“The Emerging National Technology Grid- Coupling Supercomputers, Networks, Virtual Reality to the Researchers Desktops”

1998 Annual Kansas Center for Advanced Scientific Computing Distinguished Lecture

University of Kansas

September 11,1998

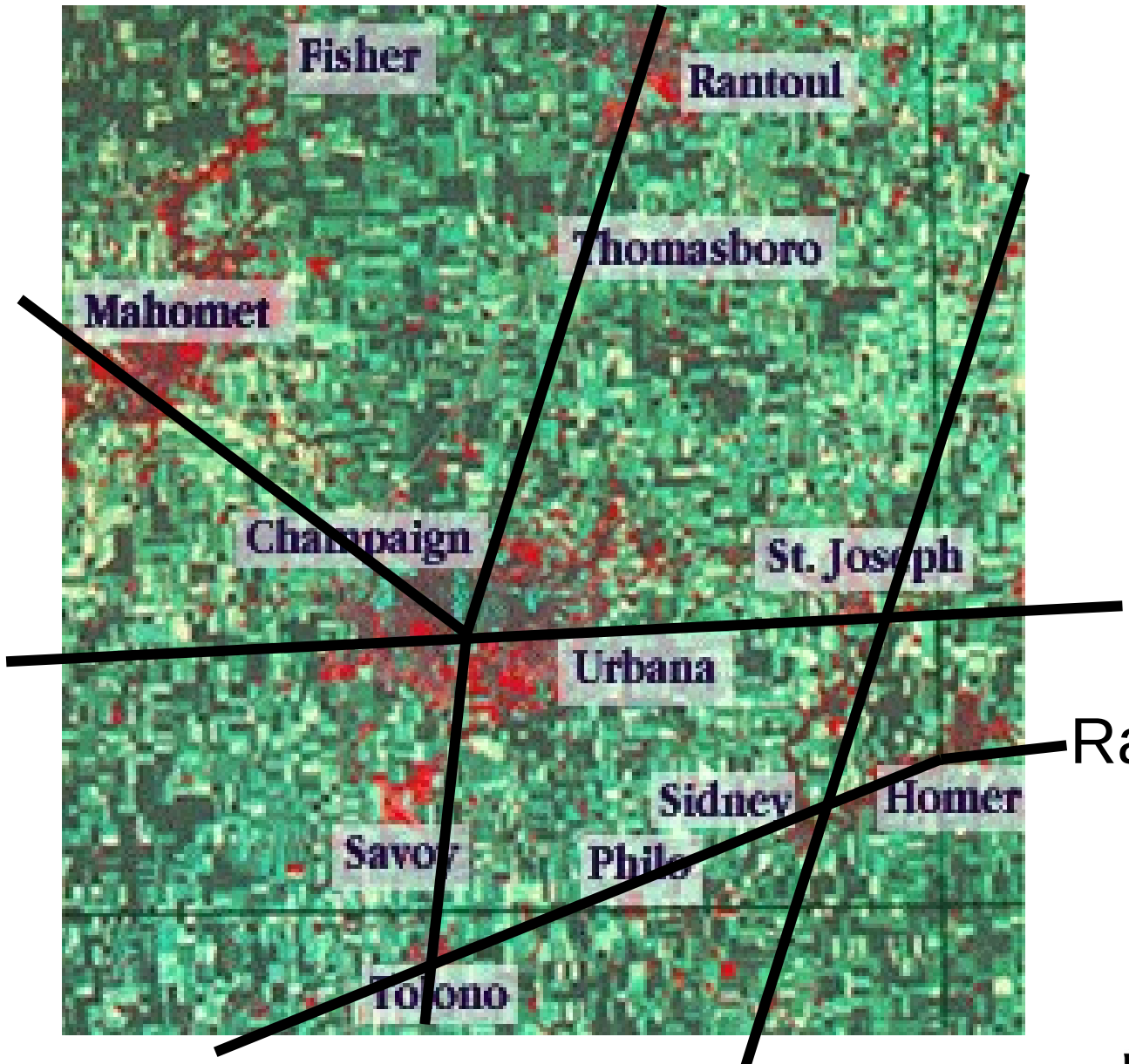
Dr. Larry Smarr

Director, National Computational Science Alliance and the National Center for Supercomputing Applications

Professor in the Departments of Physics and Astronomy

University of Illinois Urbana-Champaign

Infrastructure Leaves its Mark -- a Century Later

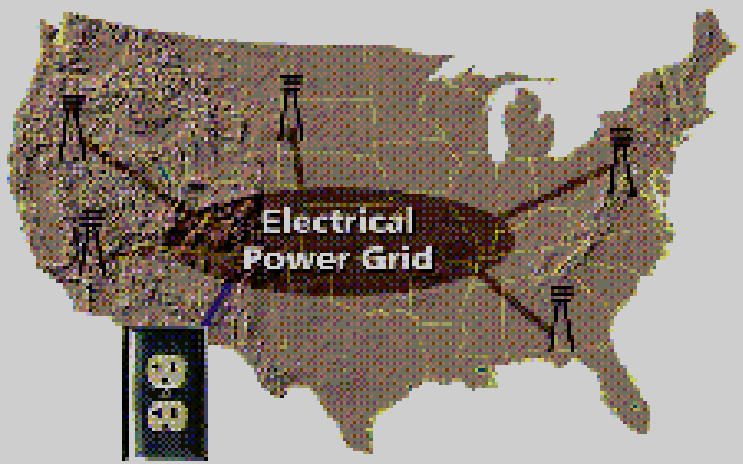


Why Is There Chicago? - Supernode on the Transportation Grid

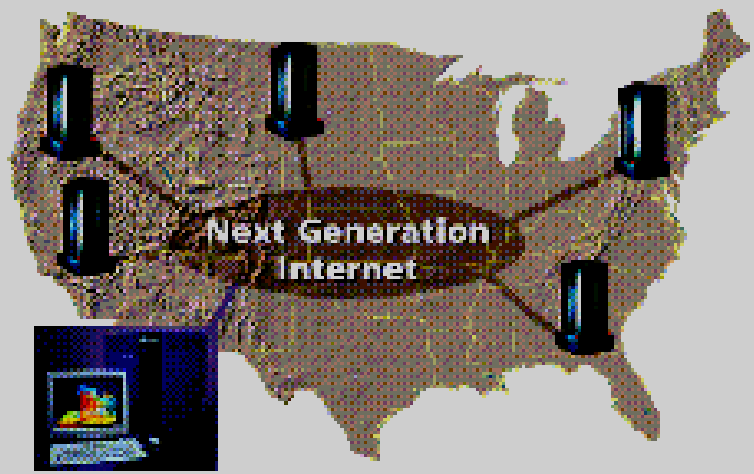
- **Railroad Infrastructure Required Caching**
  - **Grain**
  - **Livestock**
- **Caching Created Financial Markets**
  - **Board of Trade**
- **Retailing Center Emerges**
  - **Manufactured Goods Need Middleware**
  - **Inventory and Redistribution**
- **Today Air Transport, Telecom Supernode**
- Cronon, William. *Nature's Metropolis: Chicago and the Great West*

The Emerging Concept of a National Scale Information Power Grid

Imagine a national computing and information infrastructure that allowed everyone to access the information resources of the nation in much the same way that one accesses electrical power today; an "Information Power Grid"

