High Performance Cyberinfrastructure Enabling Data-Driven Science Supporting Stem Cell Research

Invited Presentation

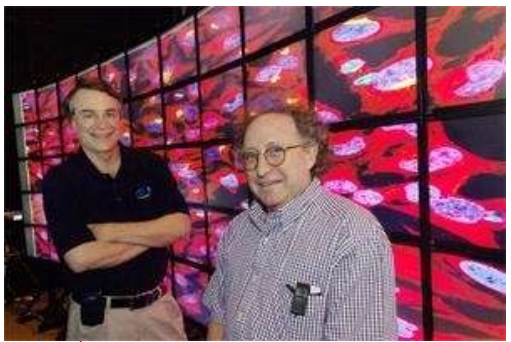
Sanford Consortium for Regenerative Medicine

Salk Institute, La Jolla

Larry Smarr, Calit2 & Phil Papadopoulos, SDSC/Calit2

May 13, 2011

Academic Research OptIPlanet Collaboratory: A 10Gbps "End-to-End" Lightpath Cloud

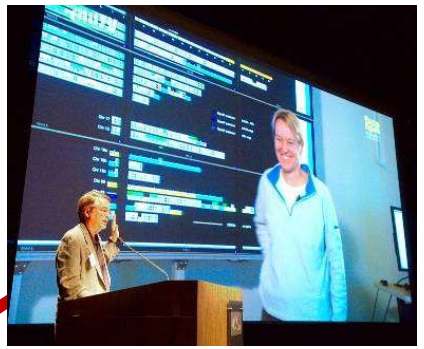


End User OptIPortal





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

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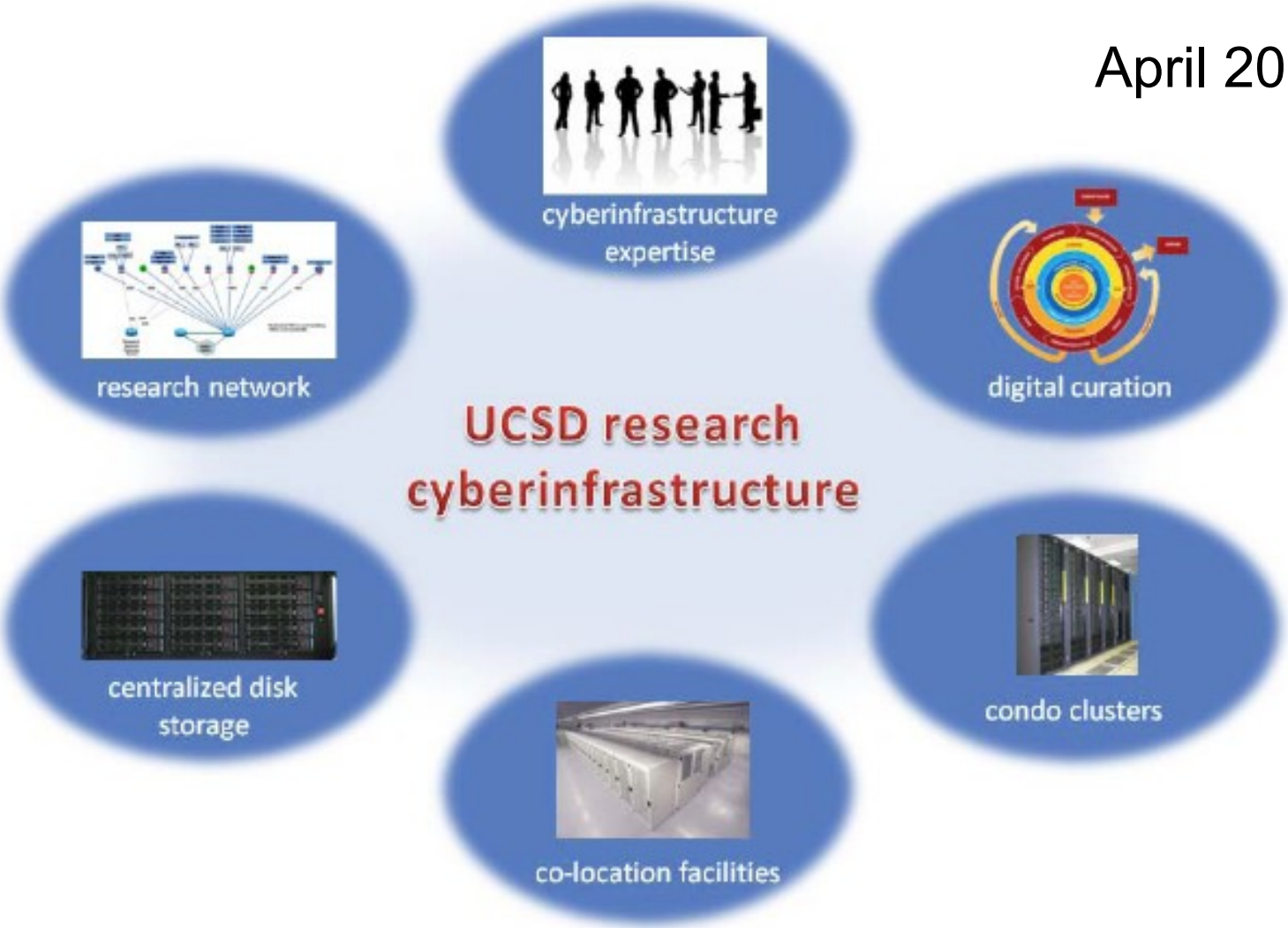
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"Blueprint for the Digital University"--Report of the UCSD Research Cyberinfrastructure Design Team

