Supercomputers and Supernetworks are Transforming Research

Invited Talk
Computing Research that Changed the World:
Reflections and Perspectives
Washington, DC
March 25, 2009

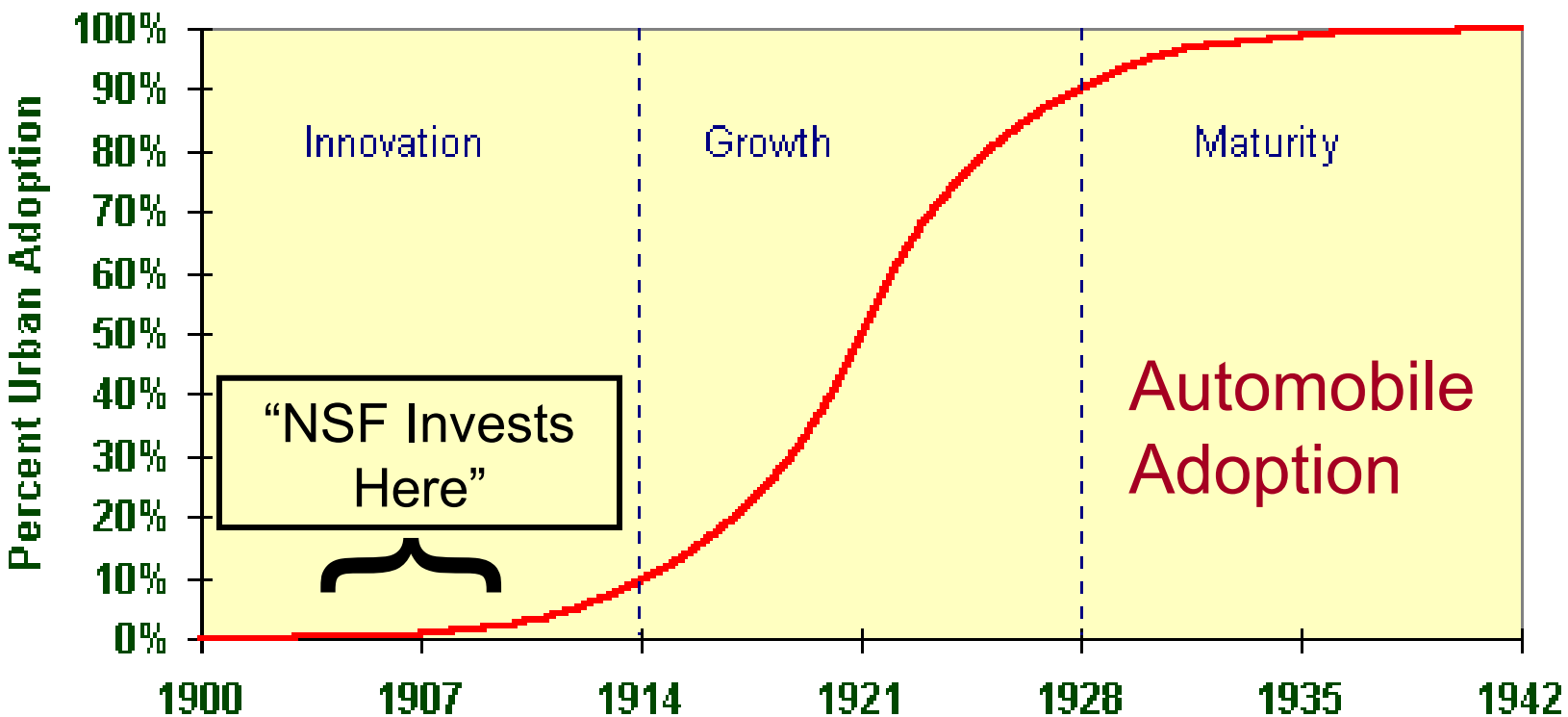
Dr. Larry Smarr
Director, California Institute for Telecommunications and Information Technology
Harry E. Gruber Professor,
Dept. of Computer Science and Engineering
Jacobs School of Engineering, UCSD

OptIPuter

it²

From Elite Science to the Mass Market

- **Four Examples I Helped "Mid-Wife":**
  - **Supercomputers to GigaHertz PCs**
  - **Scientific Visualization to Movie/Game Special Effects**
  - **CERN Preprints to WWW**
  - **NSFnet to the Commercial Internet**
- **Technologies Diffuse Into Society Following an S-Curve**