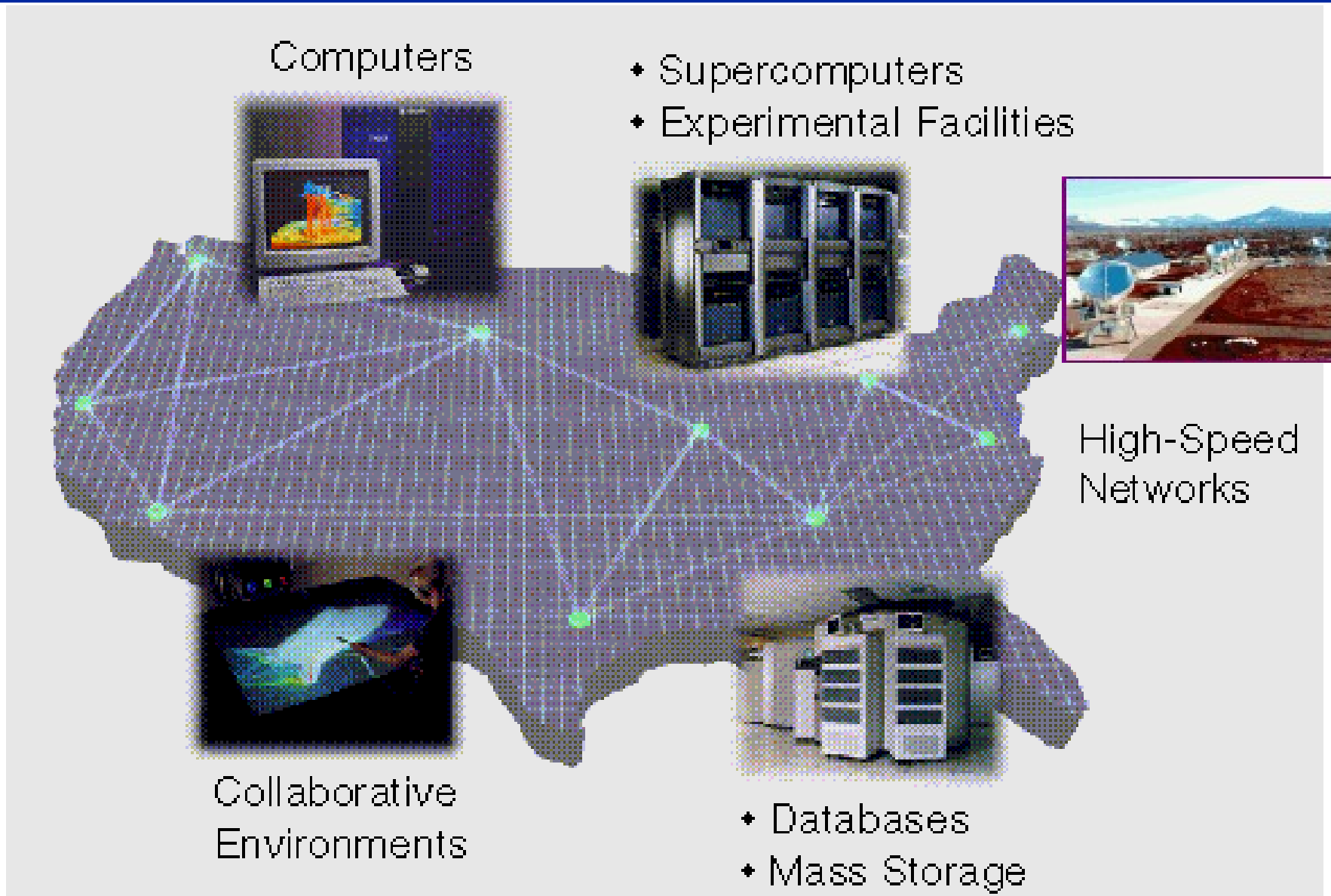


Your Electrical Power
Available Here



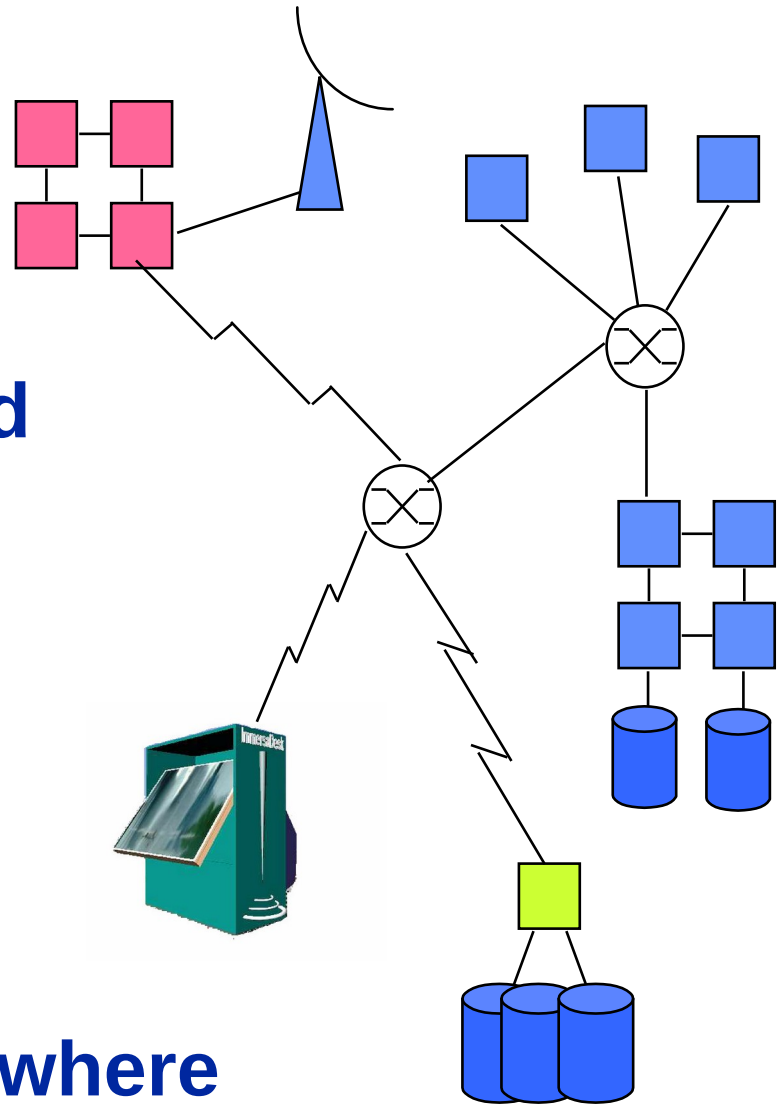
Your Information Power
Available Here

The Grid Links People with Distributed Resources on a National Scale



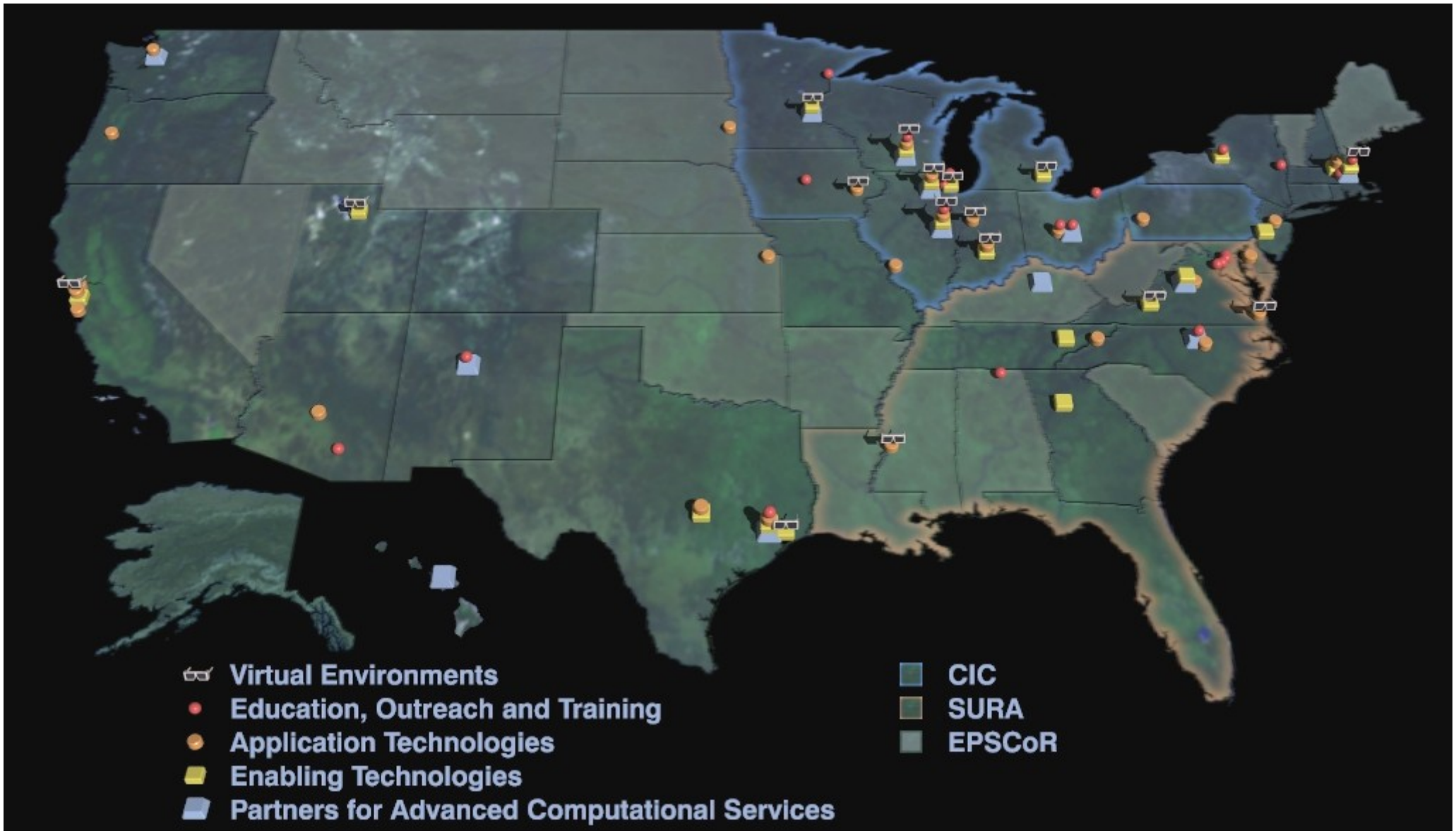
The Grid - *"Dependable, Consistent, Pervasive Access to [High-end] Resources"*

- **Dependable:**
  - Can Provide Performance and Functionality Guarantees
- **Consistent:**
  - Uniform Interfaces to a Wide Variety of Resources
- **Pervasive:**
  - Ability to "Plug In" From Anywhere



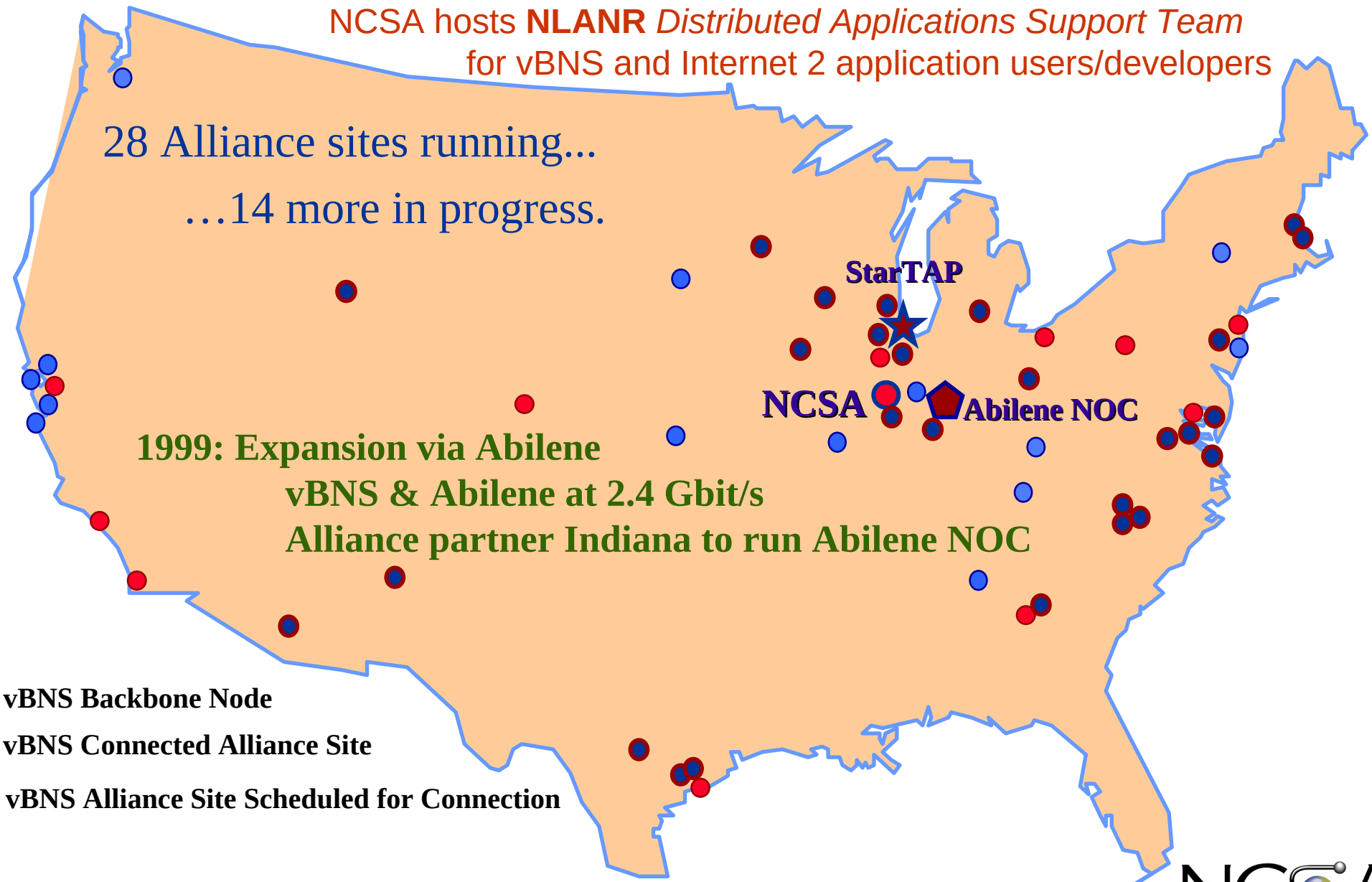
Source: Ian Foster, ANL

The NSF Alliance -Prototyping a National Scale Grid for the 21st Century



Assembling the Links in the Grid with NSF's vBNS Connections Program

NCSA hosts **NLANR** *Distributed Applications Support Team* for vBNS and Internet 2 application users/developers