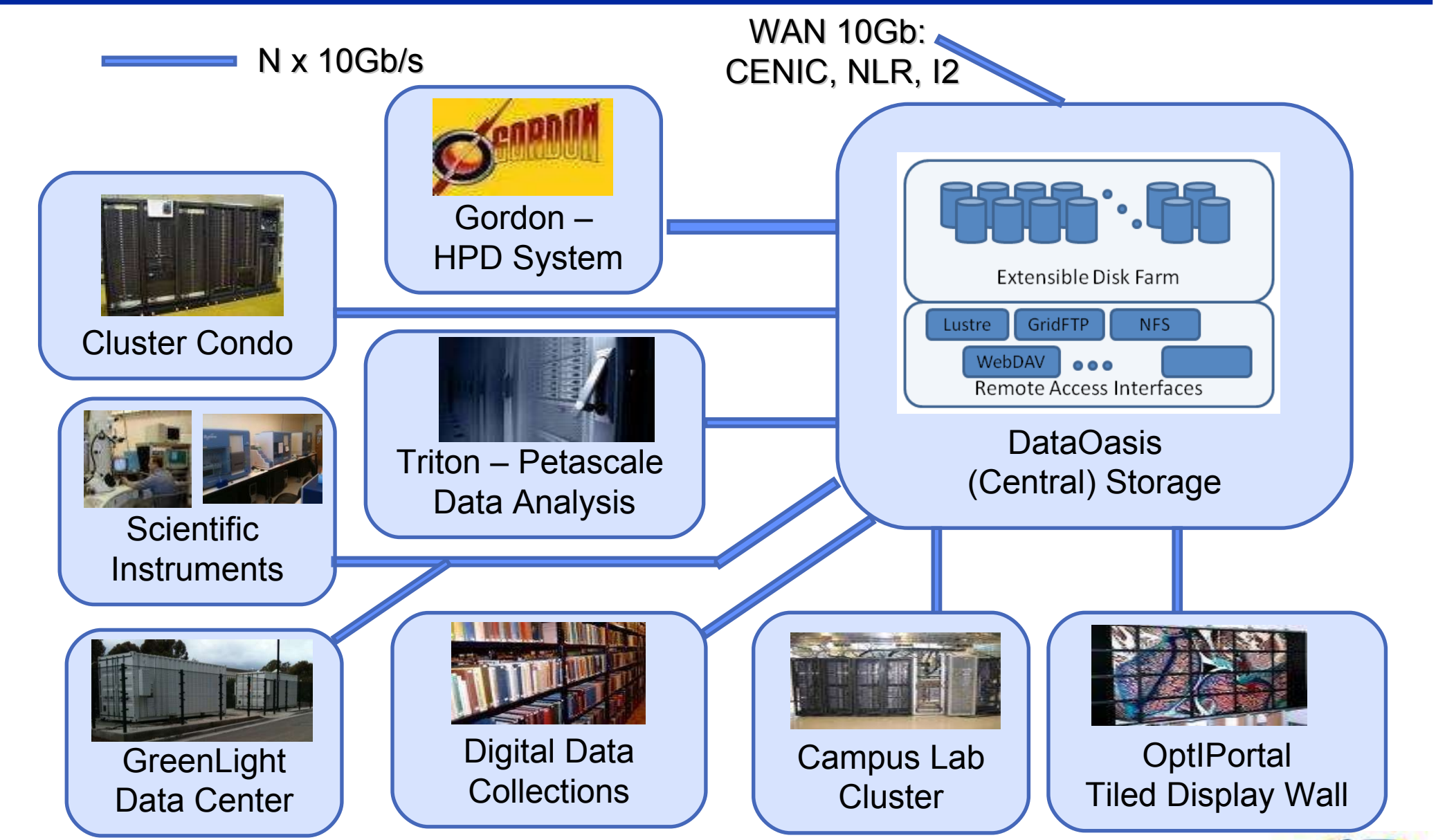
- **A Five Year Process Begins Pilot Deployment This Year**

April 2009

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



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



Source: Philip Papadopoulos, SDSC, UCSD

Moving to Shared Enterprise Data Storage & Analysis Resources: 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