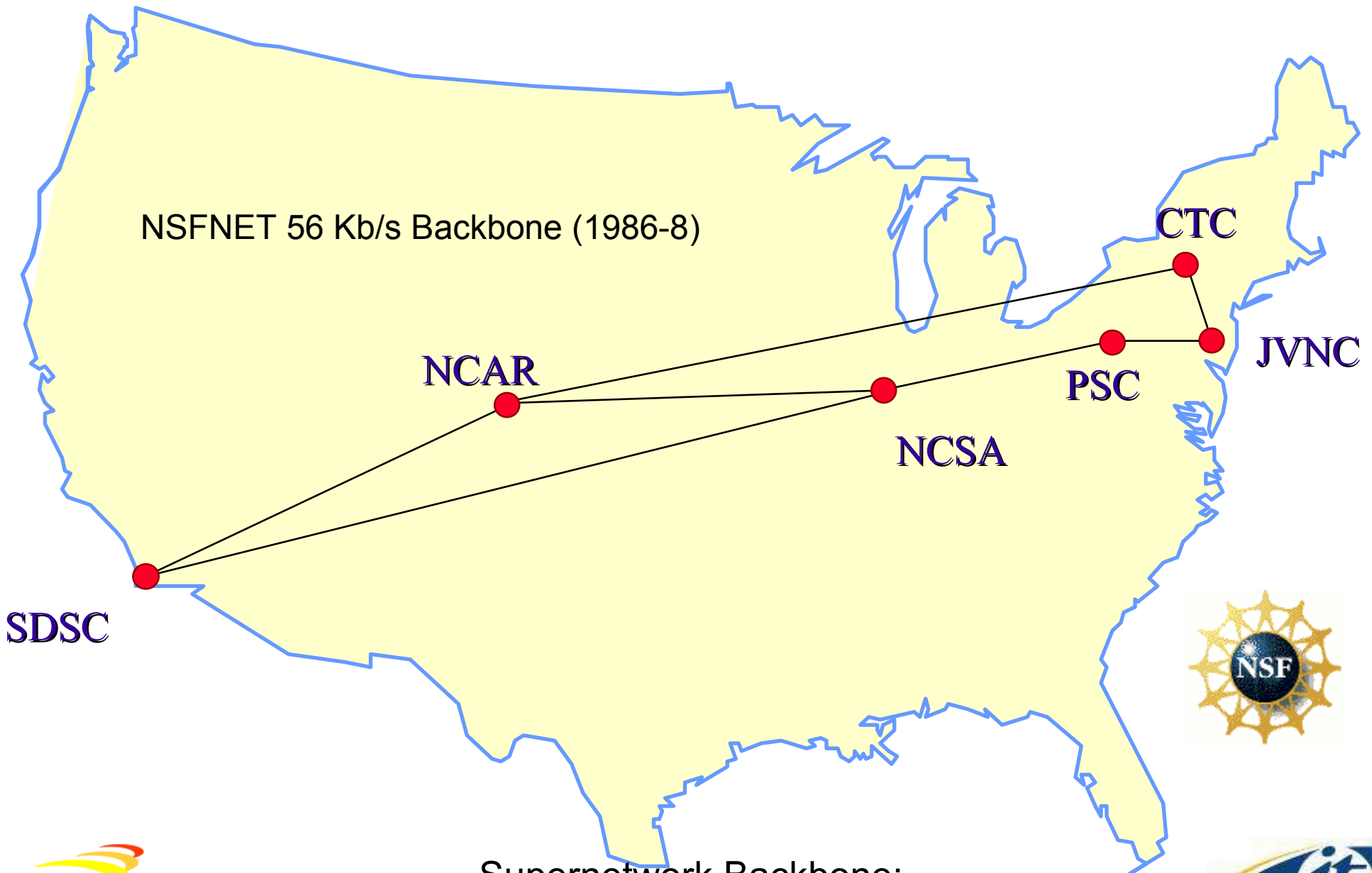


Source: Harry Dent, The Great Boom Ahead

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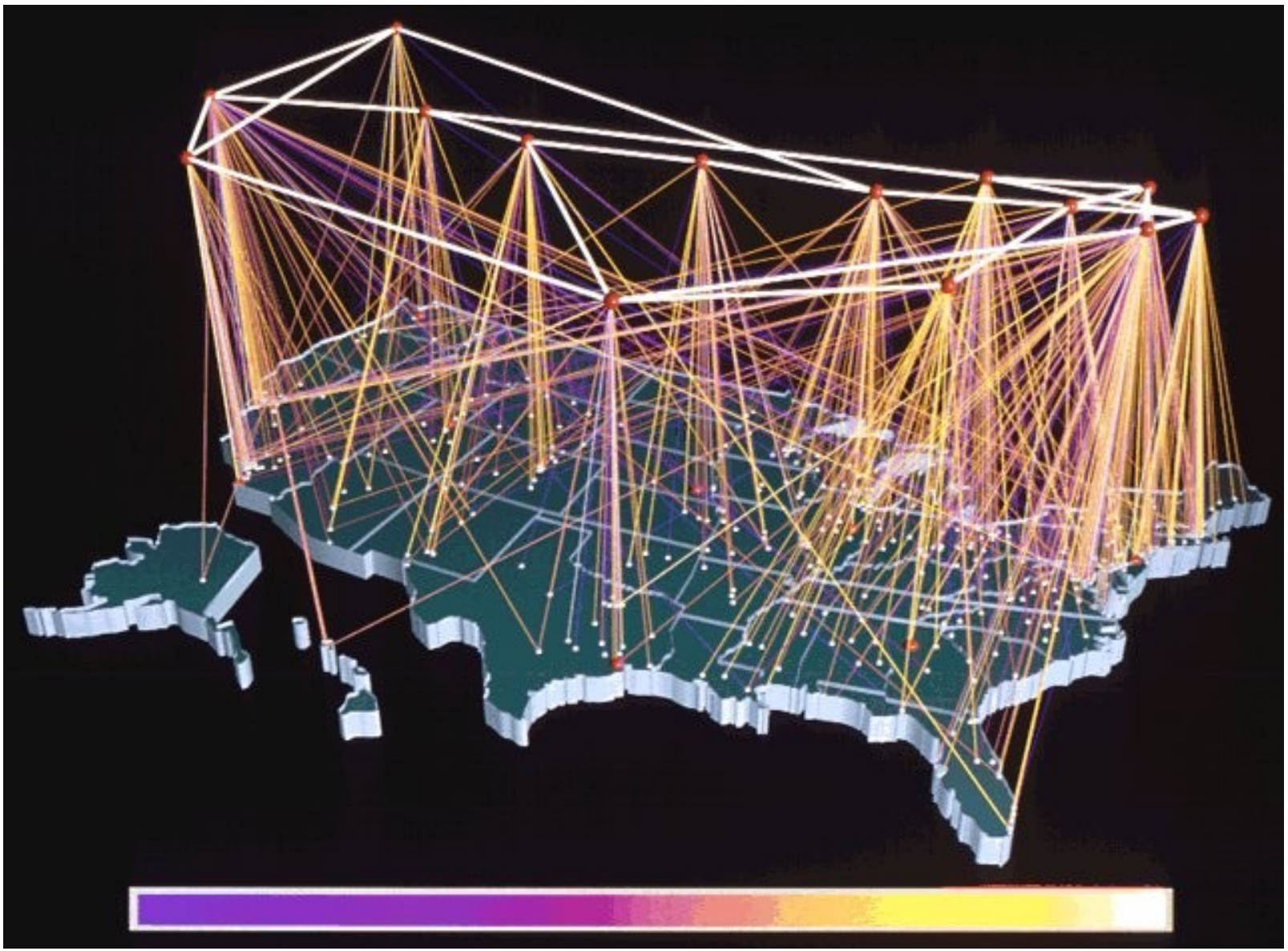
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Launching the Nation's Information Infrastructure: NSFnet Supernetwork and the Six NSF Supercomputers



Supernetwork Backbone:
56kbps is 50 Times Faster than 1200 bps PC Modem!