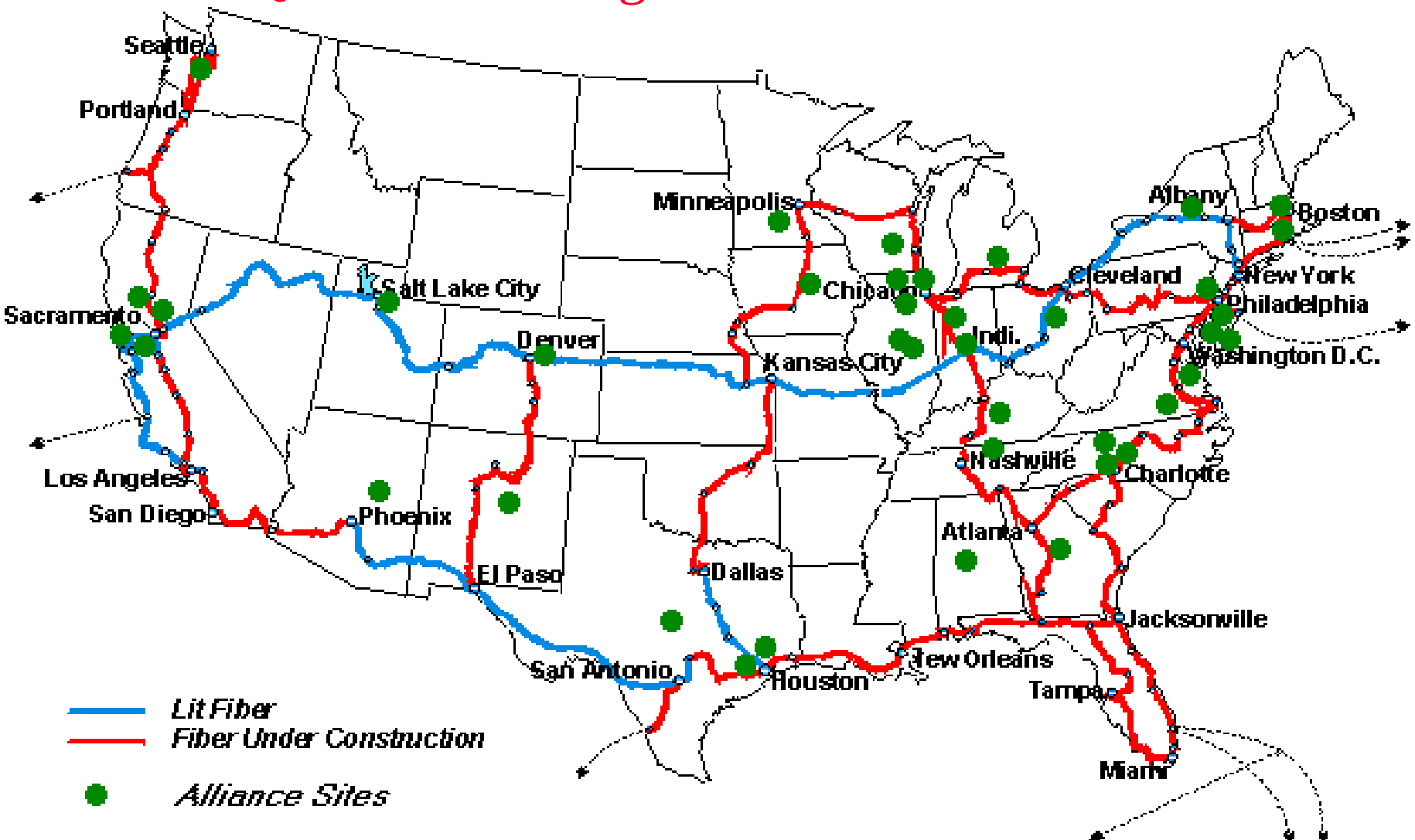


Source: Charlie Catlett, Randy Butler, NCSA Grid Team

NCSA™ National Computational Science Alliance

Qwest Nationwide Network - Backbone for Internet2 Abilene - More Links

Qwest Partnering with Cisco and Nortel

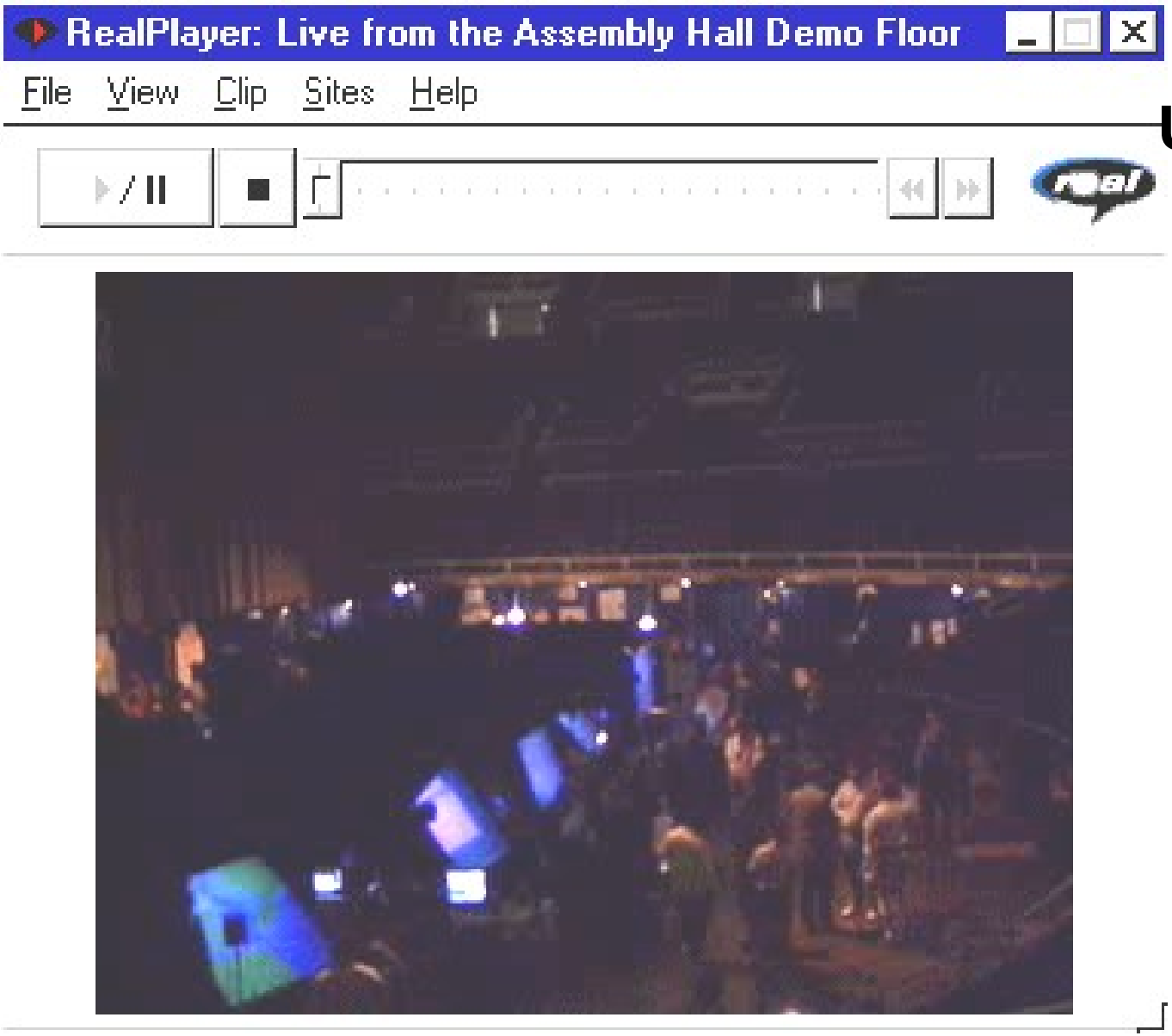


http://www.qwest.net/network/Mainmaps.html

Source: Randy Butler, NCSA

National Computational Science Alliance

Alliance‘98 Hosts 1000 Attendees With Hundreds On-Line!



April 1998 at UIUC Assembly Hall

All Speeches are Archived as WebCasts

http://alliance.ncsa.uiuc.edu/alliance98/Proceedbbings/Webcasts.html

Grid Enabled
Workshop and Training Facilities



Being Deployed Across the Alliance

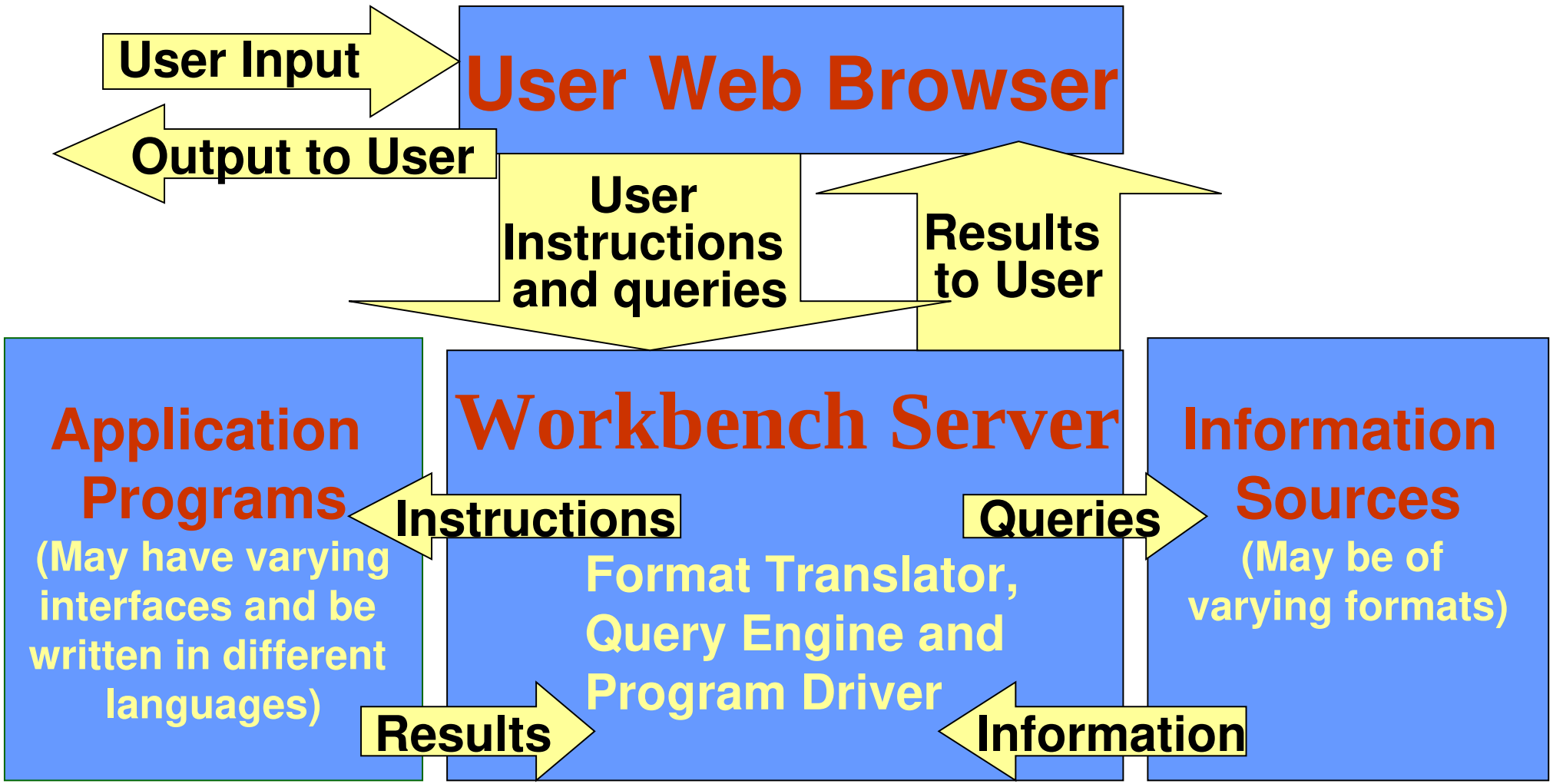
Jason Leigh and Tom DeFanti, EVL; Rick Stevens, ANL

Supercomputers, Networks, and Virtual Reality -- Computational Science Reaches 80 Million People

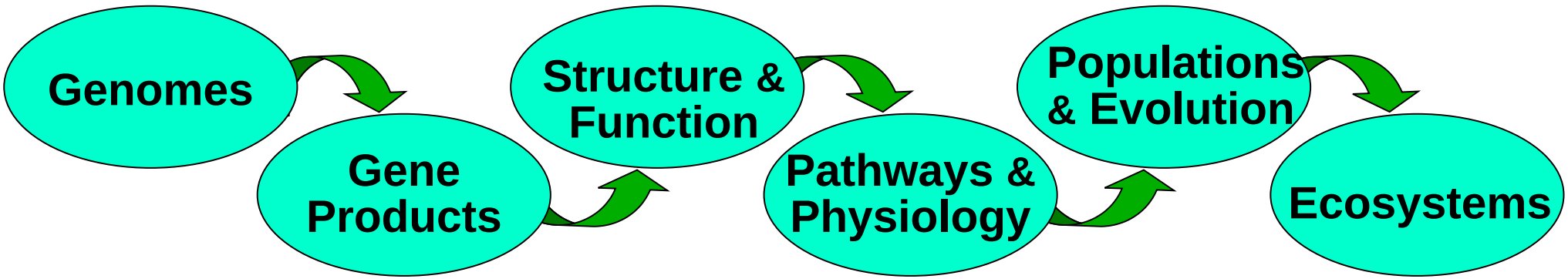


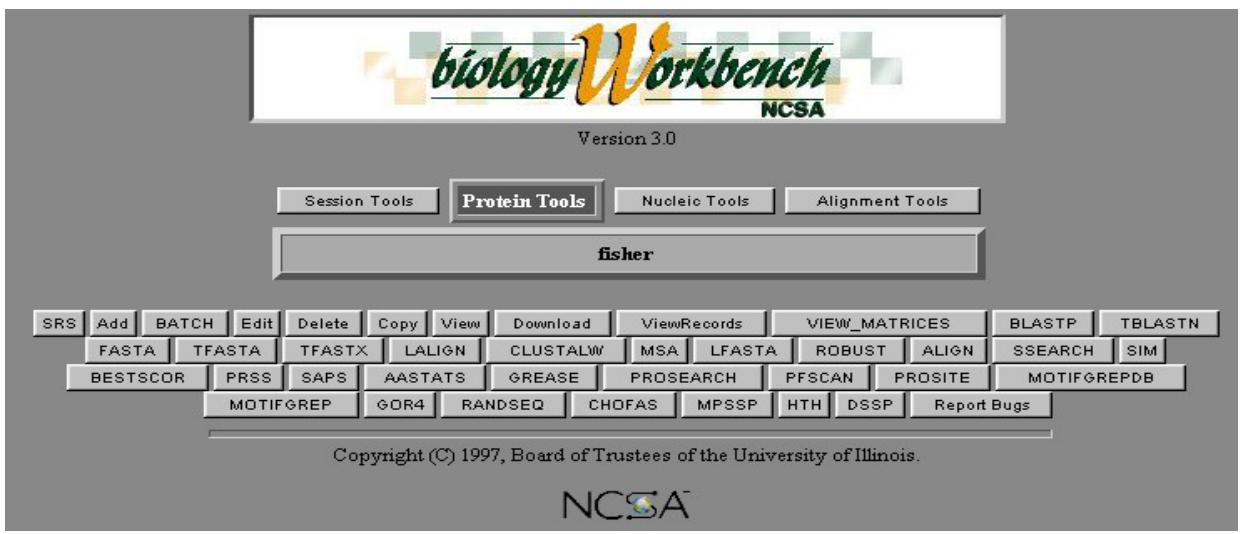
Colliding Galaxies (Smithsonian IMAX)-Donna Cox, Bob Patterson, NCSA-From "Cosmic Voyage"-Nominated for Academy Award 1997