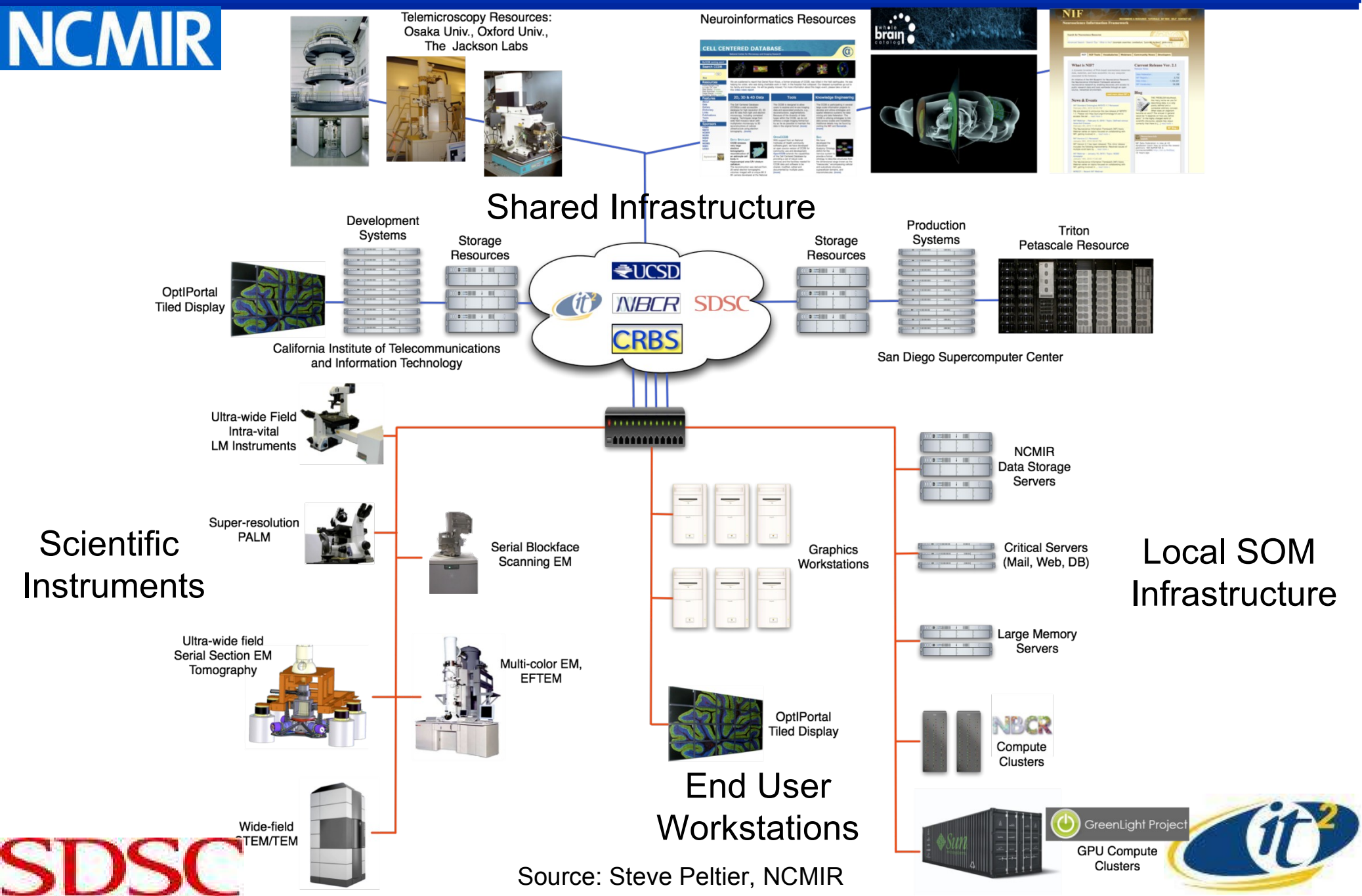
Calit2 GreenLight

Campus
Research
Network

SDSC

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NCMIR's Integrated Infrastructure of Shared Resources



Source: Steve Peltier, NCMIR

The GreenLight Project: Instrumenting the Energy Cost of Computational Science

- **Focus on 5 Communities with At-Scale Computing Needs:**
  - Metagenomics
  - Ocean Observing
  - Microscopy
  - Bioinformatics
  - Digital Media
- **Measure, Monitor, & Web Publish Real-Time Sensor Outputs**
  - Via Service-oriented Architectures
  - Allow Researchers Anywhere To Study Computing Energy Cost
  - Enable Scientists To Explore Tactics For Maximizing Work/Watt
- **Develop Middleware that Automates Optimal Choice of Compute/RAM Power Strategies for Desired Greenness**
- **Data Center for School of Medicine Illumina Next Gen Sequencer Storage and Processing**





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Source: Tom DeFanti, Calit2; GreenLight PI

NSF

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Next Generation Genome Sequencers Produce Large Data Sets

Data Volume	Total	Final	Comment
HiSeq 2000 200G run			
Image Data	32 TB	0	
Intensity Data	2 TB	0	Optionally transferred
Base Call / Quality Score Data	250 GB	250 GB	1 byte/base (raw) assuming qseq generation offline
Alignment Output	6 TB (3 TB)	1.2 TB	Remove intermediate files
GA_{IIx} 50G run			
Image Data	6.9	0	Optionally transferred
Intensity Data	0.93	0.93	
Base Call / Quality Score Data	0.17	0.17	
Alignment Output	1.2TB	1.2 TB	

Source: Chris Misleh, SOM

The Growing Sequencing Data Load Runs over RCI Connecting GreenLight and Triton

- **Data from the Sequencers Stored in GreenLight SOM Data Center**
  - **Data Center Contains Cisco Catalyst 6509-connected to Campus RCI at 2 x 10Gb.**
  - **Attached to the Cisco Catalyst is a 48 x 1Gb switch and an Arista 7148 switch which has 48 x 10Gb ports.**
  - **The two Sun Disks connect directly to the Arista switch for 10Gb connectivity.**
- **With our current configuration of two Illumina GAIIx, one GAII, and one HiSeq 2000, we can produce a maximum of 3TB of data per week.**
- **Processing uses a combination of local compute nodes and the Triton resource at SDSC.**
  - **Triton comes in particularly handy when we need to run 30 seqmap/blat/blast jobs. On a standard desktop computer this analysis could take several weeks. On Triton, we have the ability submit these jobs in parallel and complete computation in a fraction of the time. Typically within a day.**
- **In the coming months we will be transitioning another lab to the 10Gbit Arista switch. In total we will have 6 Sun Disks connected at 10Gbit speed, and mounted via NFS directly on the Triton resource..**
- **The new PacBio RS is scheduled to arrive in May, which will also utilize the Campus RCI in Leichtag and the SOM GreenLight Data Center.**

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Source: Chris Misleh, SOM

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Community Cyberinfrastructure for Advanced Microbial Ecology Research and Analysis