The NSFnet was Commercialized in 1995 Leading to Today's Internet



Visualization by NCSA's Donna Cox and Robert Patterson
Traffic on 45 Mbps Backbone December 1994

Fifteen Years from Bleeding Edge Research to Mass Consumer Market

- 1990 Leading Edge University Research Center-NCSA
  - Supercomputer GigaFLOPS Cray Y-MP ($15M)
  - Megabit/s NSFnet Backbone
- 2005 Mass Consumer Market
  - PCs are Multi-Gigahertz ($1.5k)
  - Megabit/s Home DSL or Cable Modem



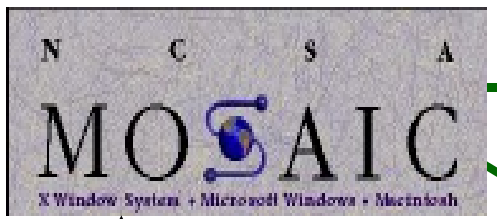
NSF Blue Waters Petascale Supercomputer (2011)
Will be Over 1 Million Times Faster than Cray Y-MP!
Enormous Growth in Parallelism
Processors: Y-MP 4, Blue Waters 200,000

OptIPuter

www.ncsa.uiuc.edu/BlueWaters/system.html

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An Unexpected Benefit of NSF Investments: *NCSA Mosaic* Led to the Modern Web World



Licensing → SPYGLASS → 100 Commercial Licensees

NCSA Programmers → NETSCAPE

1993

NCSA Collage

1990

Microsoft Internet Explorer 4.0

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

NSF

Source: Larry Smarr

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From Scientific Visualization of Supercomputing Science to Movie Special Effects







Computer Graphics
From NCSA to ILM





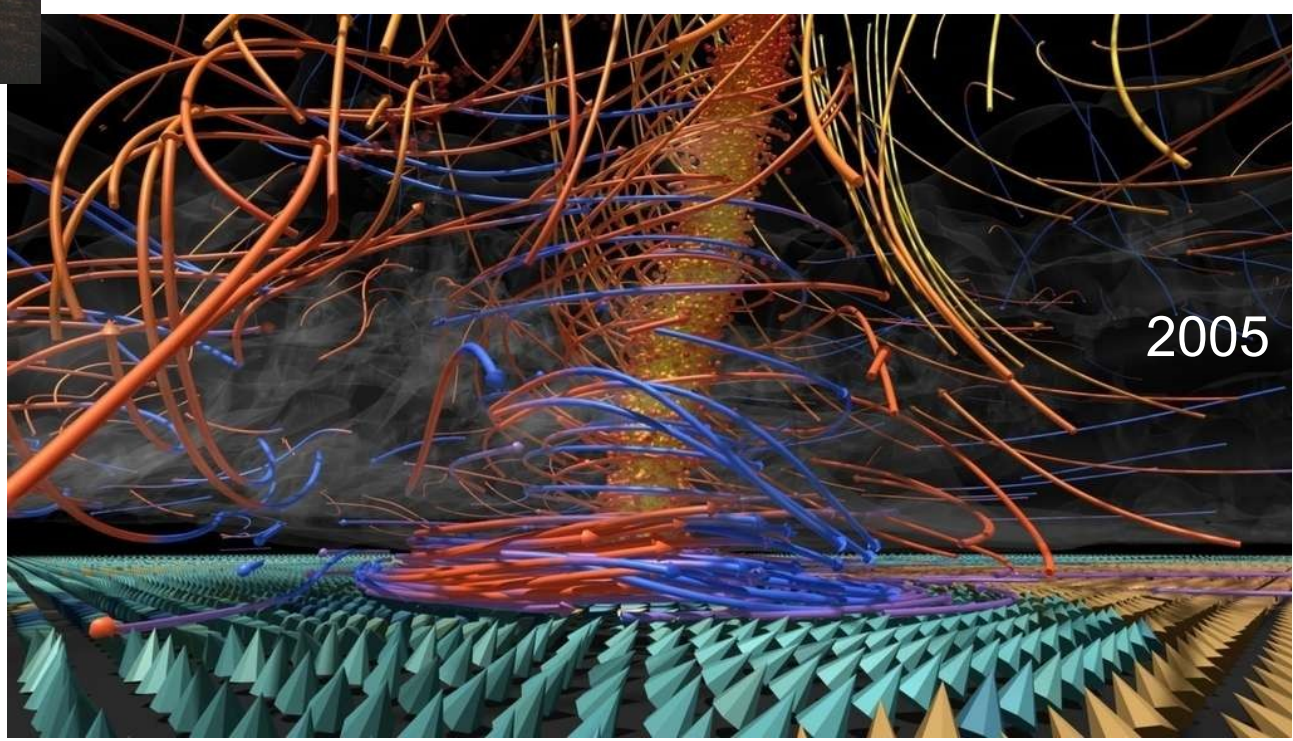


http://access.ncsa.uiuc.edu/
http://movies.warnerbros.com/twister
www.jurassicpark.com; www.jamescameron.org
www.cinemenium.com/perfectstorm/

Exponential Increases in Supercomputer Speed and Visualization Technology Drive Understanding and Applications



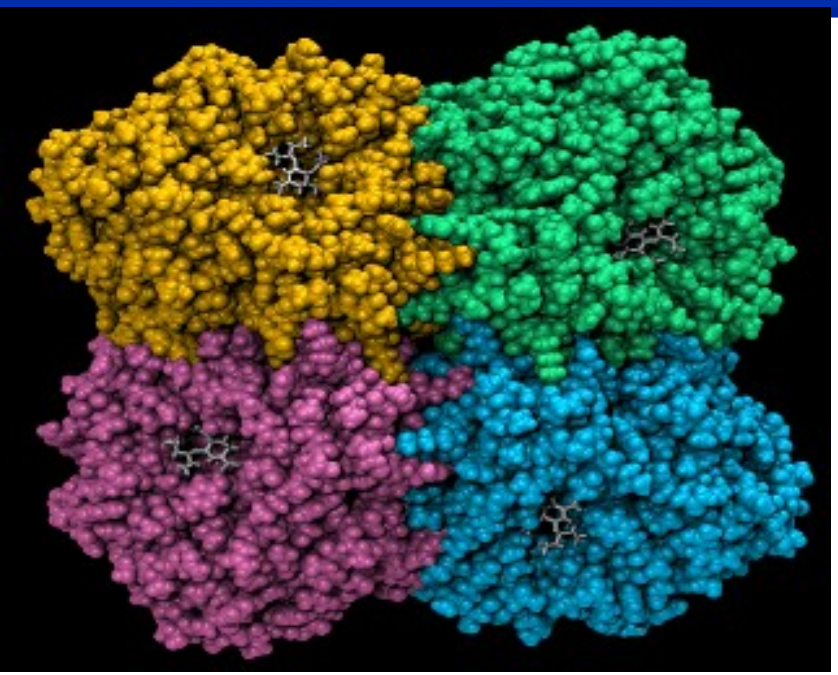
Showed Thunderstorms Arise
from Solving Physics Equations