The NCSA Information Workbench - An Architecture for Web-Based Computing



Using a Web Browser to Run Programs and Analyze Data Worldwide

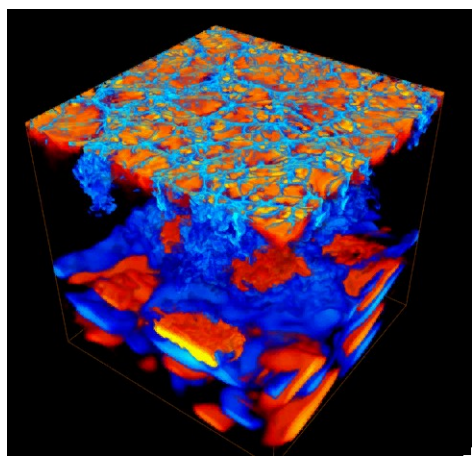
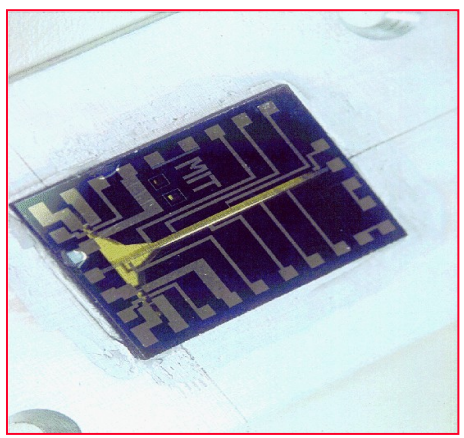
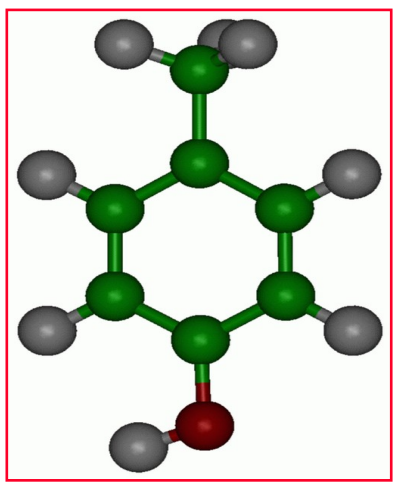




NCSA Biology Workbench
Has Over 6,000 Users From Over 20 Countries

Alliance Chemical Engineering Team
Developing the Chemical Engineer's Workbench

Couple Supercomputer Models
For All These Scales Together

O(km) O(m) O(cm) O(nm)

Access From a Web Browser!