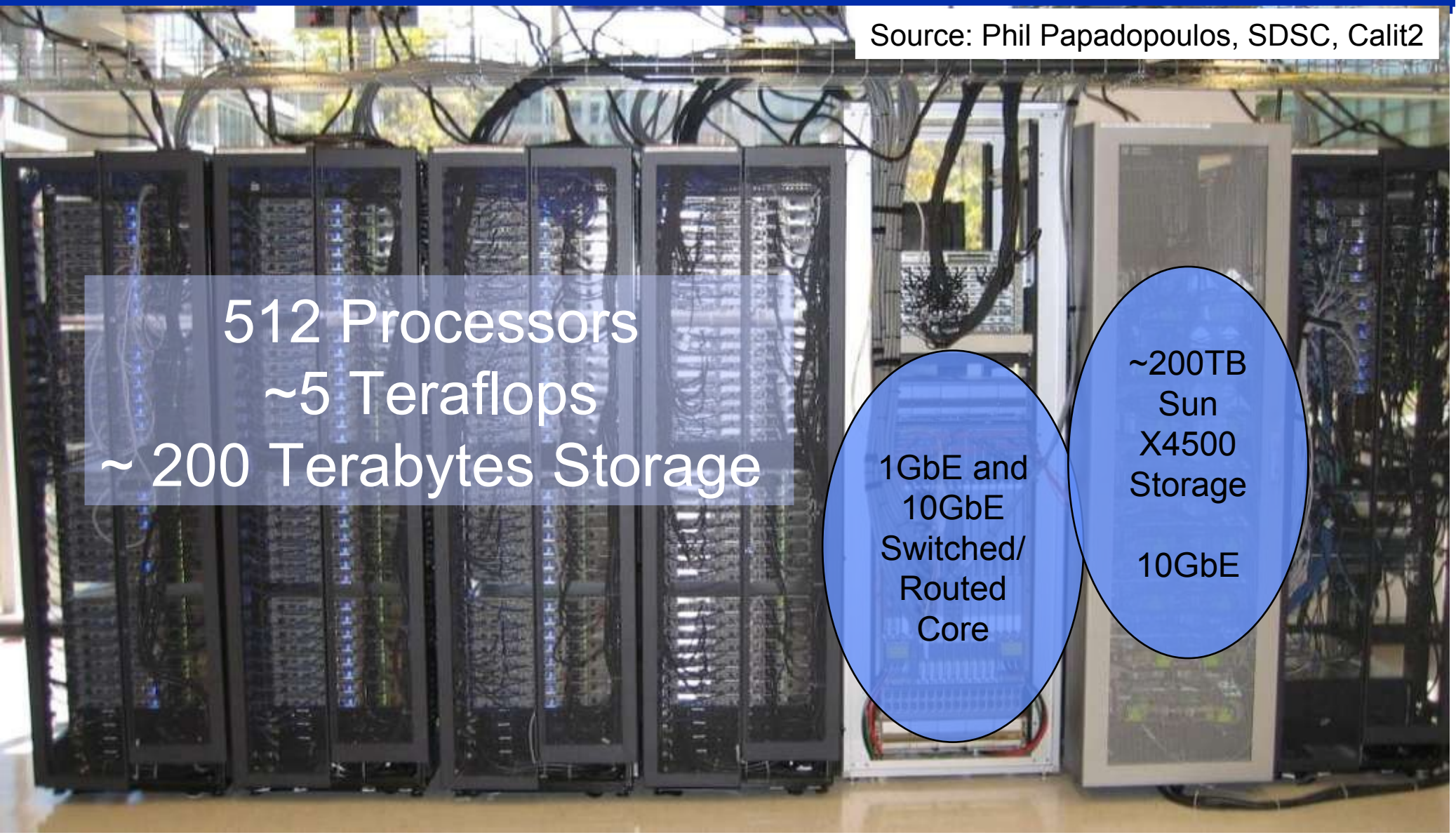


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Calit2 Microbial Metagenomics Cluster- Next Generation Optically Linked Science Data Server



