research Labs





N x 10Gb/s



Calit2 GreenLight

Campus Research Network

SDSC

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NSF Funds a Data-Intensive Track 2 Supercomputer: SDSC's Gordon-Coming Summer 2011

- **Data-Intensive Supercomputer Based on SSD Flash Memory and Virtual Shared Memory SW**
  - *Emphasizes MEM and IOPS over FLOPS*
  - *Supernode has Virtual Shared Memory:*
    - *2 TB RAM Aggregate*
    - *8 TB SSD Aggregate*
    - *Total Machine = 32 Supernodes*
    - *4 PB Disk Parallel File System >100 GB/s I/O*



- **System Designed to Accelerate Access to Massive Data Bases being Generated in Many Fields of Science, Engineering, Medicine, and Social Science**

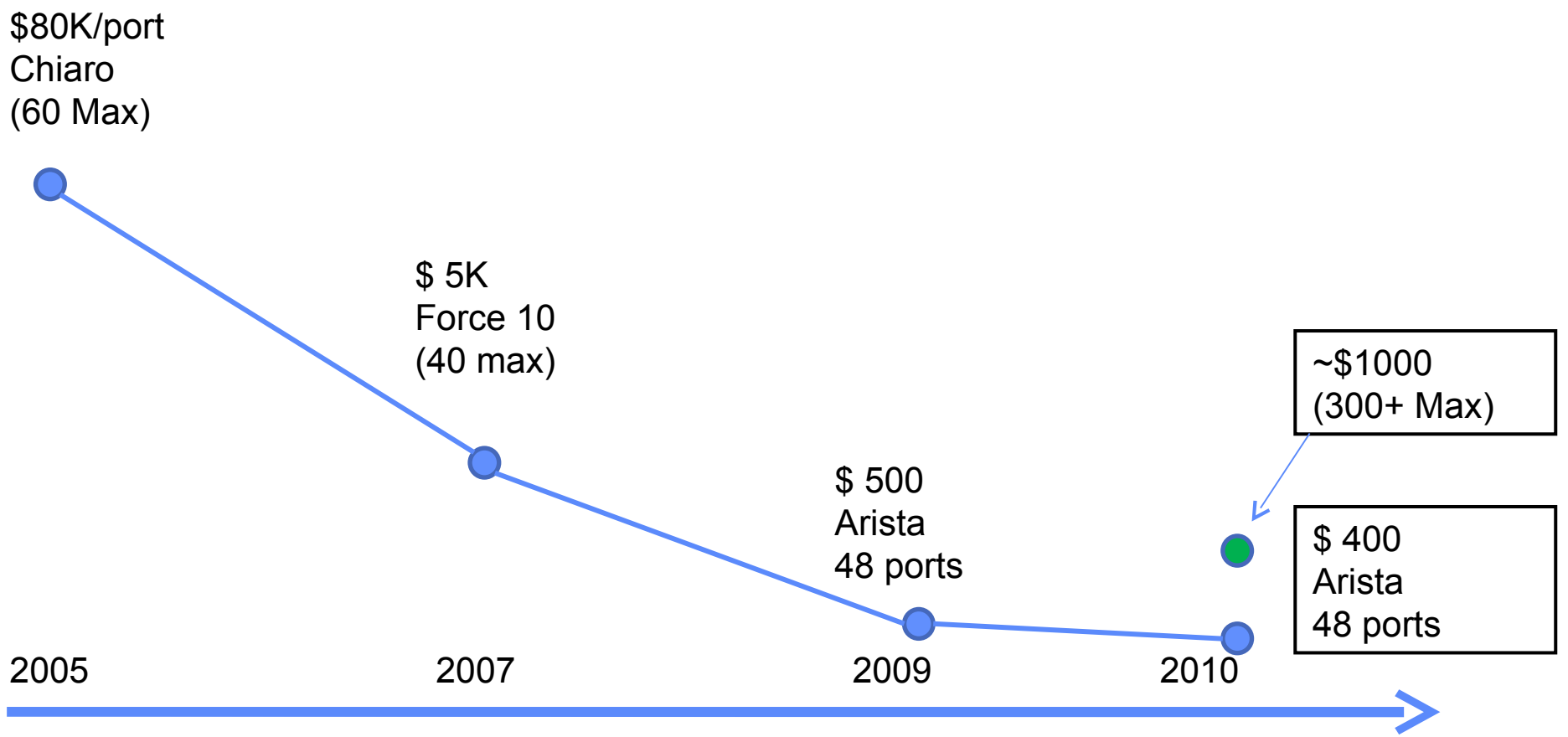
SDSC

Source: Mike Norman, Allan Snavely SDSC

it²

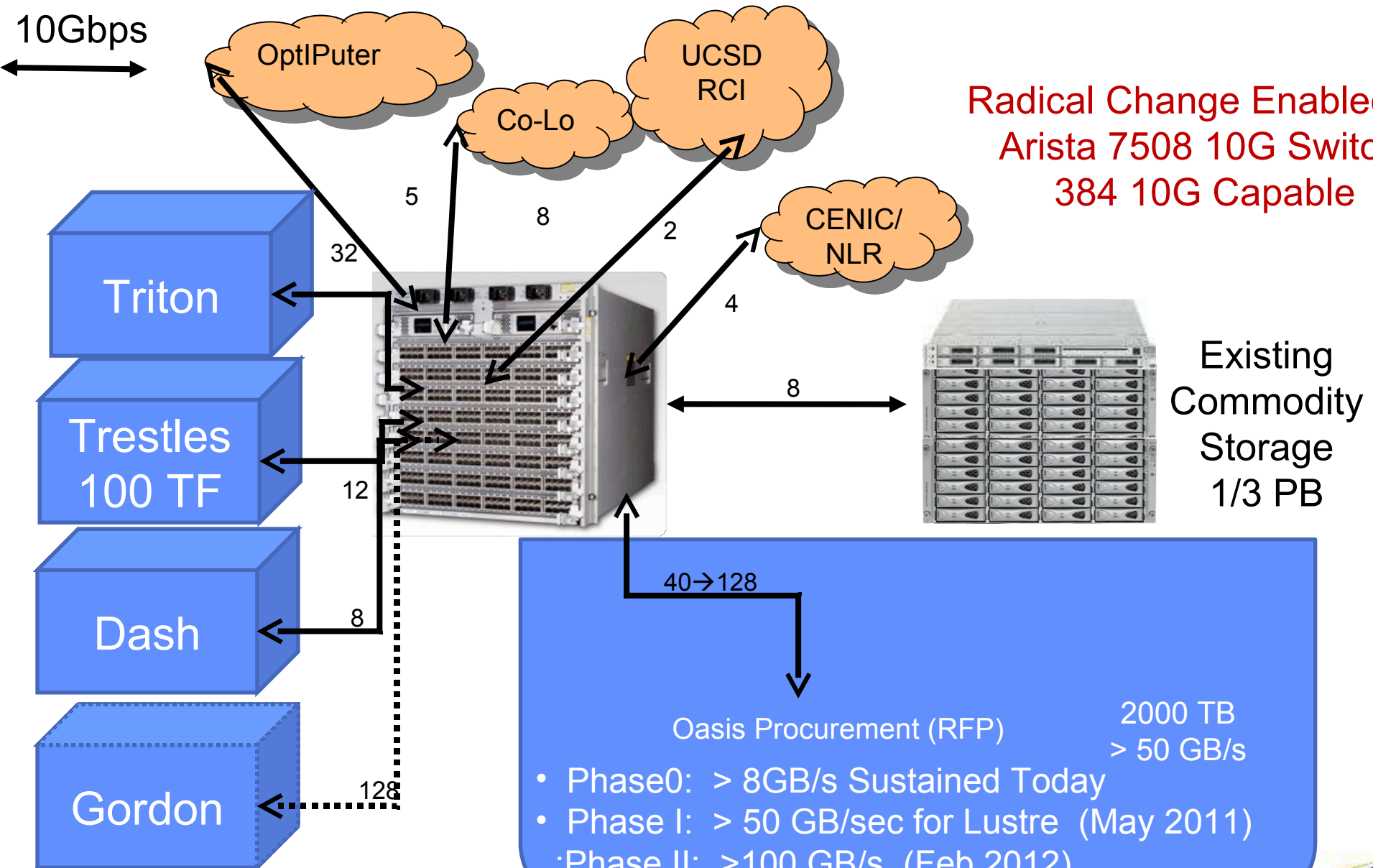
Rapid Evolution of 10GbE Port Prices Makes Campus-Scale 10Gbps CI Affordable

- Port Pricing is Falling
- Density is Rising – Dramatically
- Cost of 10GbE Approaching Cluster HPC Interconnects