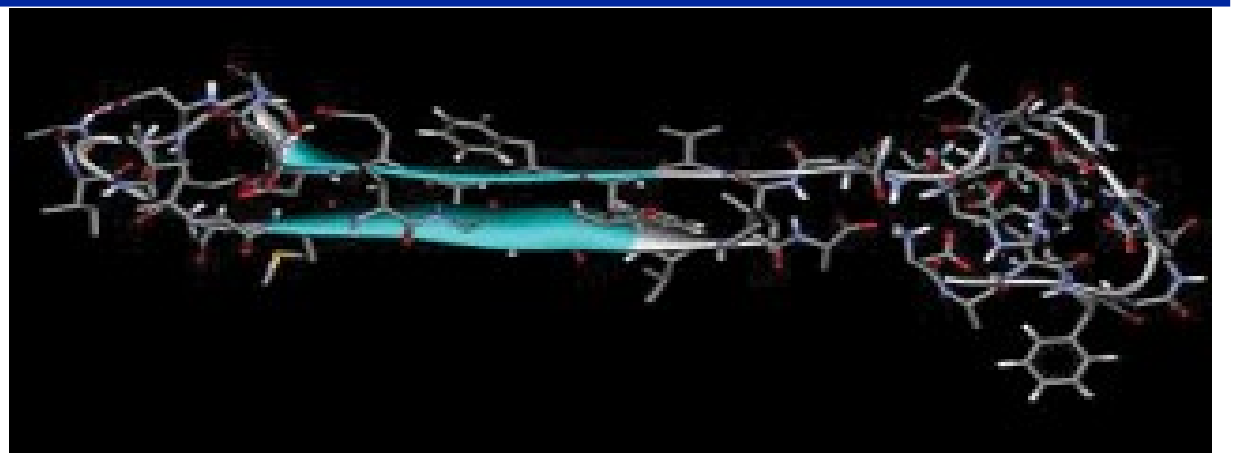
Vastly Higher Resolution
Uncovers Birth of Tornadoes

Source: Donna Cox, Robert Patterson, Bob Wilhelmson, NCSA

Frontier Applications of High Performance Computing Enabled by NSF's TeraGrid

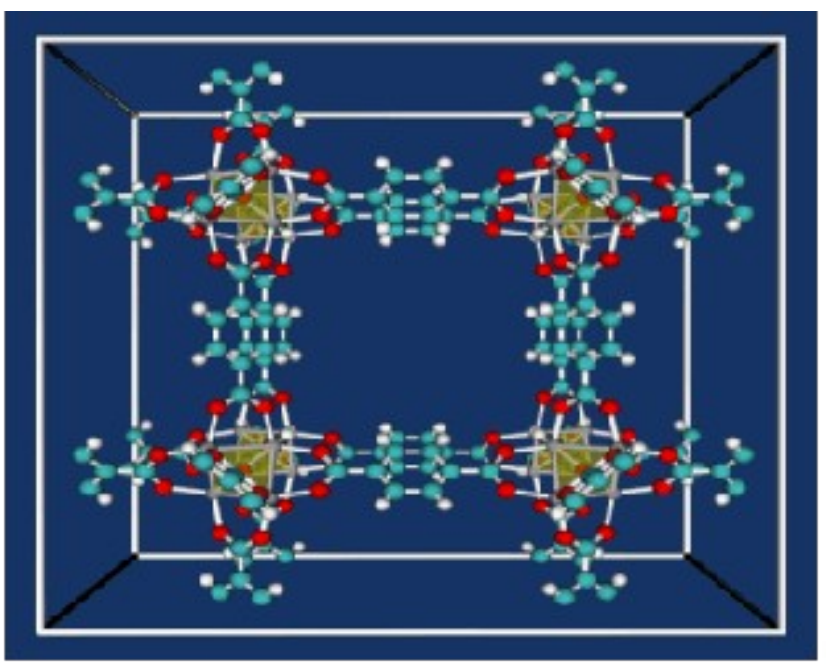


Designing Bird Flu Drugs



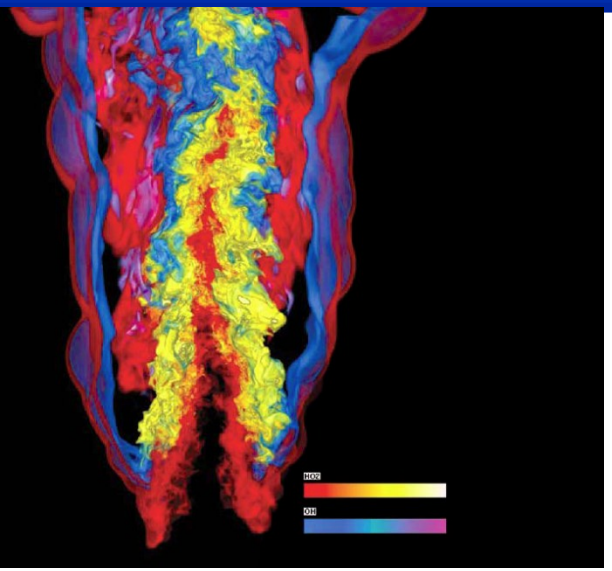
Investigating Alzheimer's Plaque Proteins