4000 Users
From 90 Countries

Gordon and Betty MOORE FOUNDATION

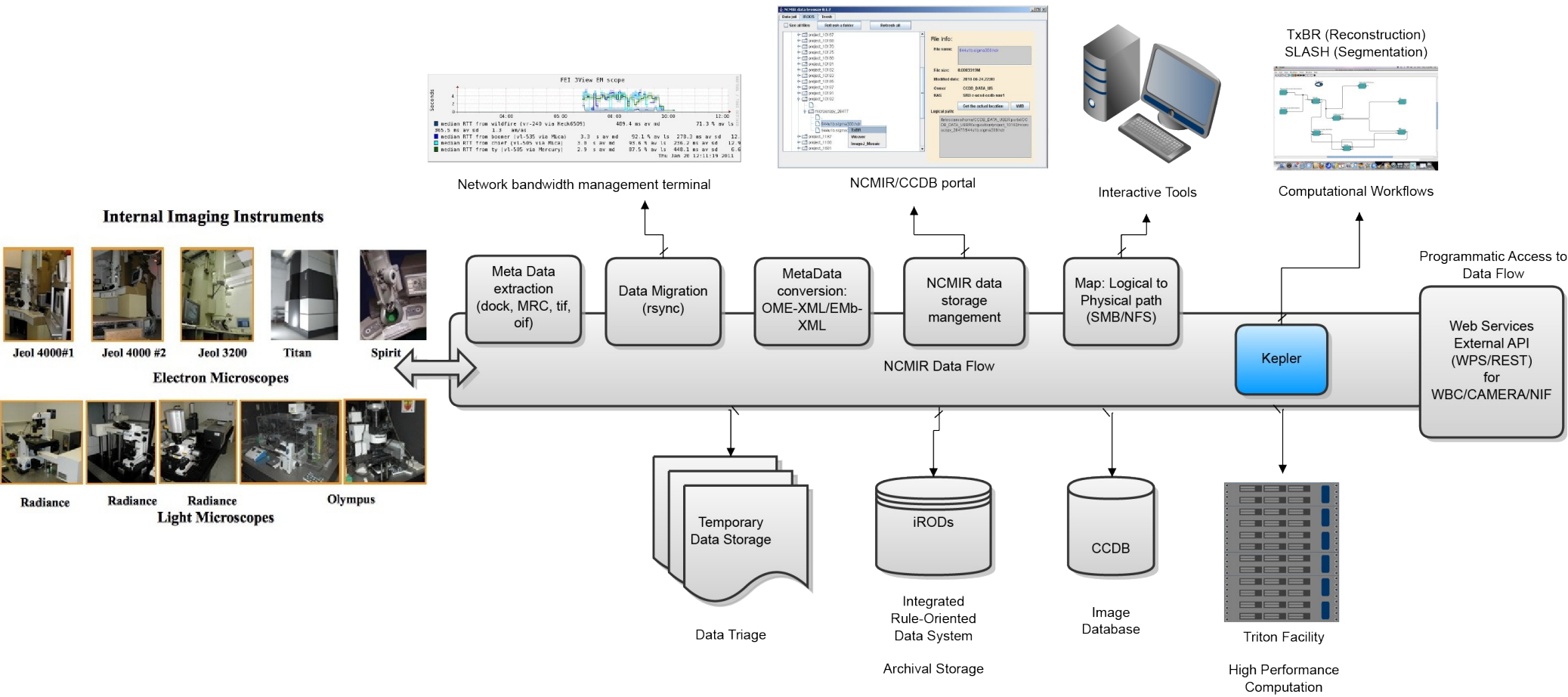
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Fully Integrated UCSD CI Manages the End-to-End Lifecycle of Massive Data from Instruments to Analysis to Archival



UCSD CI Features Kepler Workflow Technologies

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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**

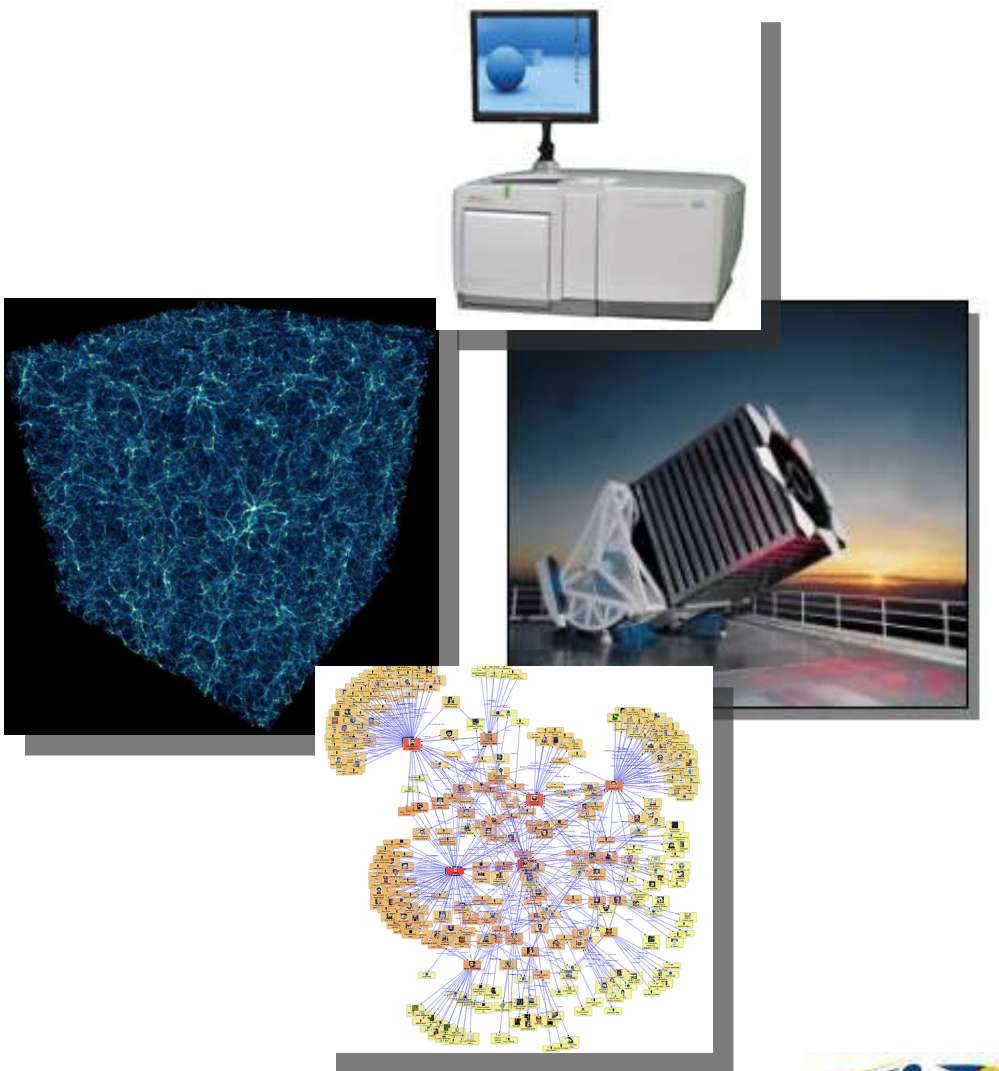
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Source: Mike Norman, Allan Snavely SDSC

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Data Mining Applications will Benefit from Gordon