Using the Grid to Optimize Chemical Plant Operations



Measurements and Experimental Design

Process Data

Parameter Estimation

Process Model

Plant-wide Control

Control Signals

Process

Grid Coupling:
- Sensors
- Networks
- Data
- HPC Models
- Controls

Goal-Create Collaborative Interface to Link Multiple Investigators With the Grid

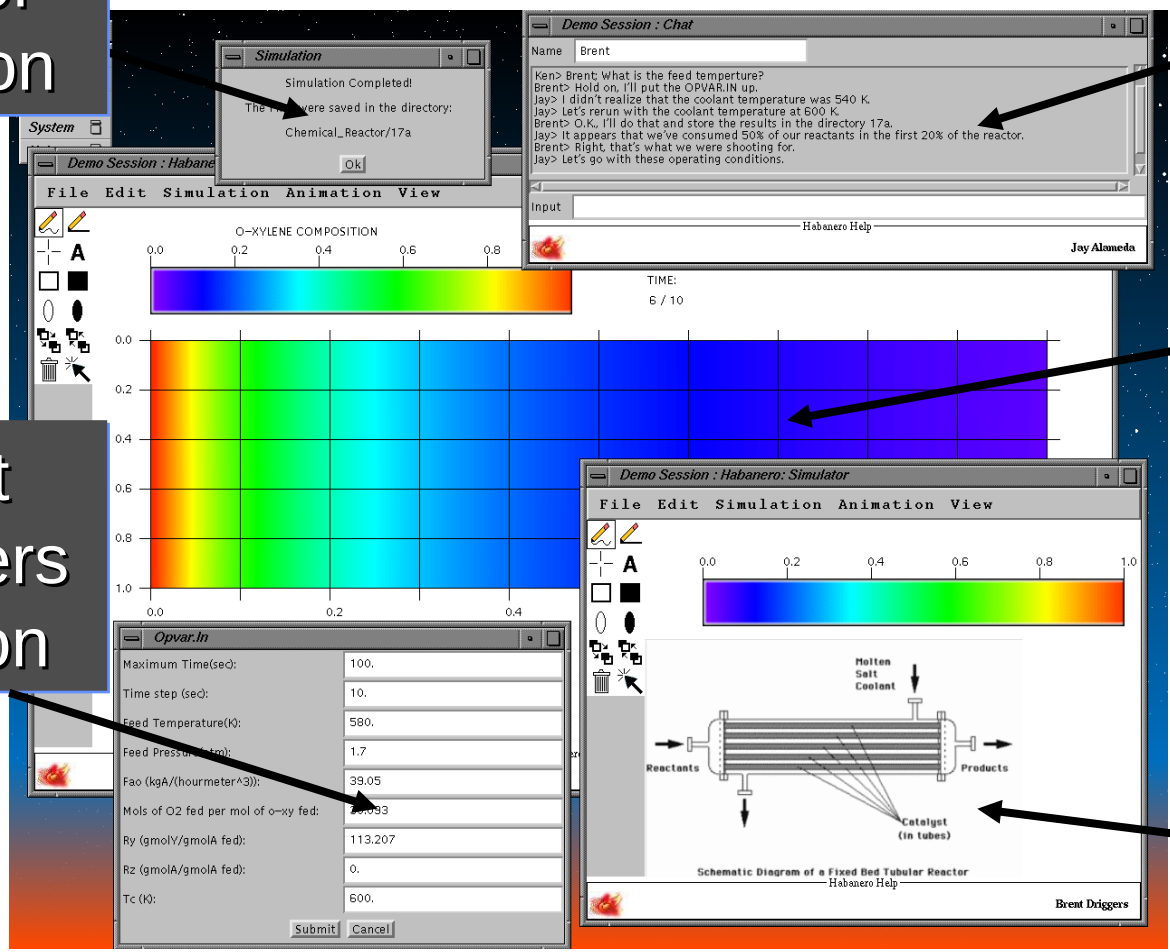
Status of Simulation

Interactive Discussion

Detailed Visualization

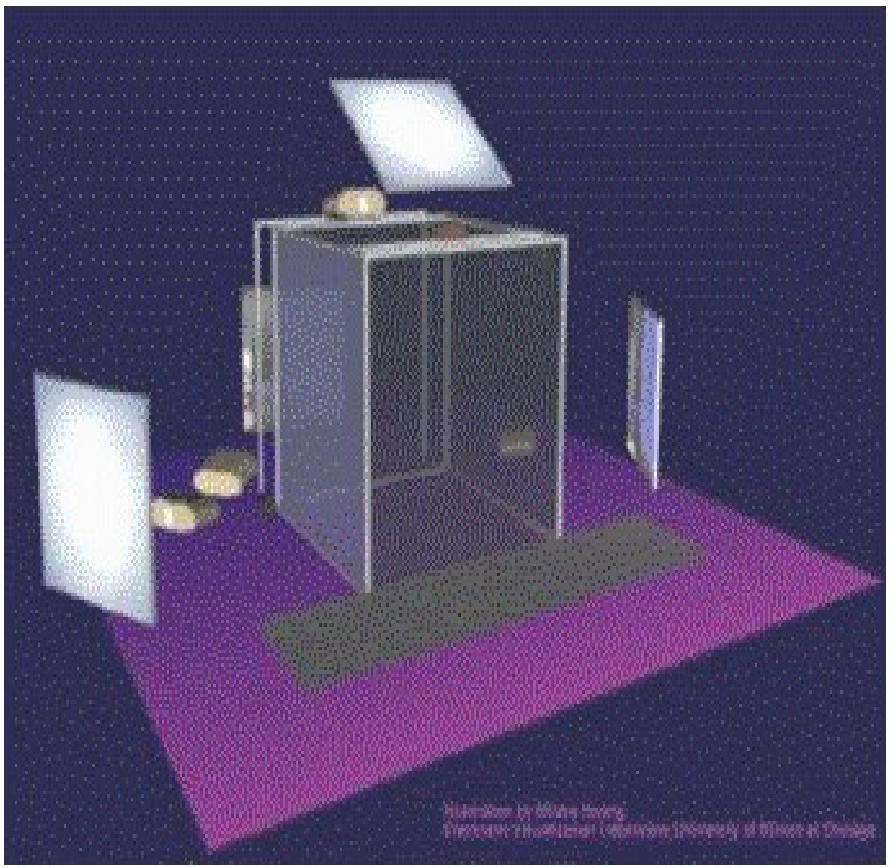
Current parameters in solution

Reactor Simulation

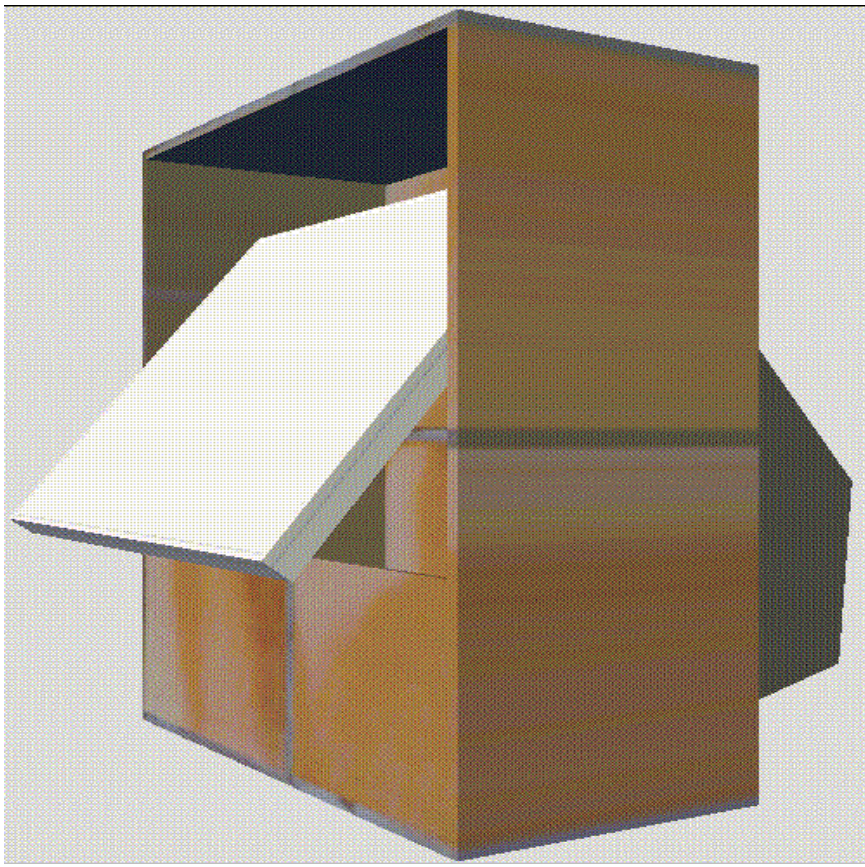


Ken Bishop, U Kansas Using NCSA Habanero

The Killer Application for the Grid - Collaborative Tele-Immersion



CAVE

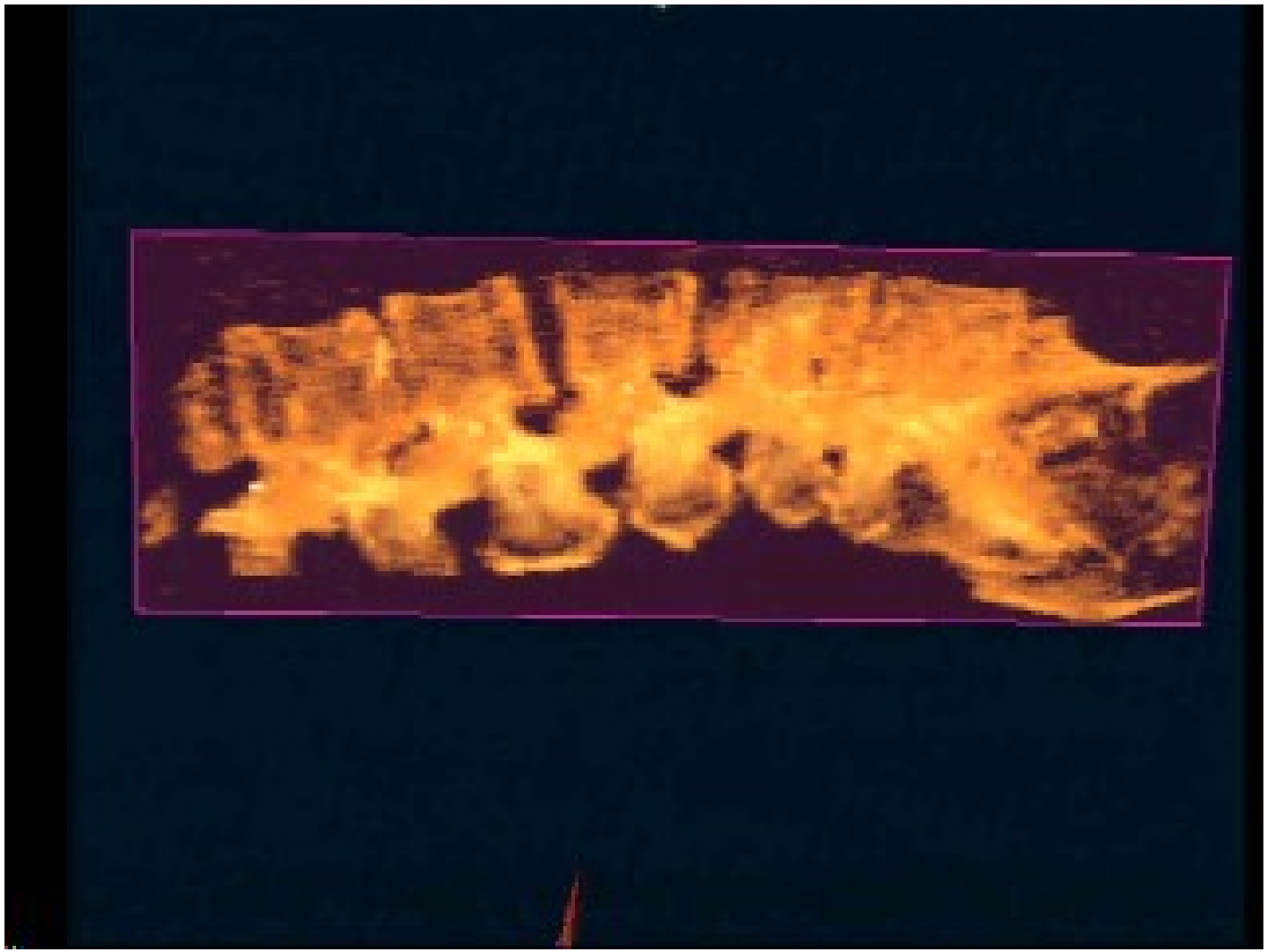


ImmersaDesk

Different Physical Implementations of the Alliance CAVE Software Libraries

Image courtesy: Electronic Visualization Laboratory, UIUC

Toward Remote Medical Analysis - Human Spine CAT Scan Data in the CAVE

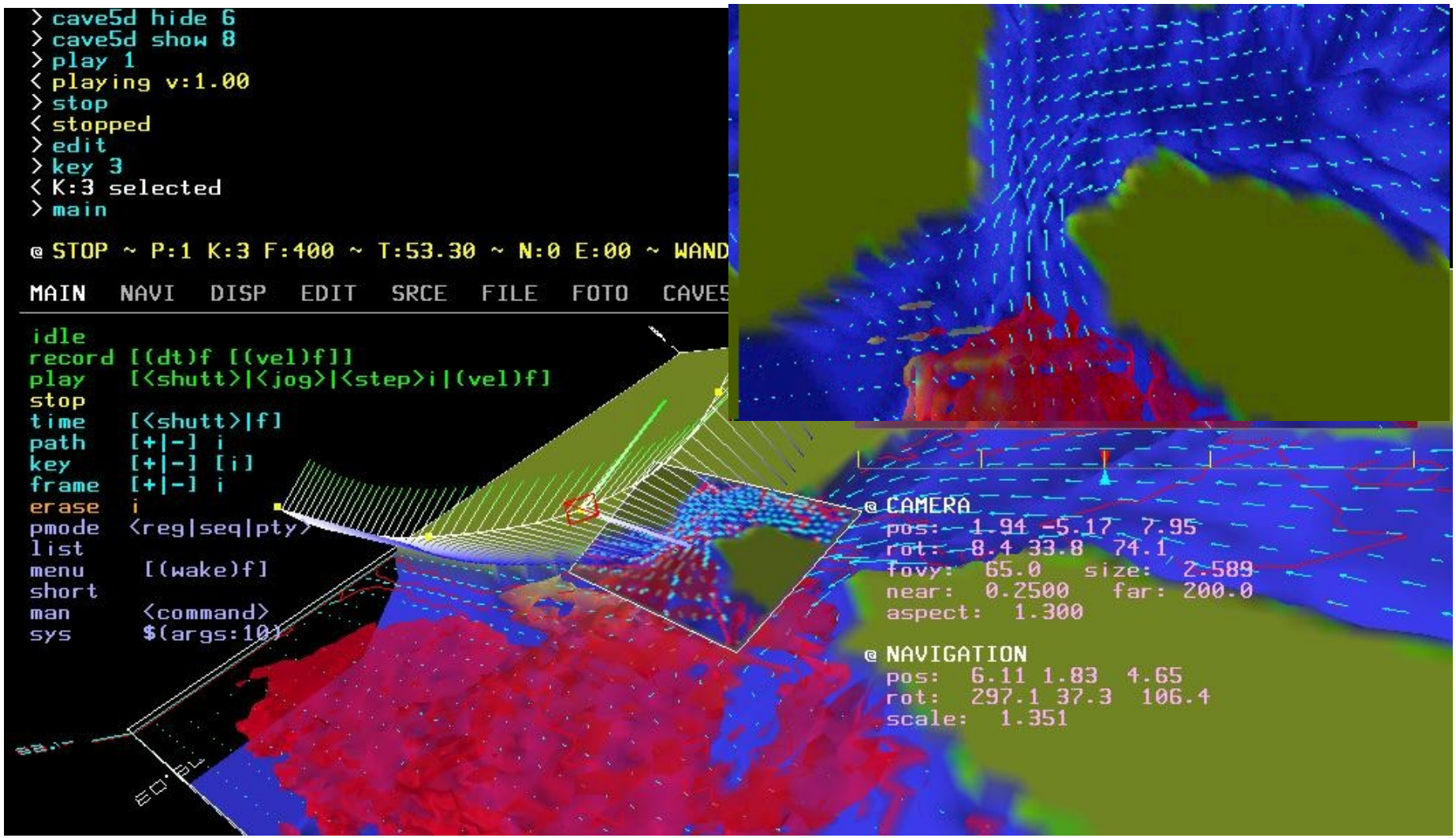


LBL: Tom Budinger, Thomas Schoenemann, Jonathan Maltz
NCSA: Rachael Brady, Clint Potter

Alliance Scientific Instrument Team

NCSA™
National Computational Science Alliance

Goal-Analyze and Record Complex Data sets Using Interactive Virtual Environments

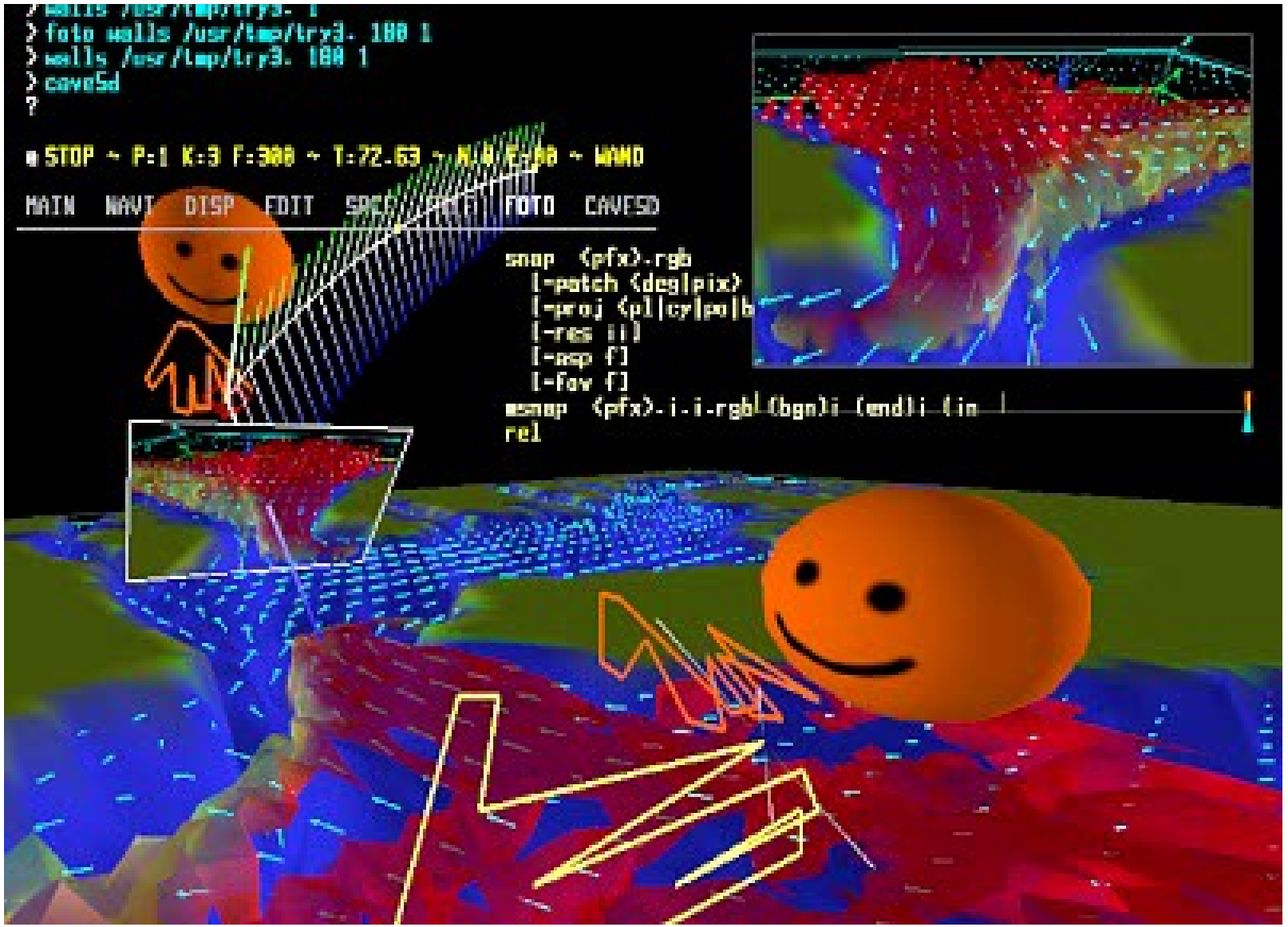


Cave5d Enables Interactive Visualizations of Time-Varying, 3-Dimensional Vis5d Data Sets in CAVE Environments

Donna Cox, Robert Patterson, Stuart Levy, Marcus Thiebaux, Virtual Director Team
Glenn Wheless, Cathy Lascara, Old Dominion Univ.

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National Computational Science Alliance