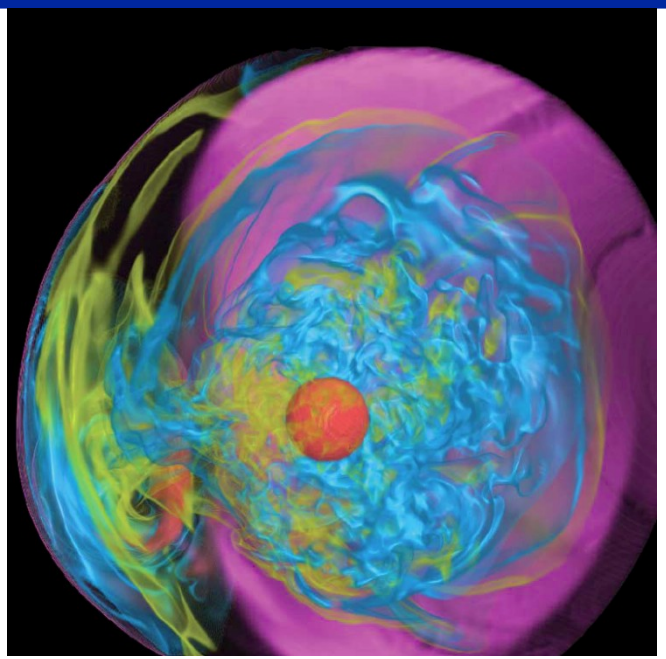


Improving Hydrogen Storage in Fuel Cells

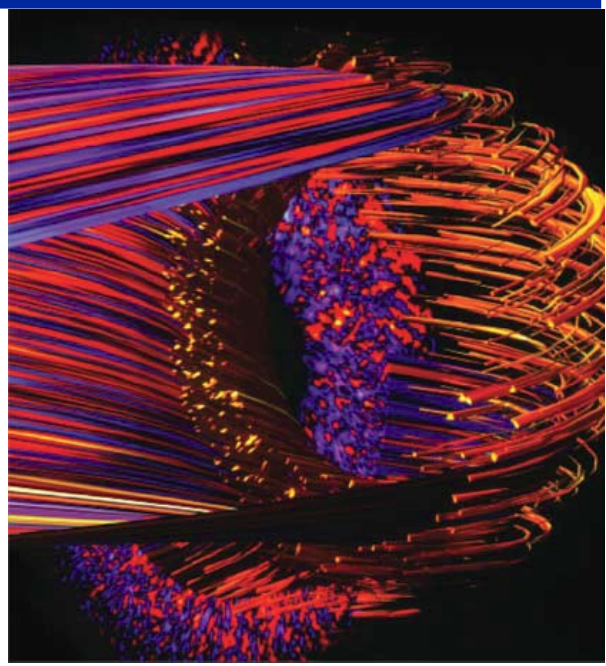
Department of Energy Office of Science
Leading Edge Applications of Petascale Computers



Flames

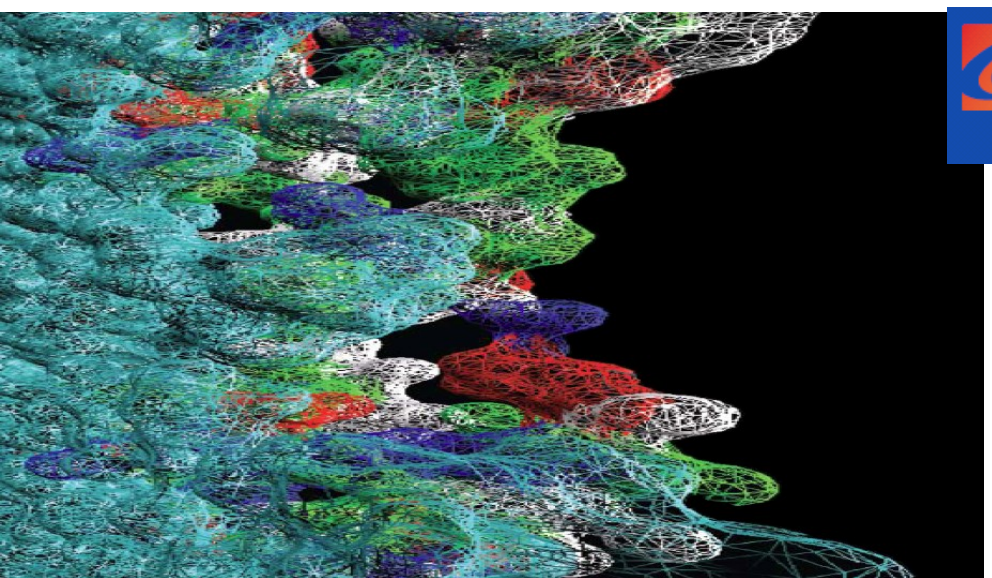


Supernova

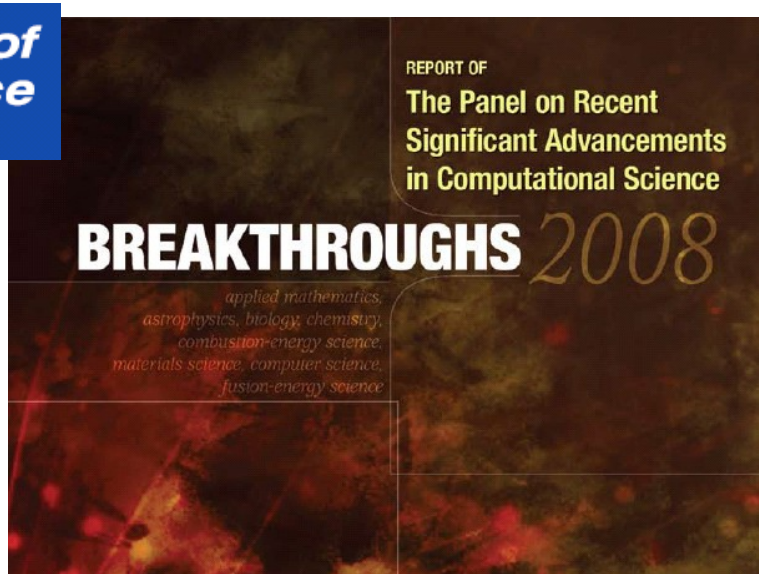


Fusion

Parkinson's



Office of Science
U.S. DEPARTMENT OF ENERGY

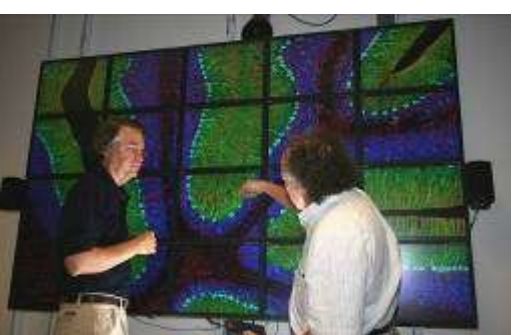


"Broadband" Depends on Your Application: Data-Intensive Science Needs Supernetworks









- **Mobile Broadband**
  - **0.1-0.5 Mbps**

100,000 Fold Range
All Here Today!