- *De Novo* Genome Assembly from Sequencer Reads & Analysis of Galaxies from Cosmological Simulations & Observations
  - *Will Benefit from Large Shared Memory*
- Federations of Databases & Interaction Network Analysis for Drug Discovery, Social Science, Biology, Epidemiology, Etc.
  - *Will Benefit from Low Latency I/O from Flash*



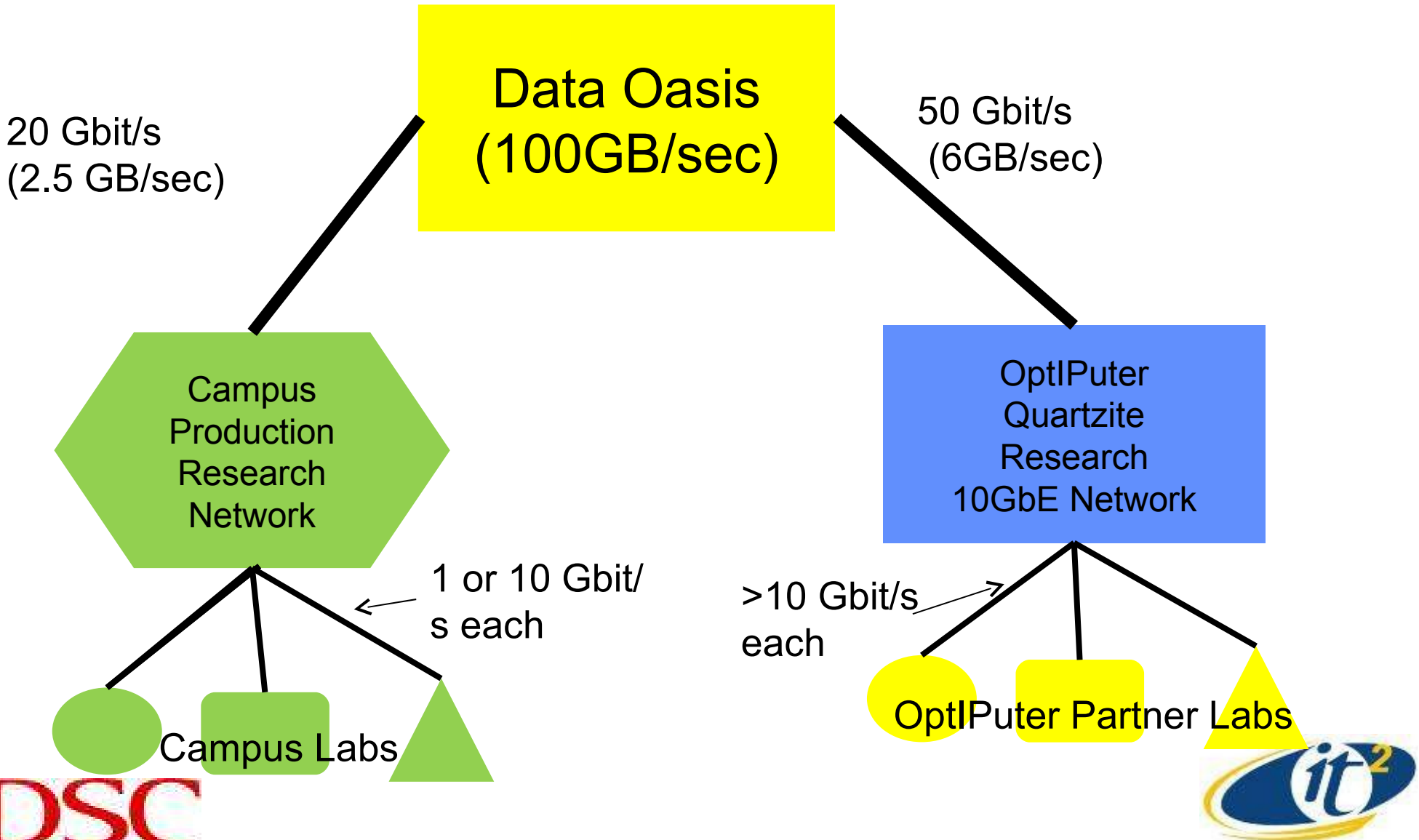
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Source: Mike Norman, SDSC

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IF Your Data is Remote, Your Network Better be "Fat"