Avatars Show Head & Hand Pointing in Shared Virtual Space



Donna Cox, Robert Patterson, Stuart Levy

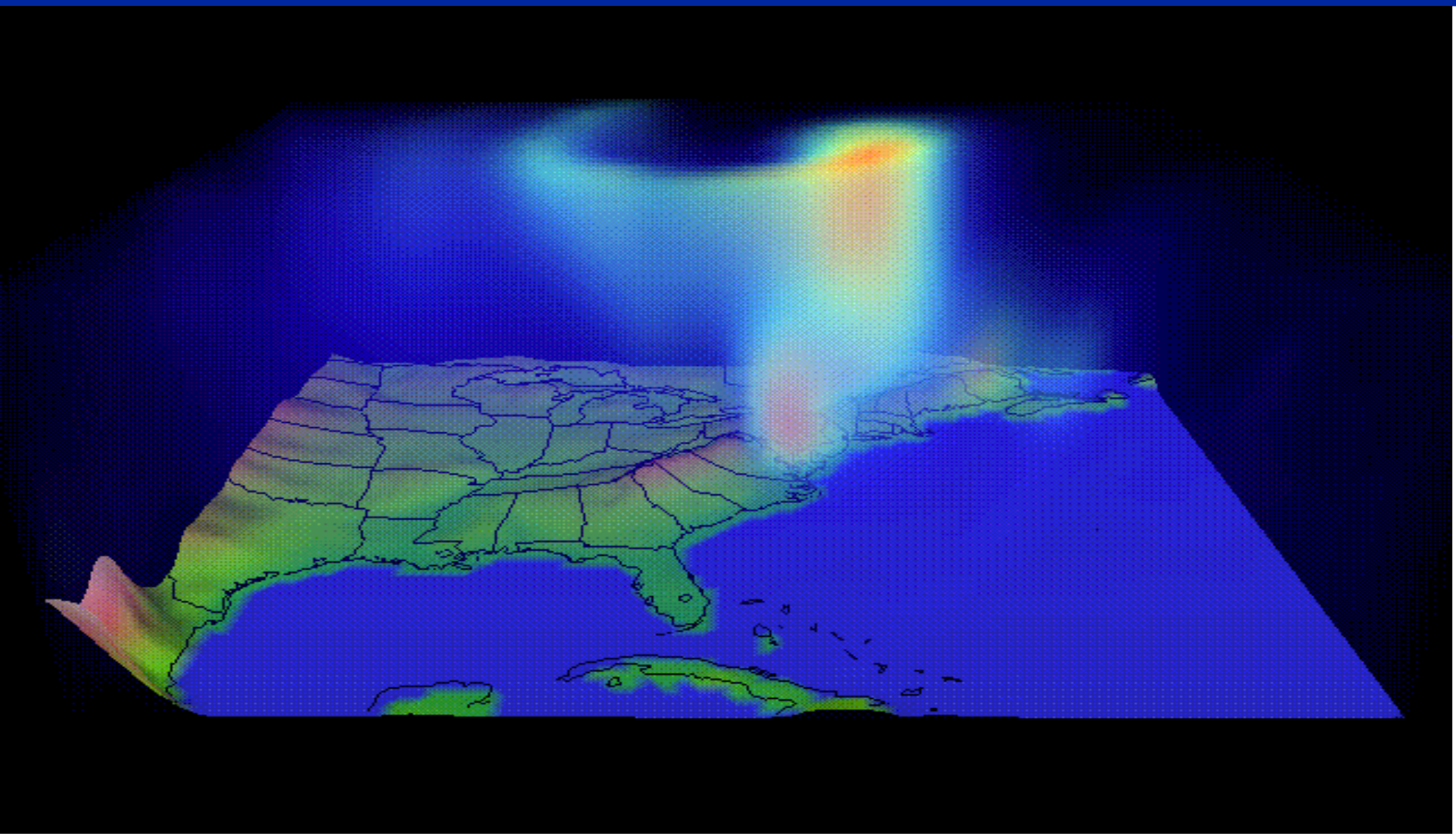
Goal-Create Shared Virtual Environment

CVD -- Collaborative Virtual Director



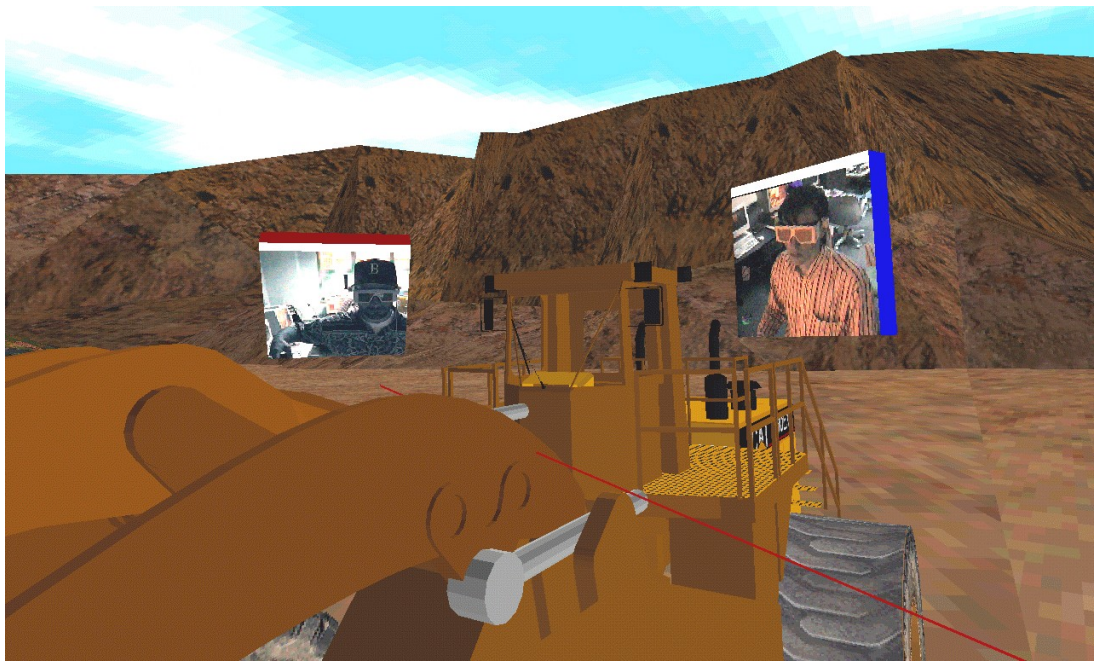
Donna Cox, Robert Patterson, Stuart Levy, NCSAVirtual Director Team
Glenn Wheless, Old Dominion Univ.

Goal-Linking the CAVE to the Desktop: Collaborative Java3D



Standalone or CAVE-to-Laptop-Collaborative

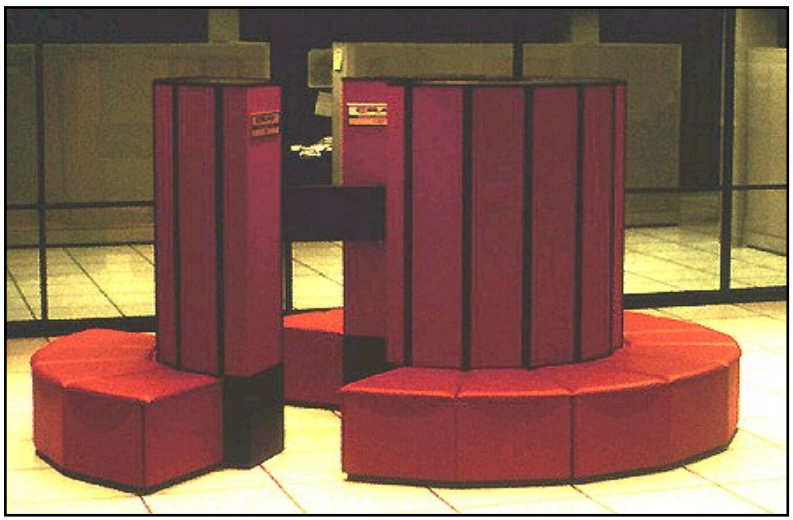
A Working Model-Caterpillar's Collaborative Virtual Prototyping Environment





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

The Continuing Exponential Agent of Change



1985

Cray X-MP Supercomputer

Located at National Center

Cost: $8,000,000

No Built in Graphics

56 kbps NSFnet Backbone

1998



Personal Computer

Located on Desktops

Cost: $2,000

Interactive 3D Graphics

56 kbps Modem to Home

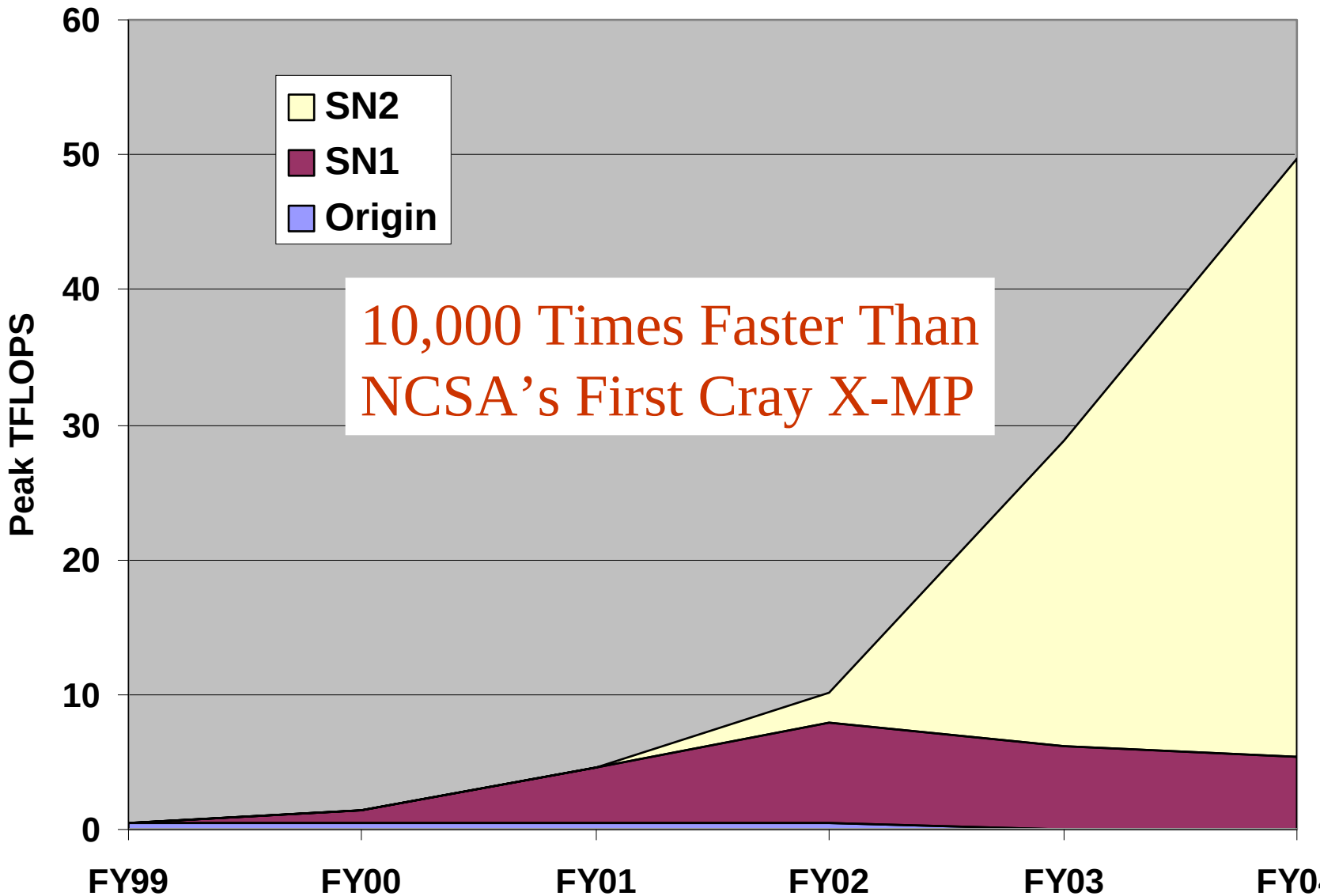
Supernodes on the Grid - When You Need 100x the Power of Your PC



NCSA Origin Supercomputer Cluster

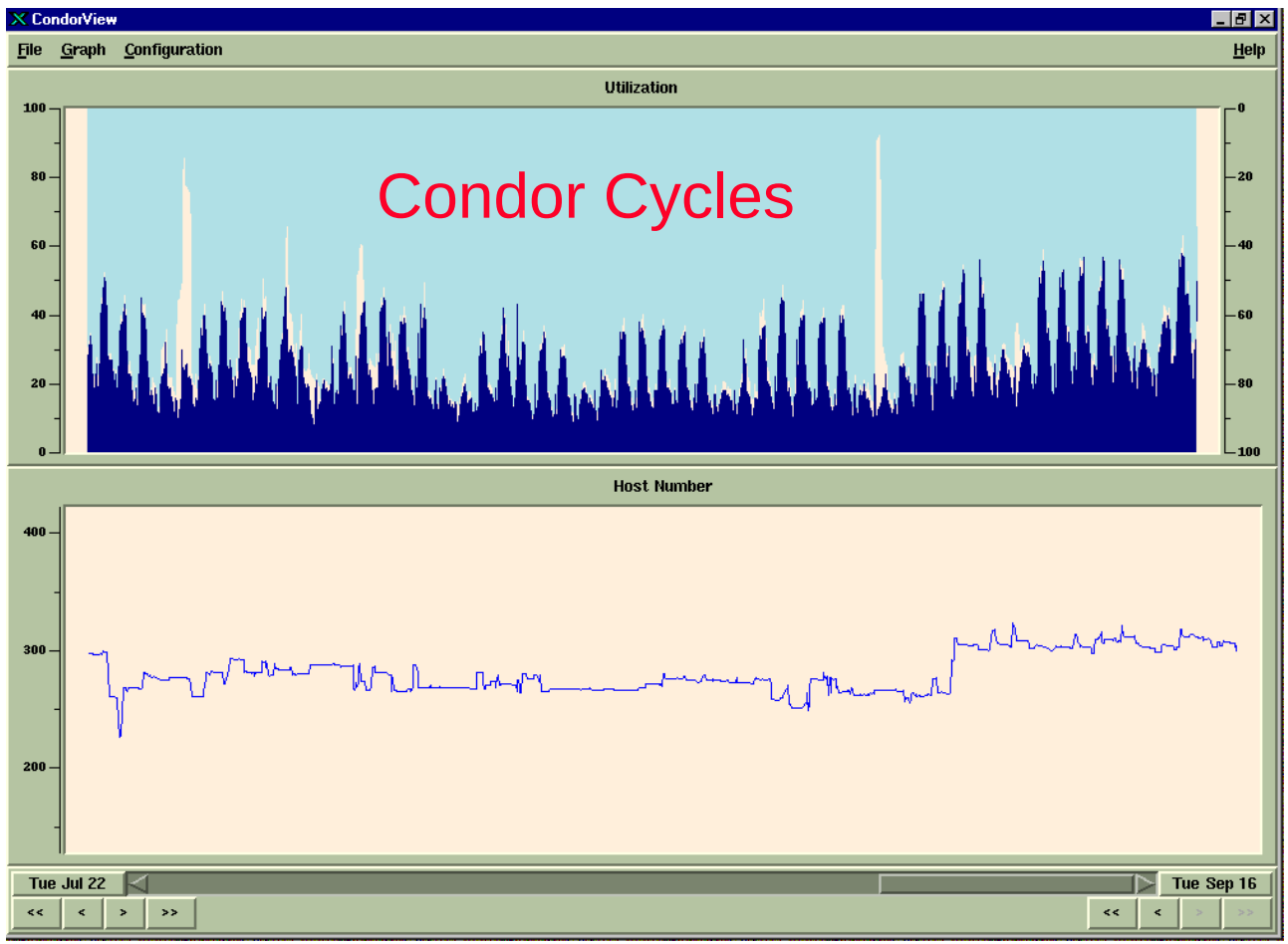
NCSA™
National Computational Science Alliance

The Supercomputers of the Next Five Years Perform Trillions of Multiplications / Second!