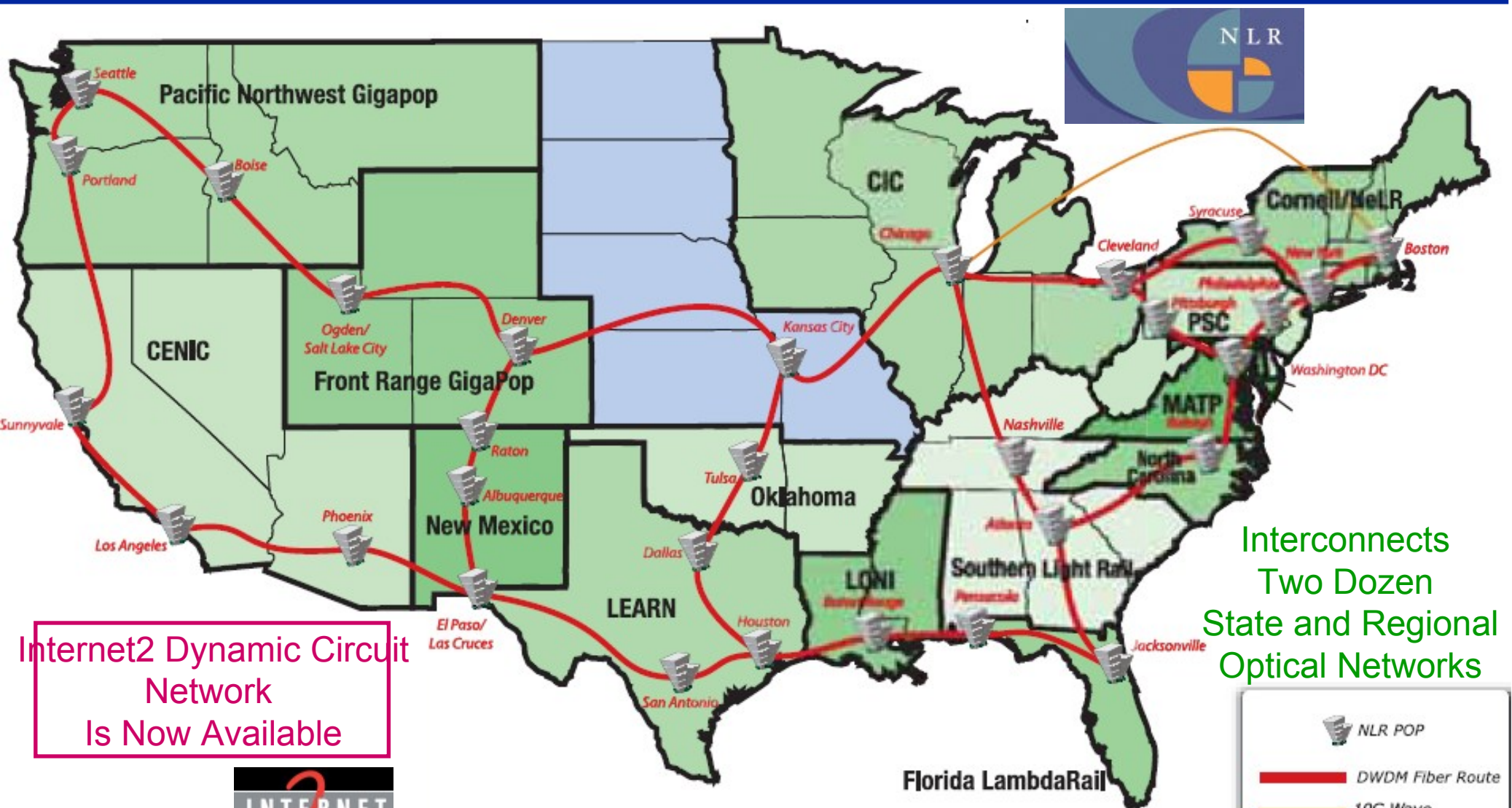
- **Home Broadband**
  - **1-5 Mbps**

"The future is already here,
it's just not evenly distributed"
William Gibson, Author of Neuromancer

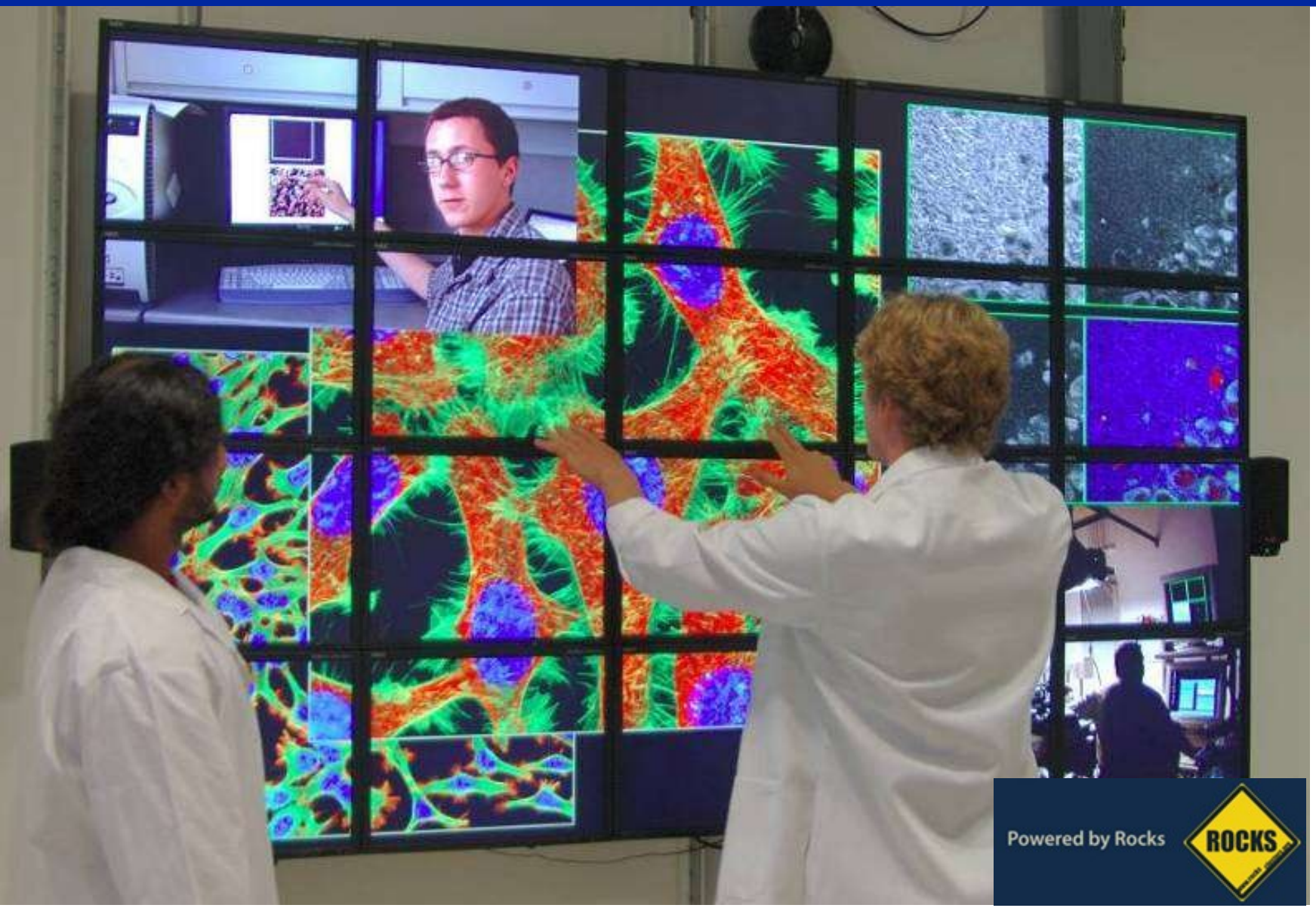
- **University Dorm Room Broadband**
  - **10-100 Mbps**