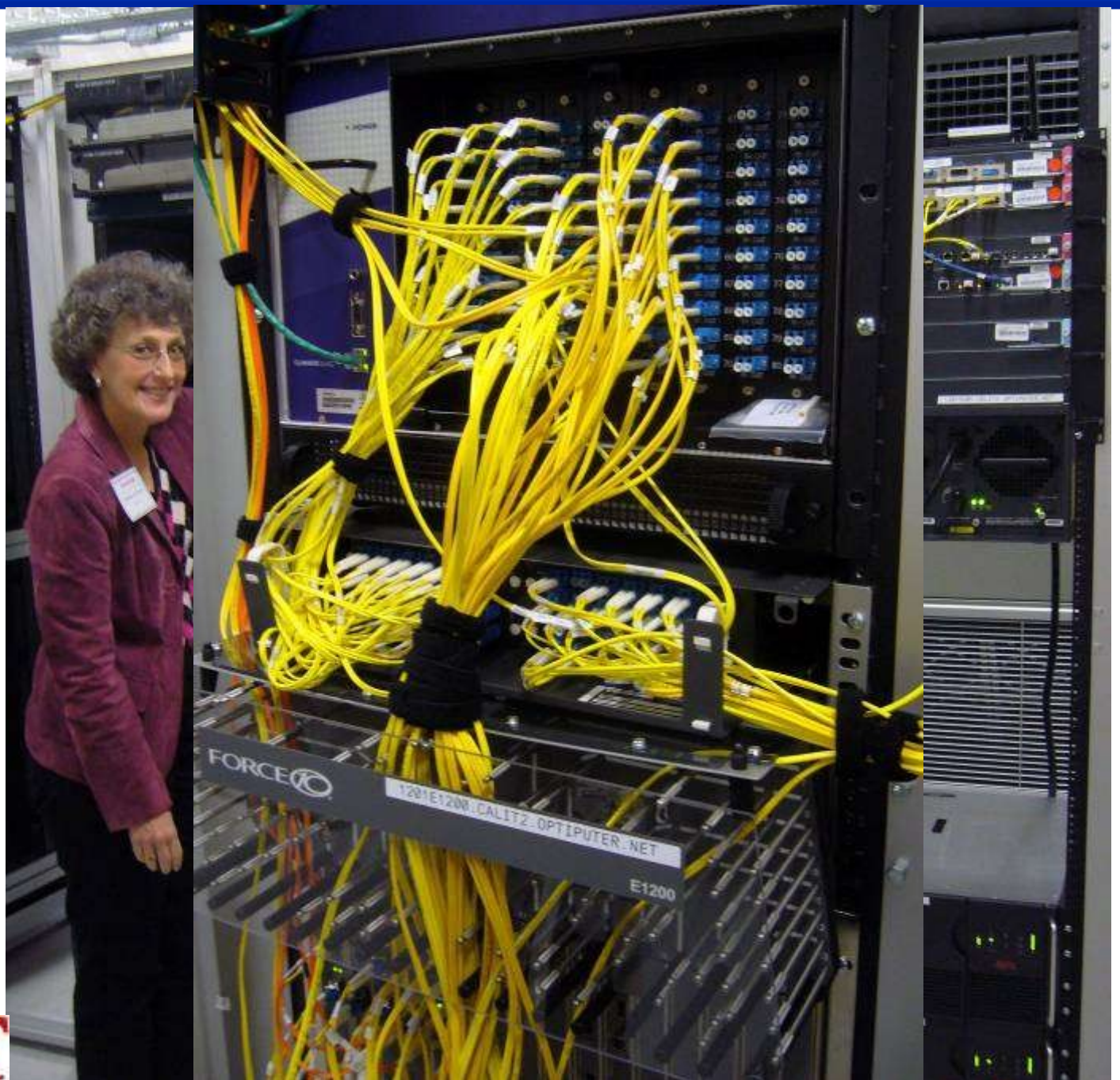
1TB @ 10 Gbit/sec = ~20 Minutes
1TB @ 10 Mbit/sec = ~10 Days



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Calit2 Sunlight OptIPuter Exchange Contains Quartzite



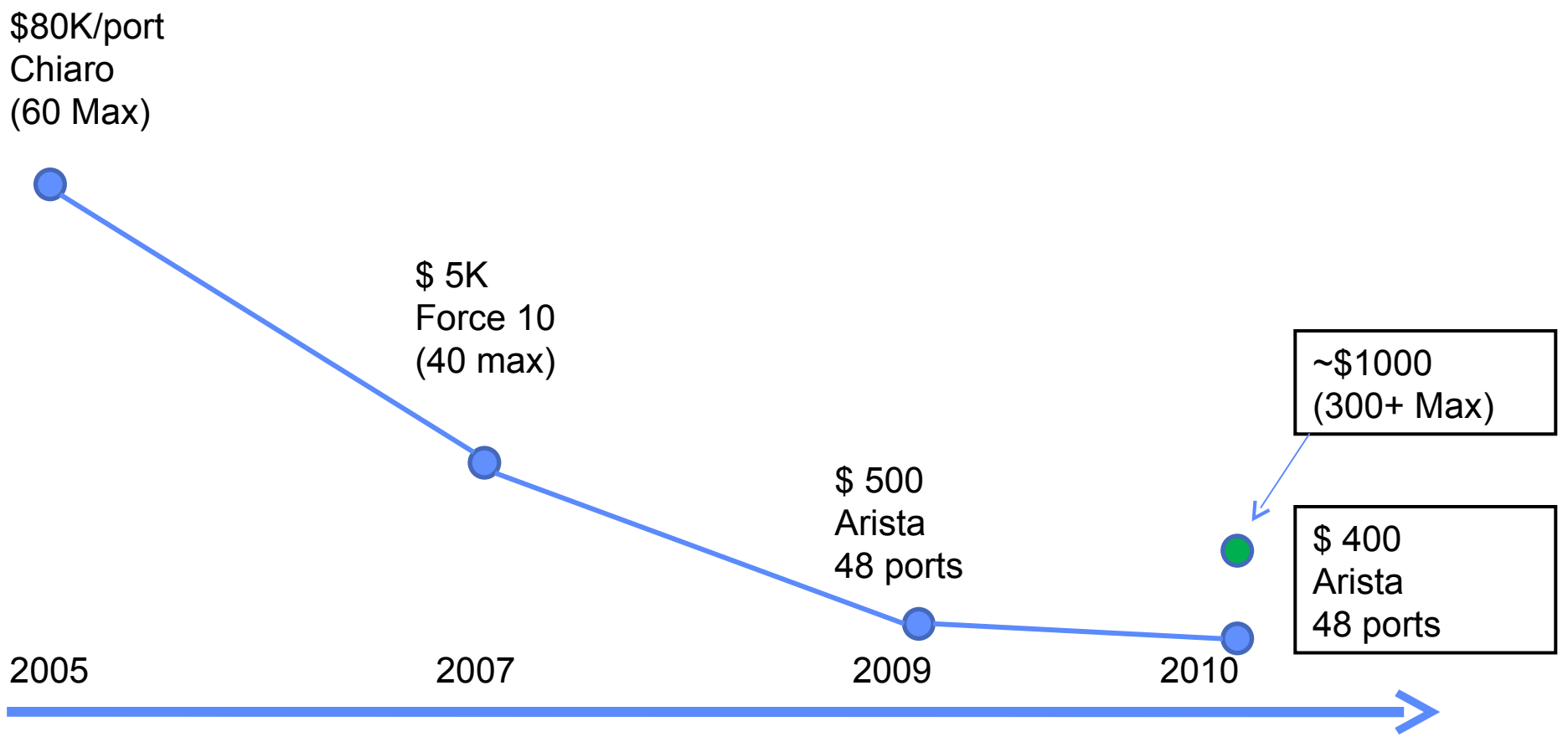
Maxine Brown, EVL, UIC OptIPuter Project Manager