Harnessing the Unused Cycles of Networks of Workstations

Alliance Nanotechnologies Team Used Univ. of Wisconsin Condor Cluster - Burned 1 CPU-Year in Two Weeks!



University of Kansas is Installing Condor

National Computational Science Alliance

Buying a Supercomputer by the Yard!

“Supercomputer performance at mail-order prices”-- Jim Gray, Microsoft

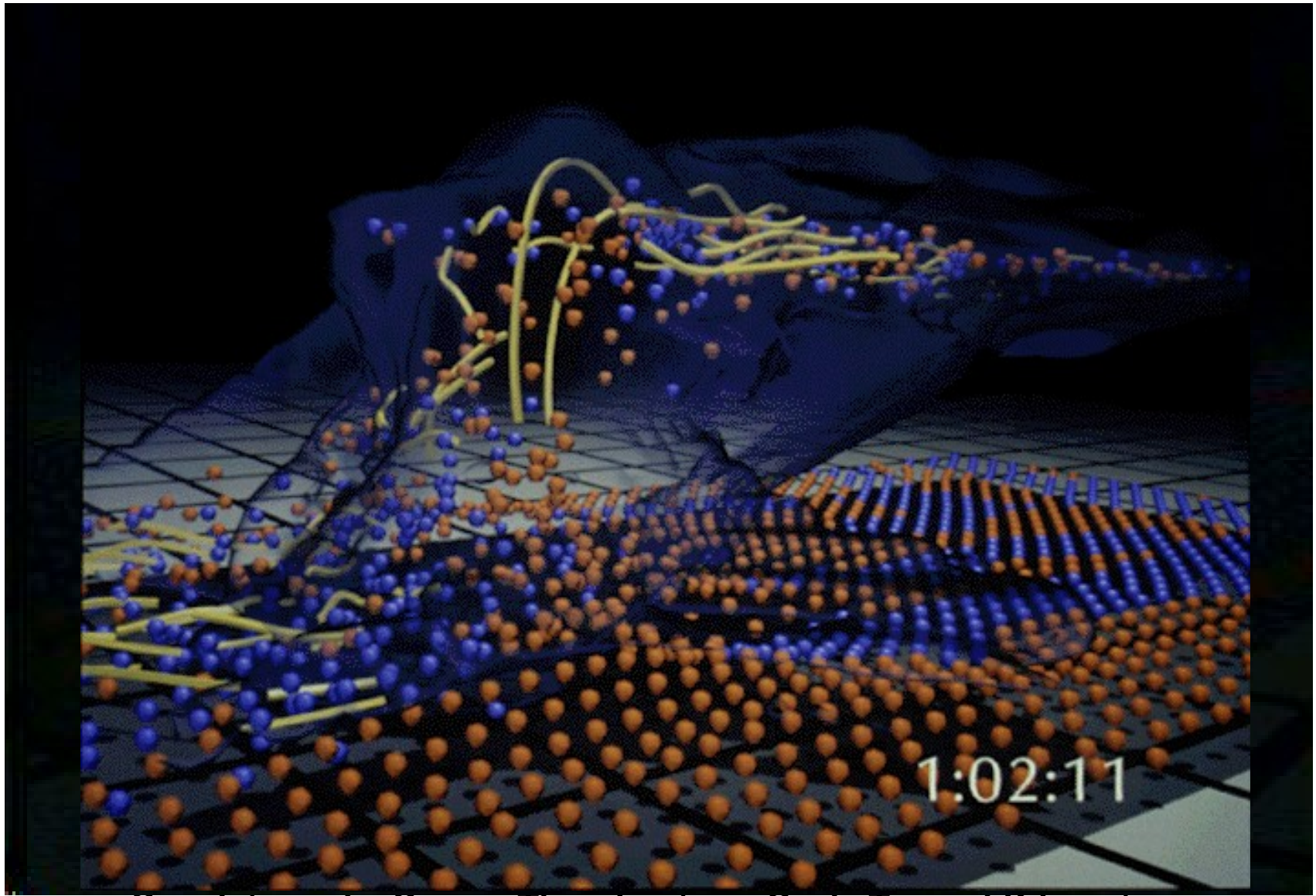


192 Hewlett Packard
300 MHz



64 Compaq 333 MHz

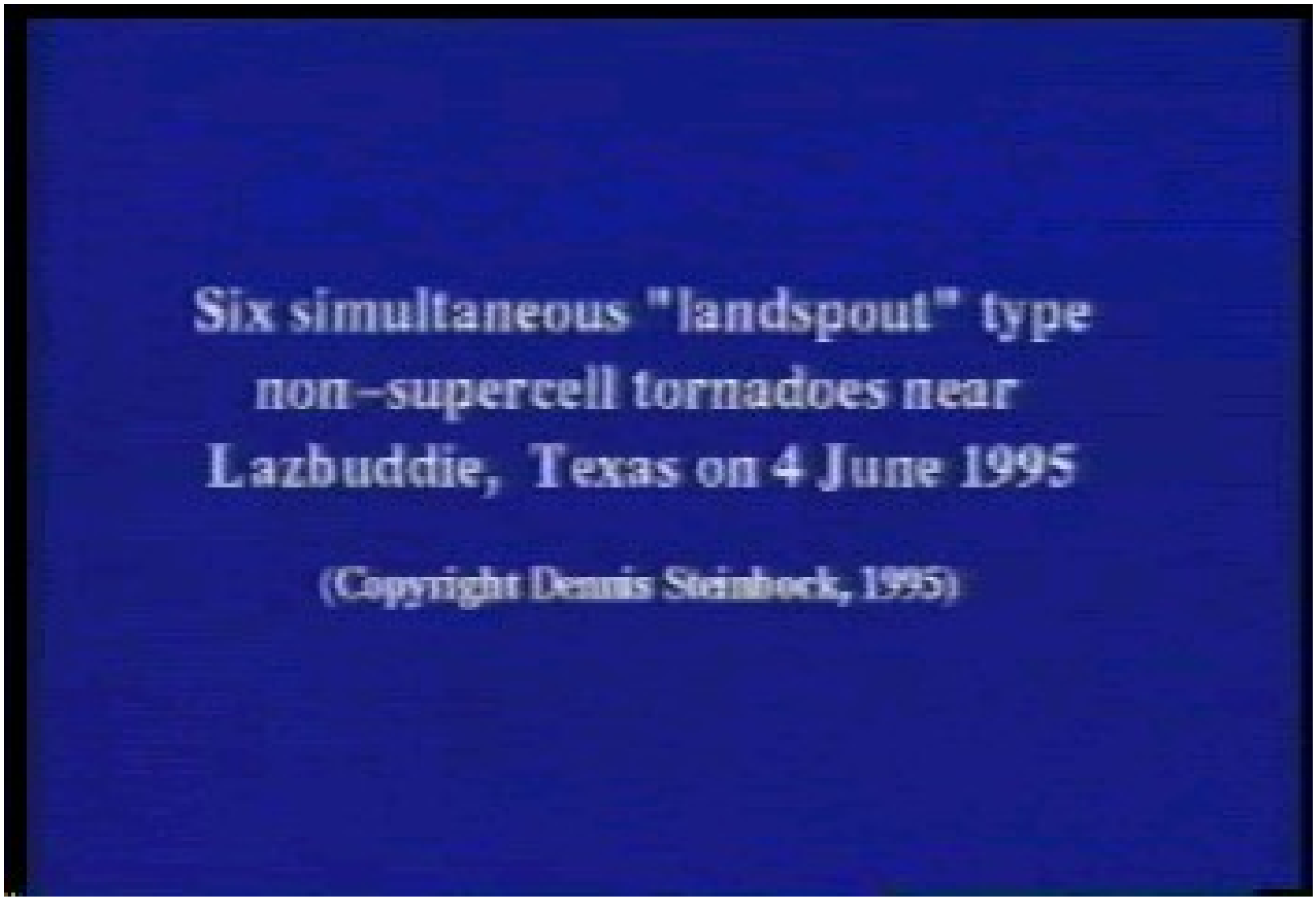
Scientific Visualization of a Thunderstorm Simulation 1988



Simulation of a Severe Thunderstorm-Scale Tens of Kilometers

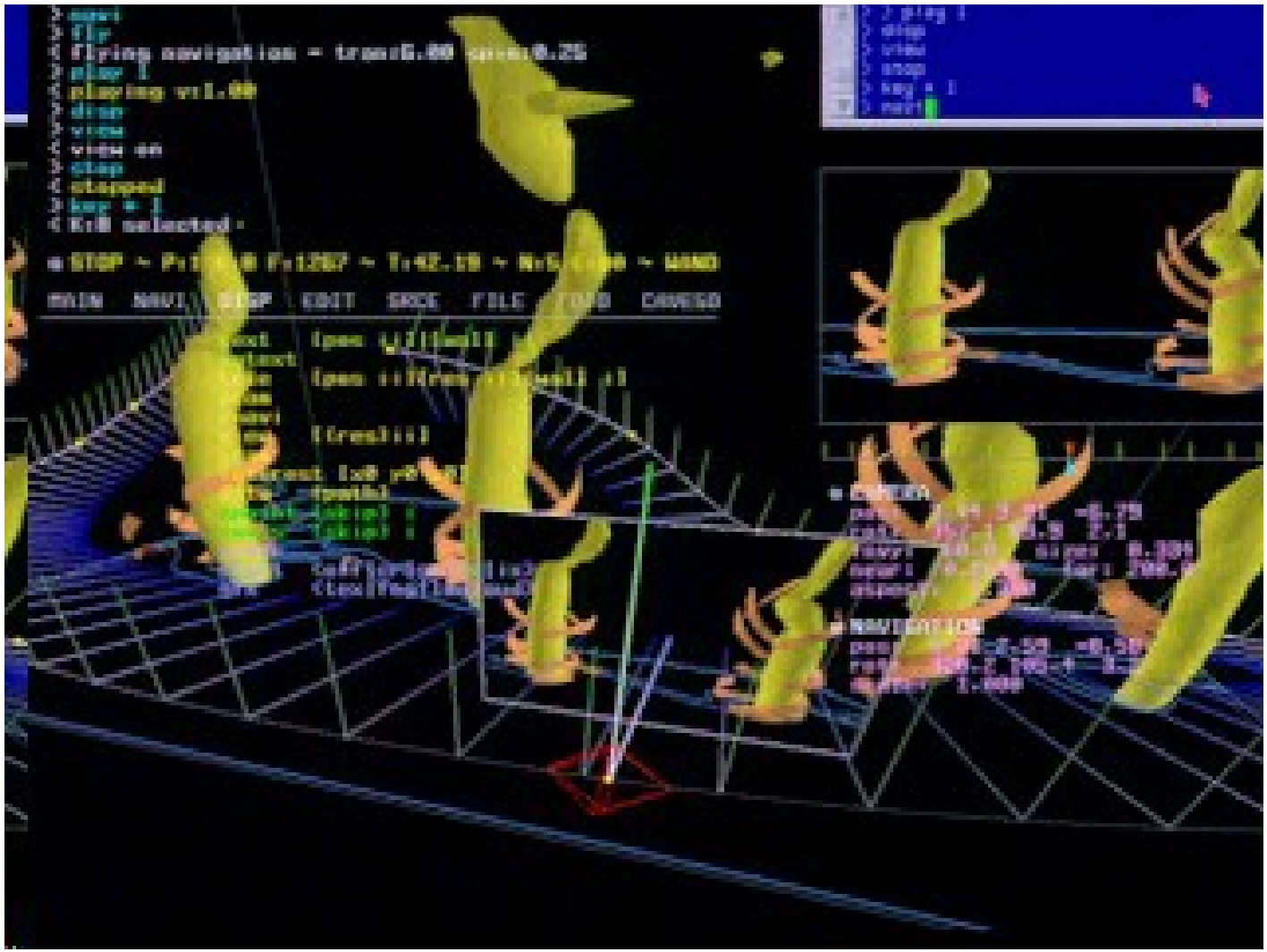
http://www.ncsa.uiuc.edu/SCMS/Metascience/Articles/MS_Study-Numerically-Modeled-Severe-Storm-Wilhelmson.html