- **Dedicated Supernetwork Broadband**
  - **1,000-10,000 Mbps**

Dedicated 10,000Mbps Supernetworks Tie Together State and Regional Fiber Infrastructure



NSF's OptIPuter Project: Using Supernetworks to Meet the Needs of Data-Intensive Researchers



OptIPortal–Termination Device for the OptIPuter Global Backplane

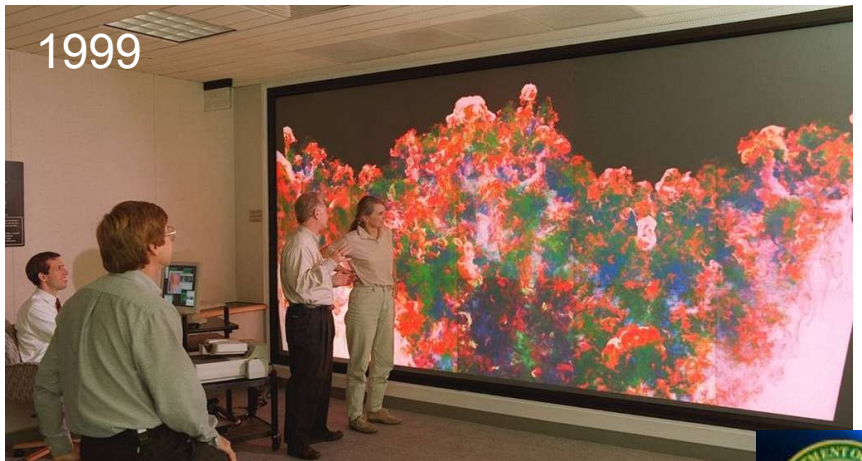
Powered by Rocks

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

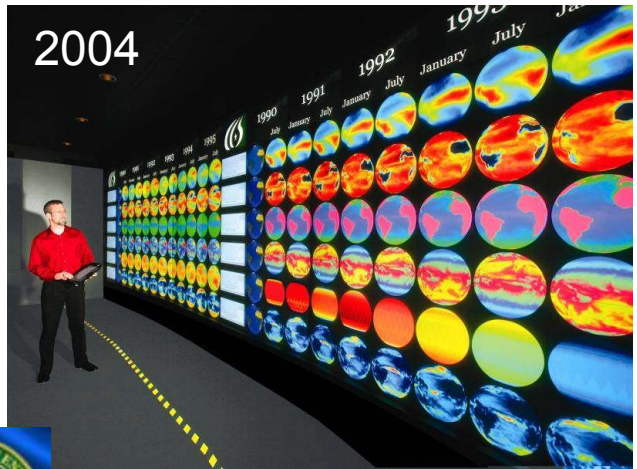
Challenge—How to Bring Scalable Visualization Capability to the Data-Intensive End User?



