"Supercomputers: Directions in Technology, Architecture, and Applications"

Keynote Presentation

Supercomputer '98

Mannheim, Germany

June 18, 1998

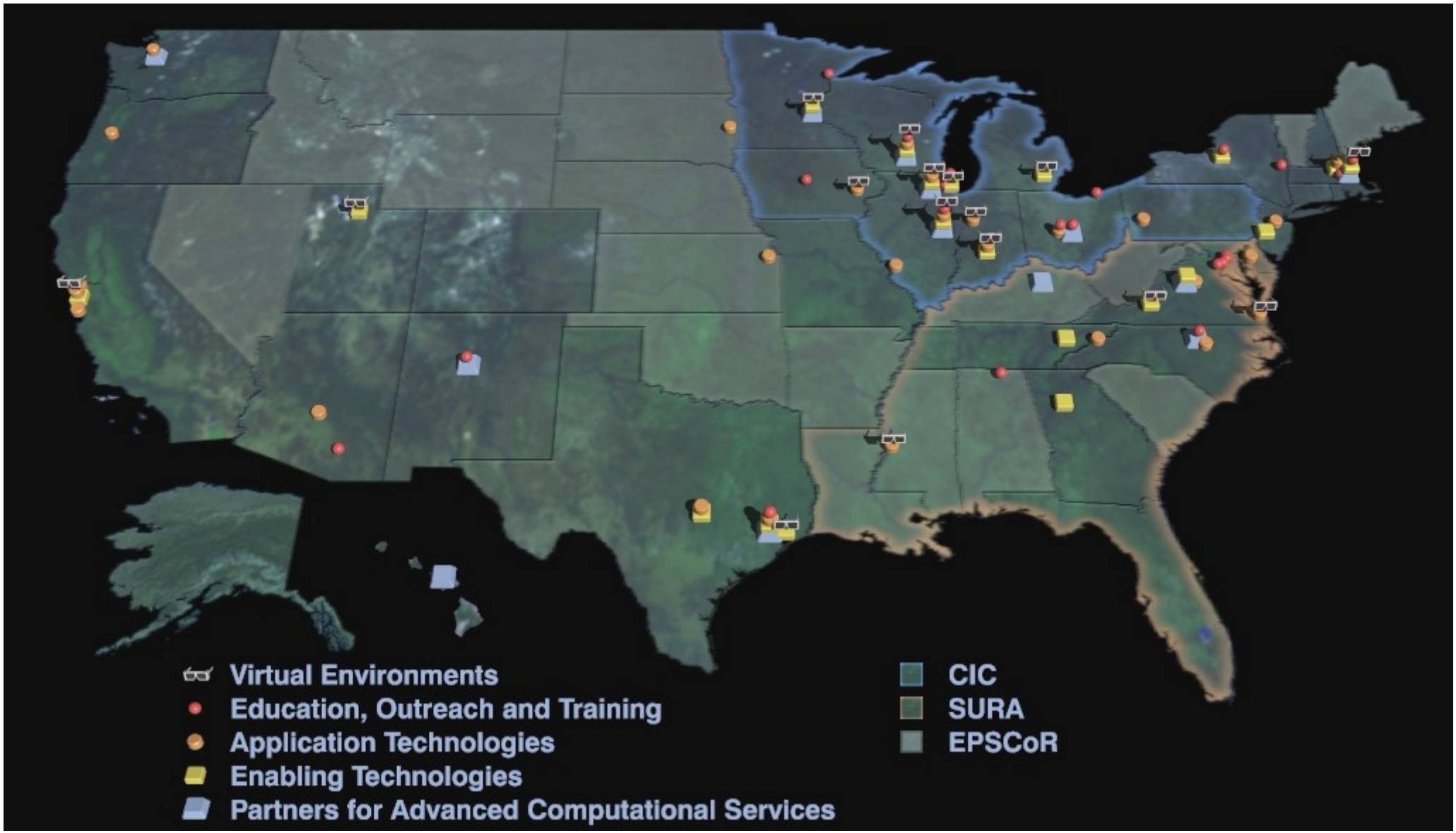
Dr. Larry Smarr

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

Professor in the Departments of Physics and Astronomy