Multiple Tornadoes-
The Real Thing



Observation of a Multiple Landspouts-Each on Scale of Tens of Meters

Multiple Tornado Simulation Analysis in the CAVE using Virtual Director



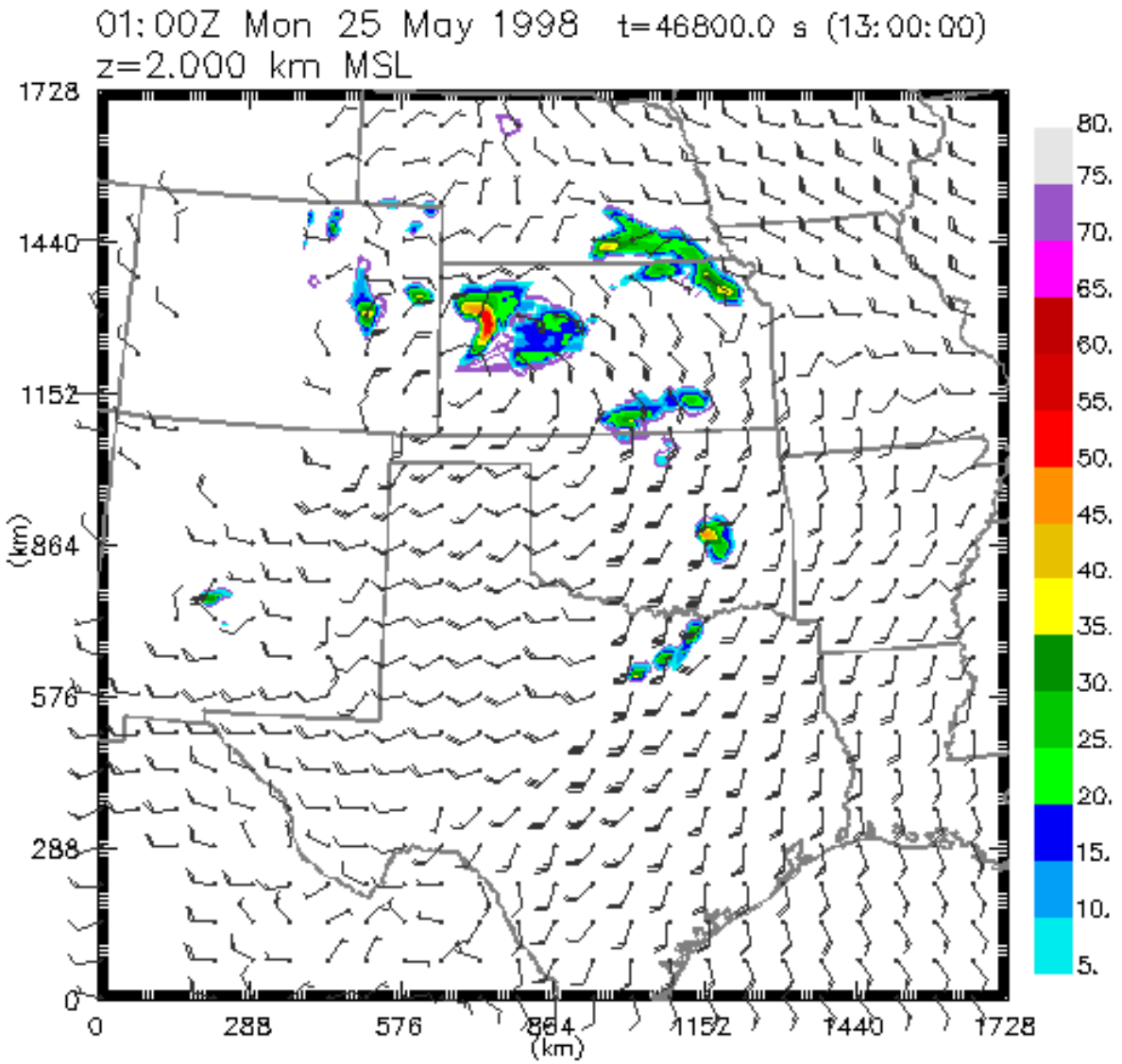
Yellow Iso = Vorticity
Trajectories = Wind Flow
Grey Iso = Rainwater Cloud

Donna Cox, Robert Patterson, Stuart Levy, NCSA Virtual Director Team
Bruce Lee & Bob Wilhelmson, 3000 cpu-hour CM-5 Simulation

NCSA™
National Computational Science Alliance

Storm and Mesoscale Ensemble Experiment 1998 - Center for Analysis and Prediction of Storms

Kelvin Droegemeier, Director, CAPS



Run in Morning - Compare with Reality in the Afternoon!

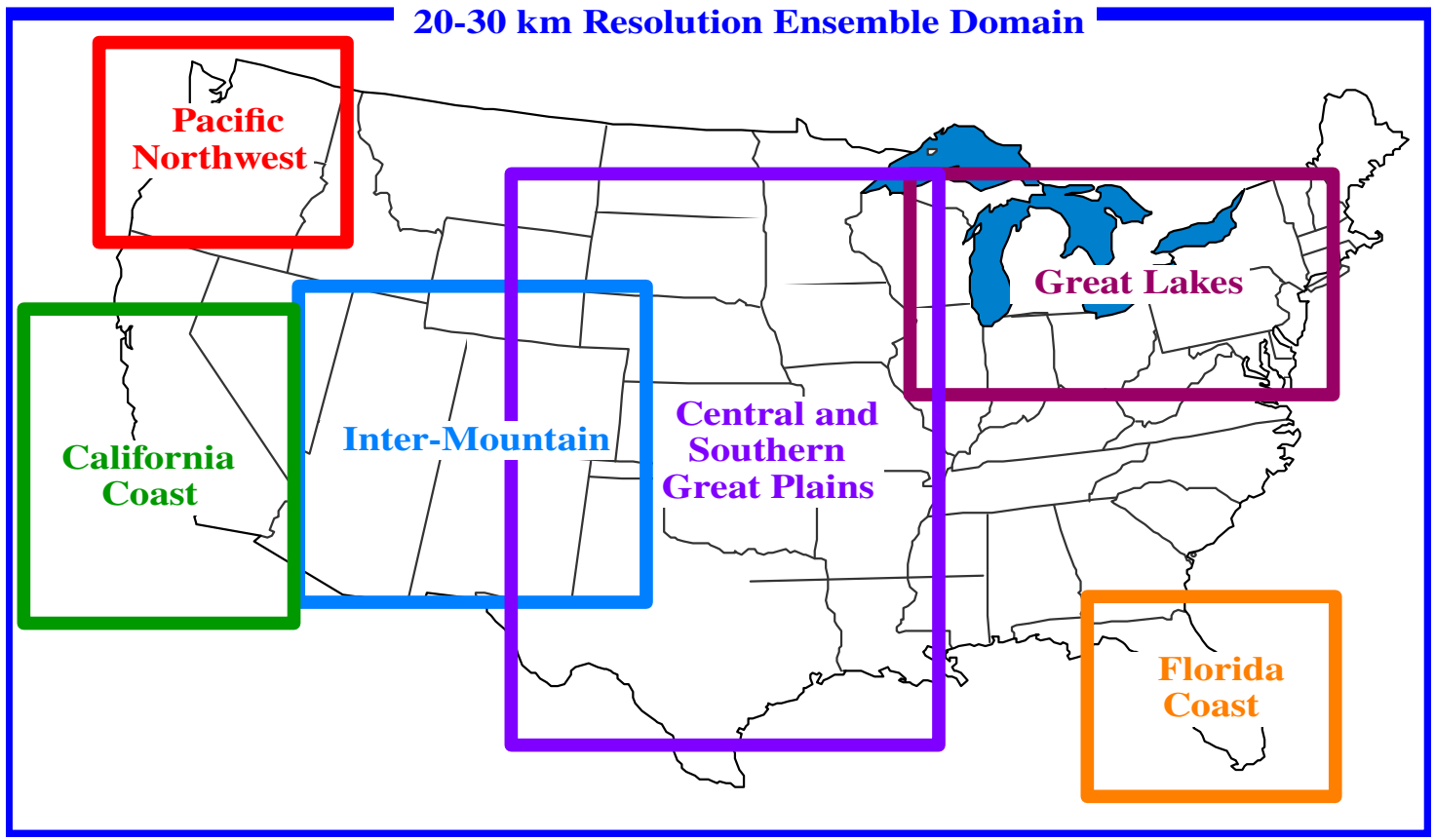
CAPS
Collaborators:
NCAR
NSSL
AFWA
NCEP

http://origin.caps.ou.edu/~samex/arps/19980524/12Z_nc9/13h/refl-2km.gif

Predicting Spring Storms in 1999 and Beyond -- A Grid Based Computational Science Experiment

- NCSA and Regional Models Running Concurrently
- Local NEXRAD Doppler Radars to Initialize Models
- Models Accessed Over Web by Airlines, Agencies

NCSA Requirement: 5 Hr./day on Origin 128 for 2 Months Spring '99

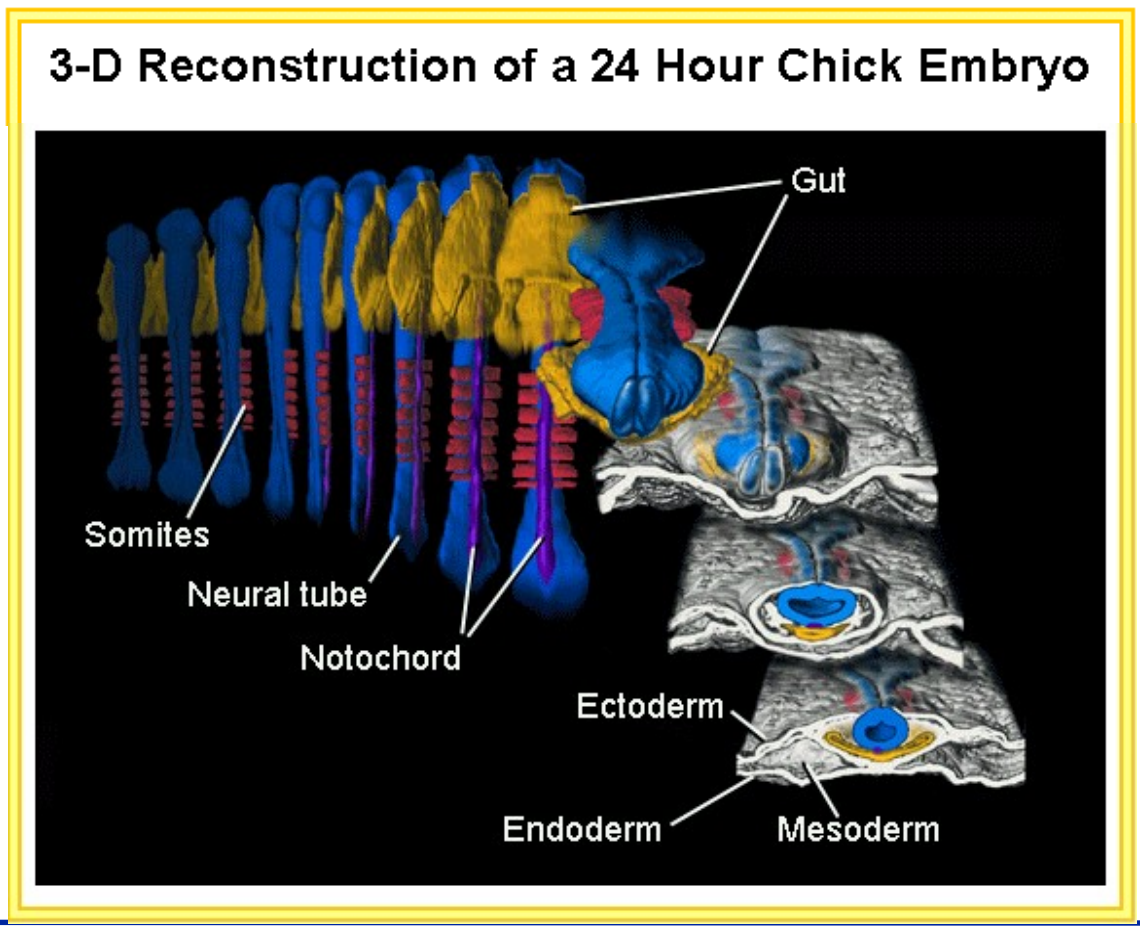


Kelvin Droegemeier, Director CAPS, Univ. Oklahoma

National Computational Science Alliance

Bringing the Grid to K-12





Bringing the Grid to Urban Centers



What's New on Chicago Mosaic

www.ci.chi.il.us/

Bringing the Grid to Rural America

The Champaign County Chamber of Commerce and NCSA - CCNet