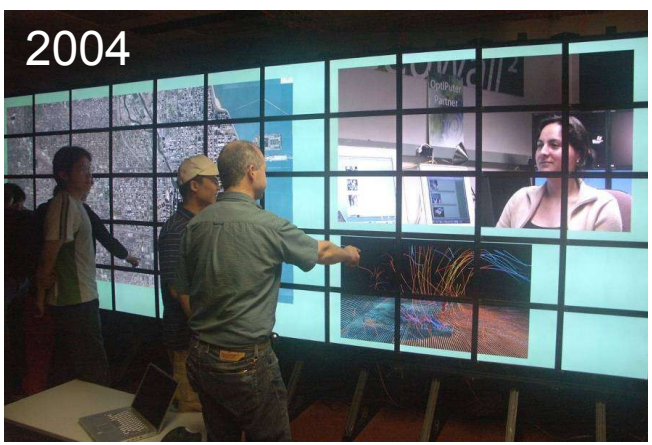
NCSA 4 MPixel
NSF Alliance PowerWall



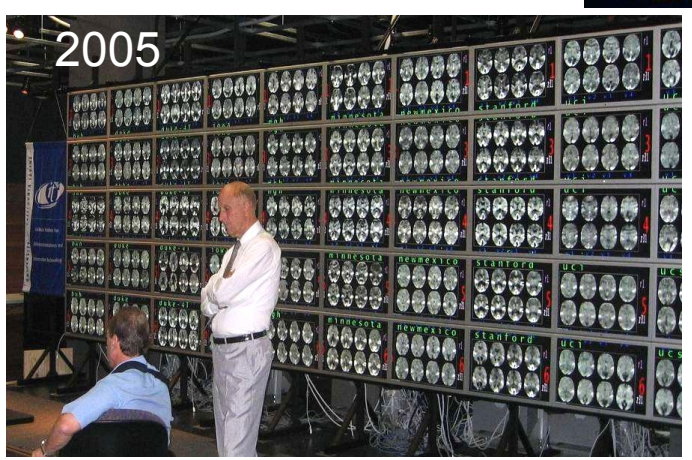
LLNL 20 Mpixel Wall



ORNL 35Mpixel EVEREST



EVL 100 Mpixel LambdaVision
NSF MRI



Calit2@UCI 200 Mpixel HiPerWall
NSF MRI



TACC 307 Mpixel Stallion
NSF TeraGrid

OptIPuter

NSF

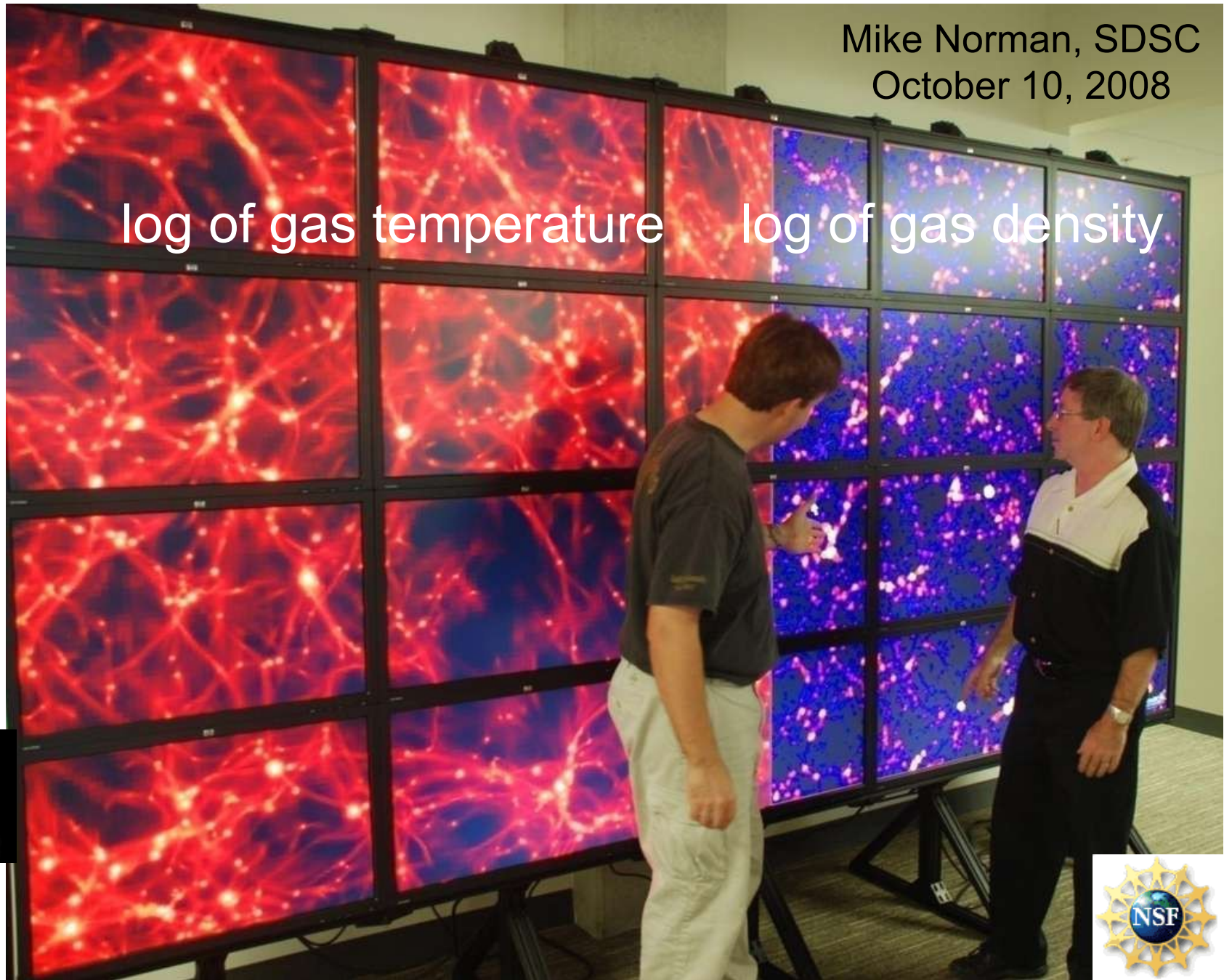
A Decade of NSF and DoE Investment--
Two Orders of Magnitude Growth!

it2

OptIPortals: Scaling up the Personal Computer For Supernetwork Connected Data-Intensive Users

SDSC
SAN DIEGO SUPERCOMPUTER CENTER

Two 64K Images From a Cosmological Simulation of Galaxy Cluster Formation



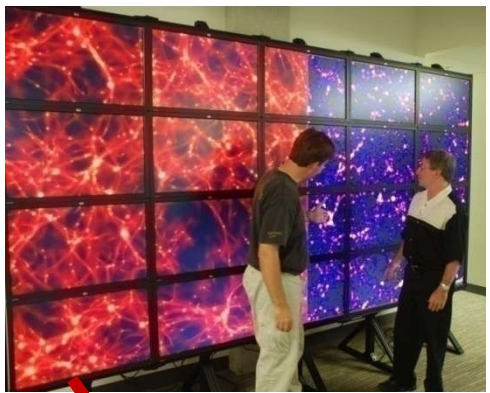
ROCKS
www.rocksclusters.org

CGLX

OptIPuter

NSF

The Data-Intensive Research "OptIPlatform" Backplane for Cyberinfrastructure: A 10Gbps Lightpath Cloud



End User OptIPortal



Instruments

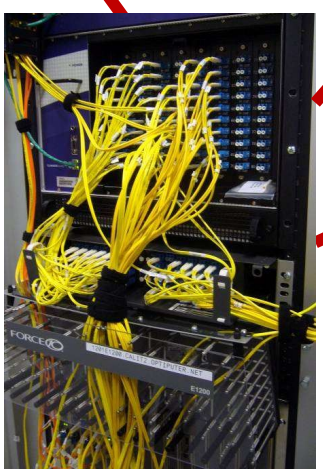


HD/4k Telepresence

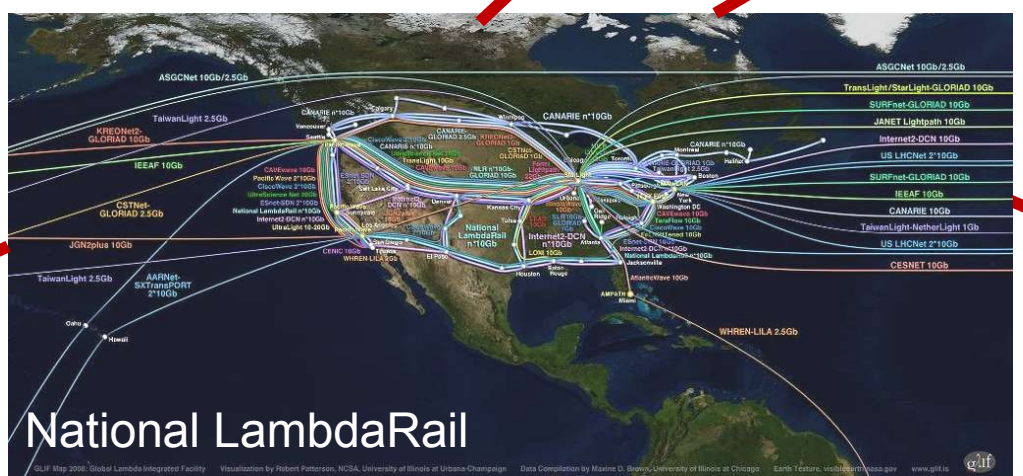


HD/4k Video Cams

HPC



10G Lightpath



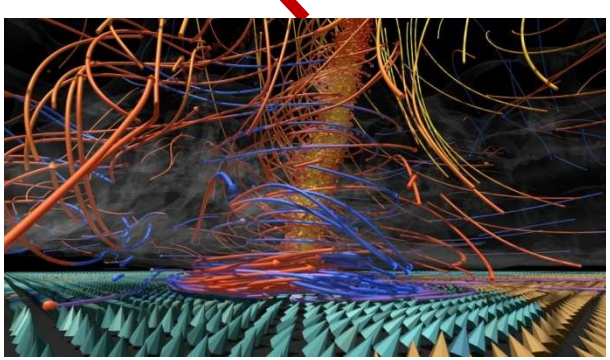
National LambdaRail

TeraGrid

Campus Optical Switch



Data Repositories & Clusters



HD/4k Video Images

OptIPuter

NSF

it2