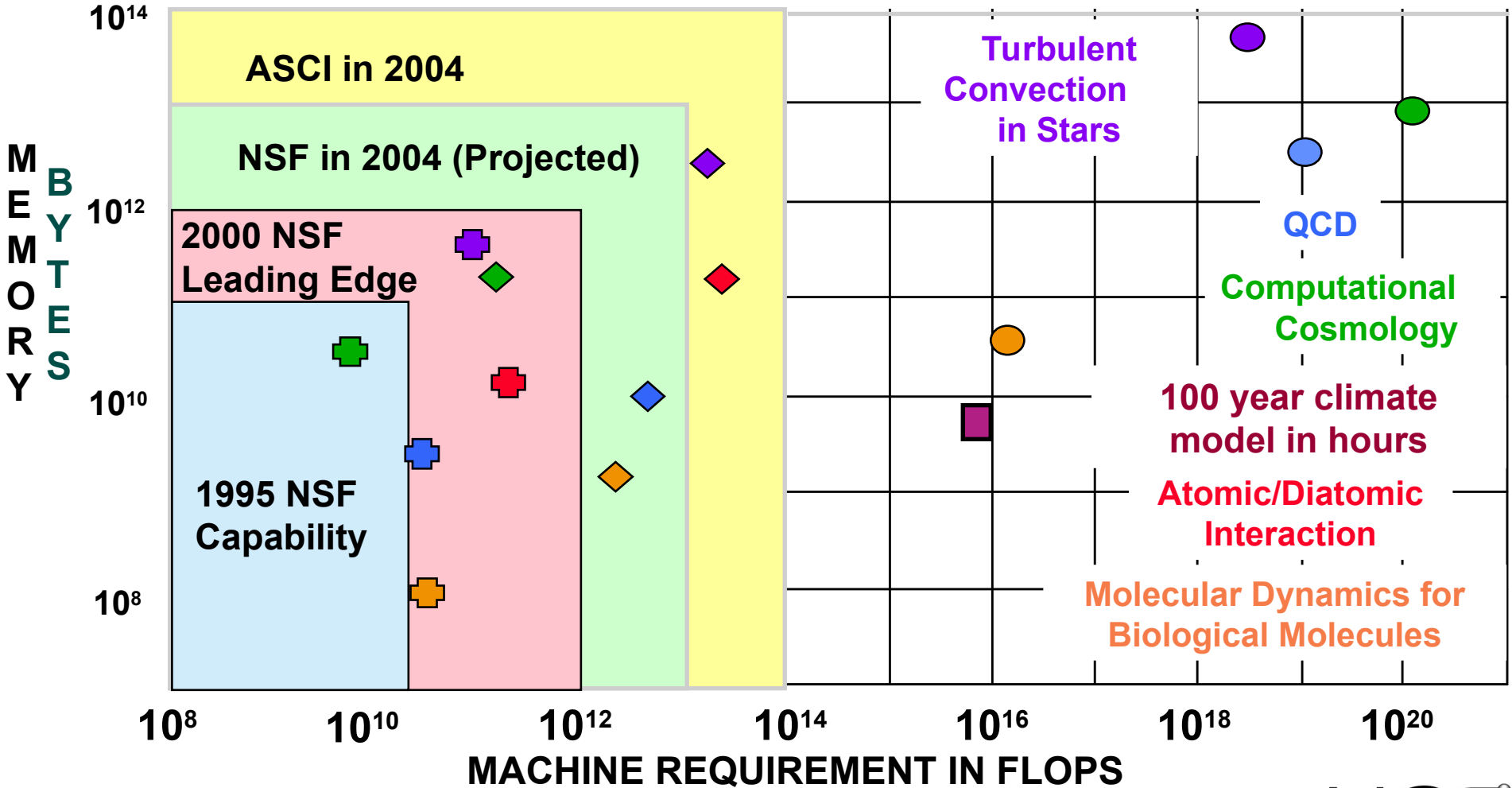
University of Illinois Urbana-Champaign

NCSA is the Leading Edge Site for the National Computational Science Alliance



Scientific Applications Continue to Require Exponential Growth in Capacity

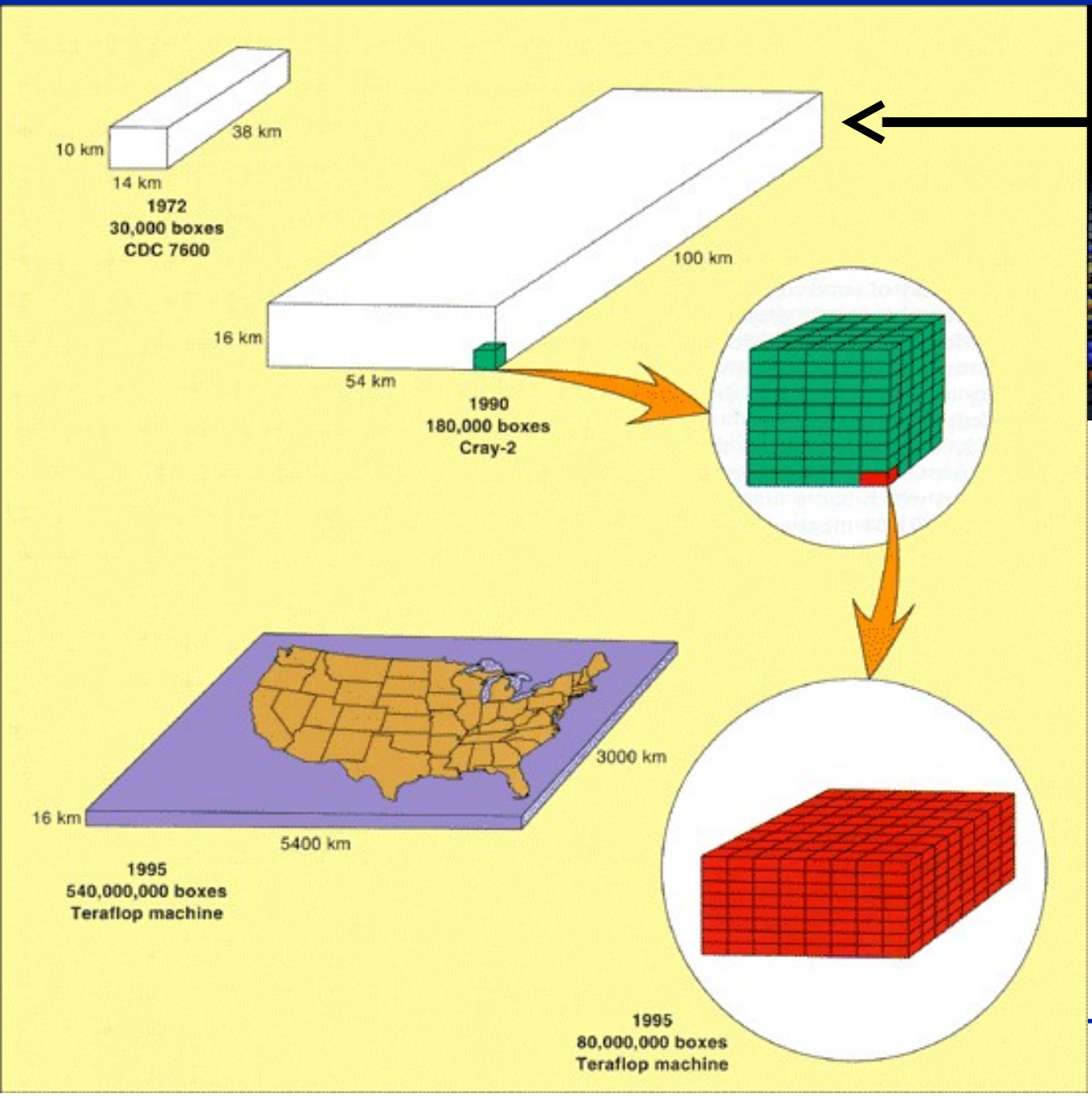
= Recent Computations by NSF Grand Challenge Research Teams