Source: Philip Papadopoulos, SDSC/Calit2

10G Switched Data Analysis Resource: SDSC's Data Oasis



Radical Change Enabled by Arista 7508 10G Switch: 384 10G Capable

SDSC

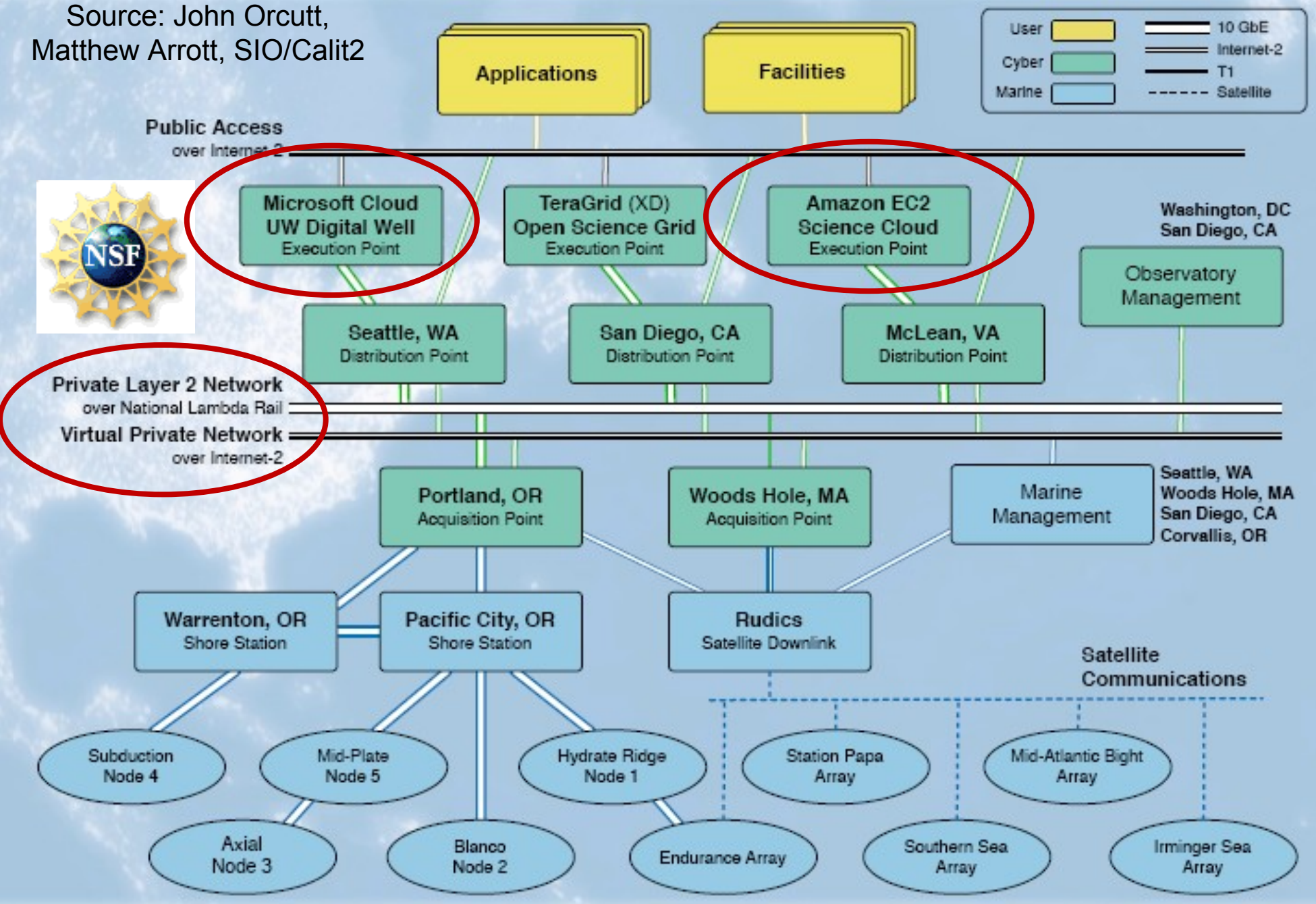
Source: Philip Papadopoulos, SDSC/Calit2

it²

OOI CI is Built on Dedicated Optical Infrastructure Using Clouds

OCEAN OBSERVATORIES INITIATIVE

Source: John Orcutt, Matthew Arrott, SIO/Calit2



California and Washington Universities Are Testing a 10Gbps Connected Commercial Data Cloud

- **Amazon Experiment for Big Data**
  - **Only Available Through CENIC & Pacific NW GigaPOP**
    - **Private 10Gbps Peering Paths**
  - **Includes Amazon EC2 Computing & S3 Storage Services**
- **Early Experiments Underway**
  - **Robert Grossman, Open Cloud Consortium**
  - **Phil Papadopoulos, Calit2/SDSC Rocks**

SDSC