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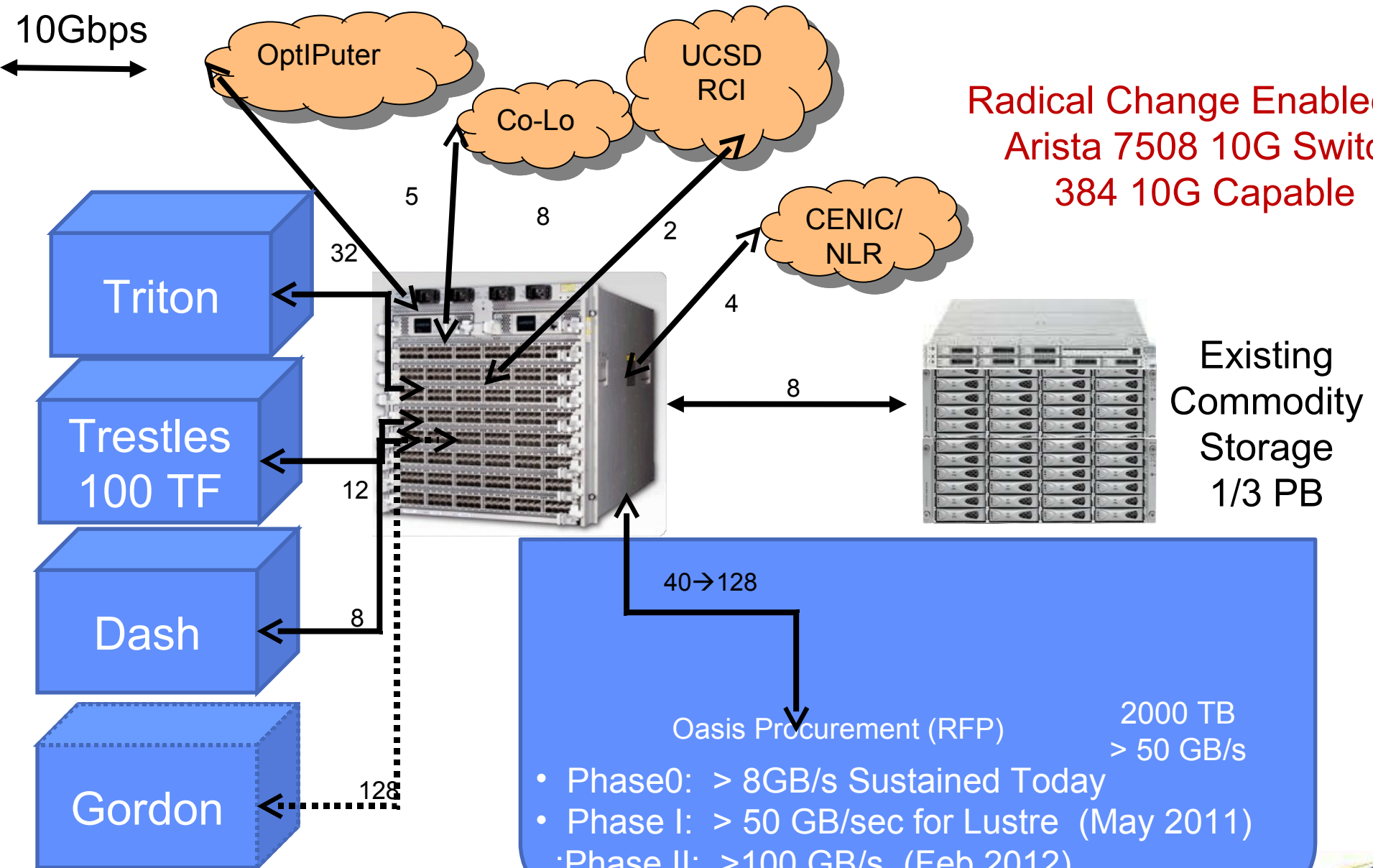
Rapid Evolution of 10GbE Port Prices Makes Campus-Scale 10Gbps CI Affordable

- 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 – Scaled Performance



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

Existing Commodity Storage 1/3 PB

SDSC

Source: Philip Papadopoulos, SDSC/Calit2

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Data Oasis – 3 Different Types of Storage



HPC Storage (Lustre-Based PFS)

- Purpose: Transient Storage to Support HPC, HPD, and Visualization
- Access Mechanisms: Lustre Parallel File System Client



Project (Traditional File Server) Storage

- Purpose: Typical Project / User Storage Needs
- Access Mechanisms: NFS/CIFS "Network Drives"



Cloud Storage

- Purpose: Long-Term Storage of Data that will be Infrequently Accessed
- Access Mechanisms: S3 interfaces, DropBox-esq web interface, CommVault

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Campus Now Starting RCI Pilot (http://rci.ucsd.edu)



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