= Next Step Projections by NSF Grand Challenge Research Teams
= Long Range Projections from Recent Applications Workshop

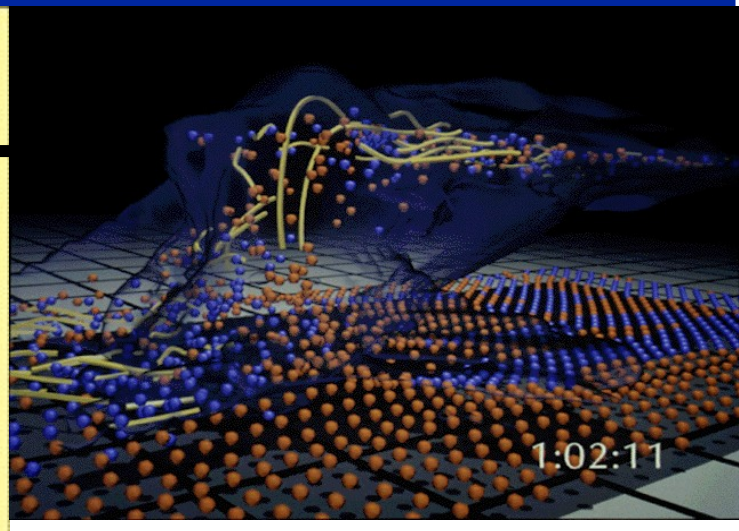


From Bob Voigt, NSF

NCSA™
National Computational Science Alliance

The Promise of the Teraflop - From Thunderstorm to National-Scale Simulation

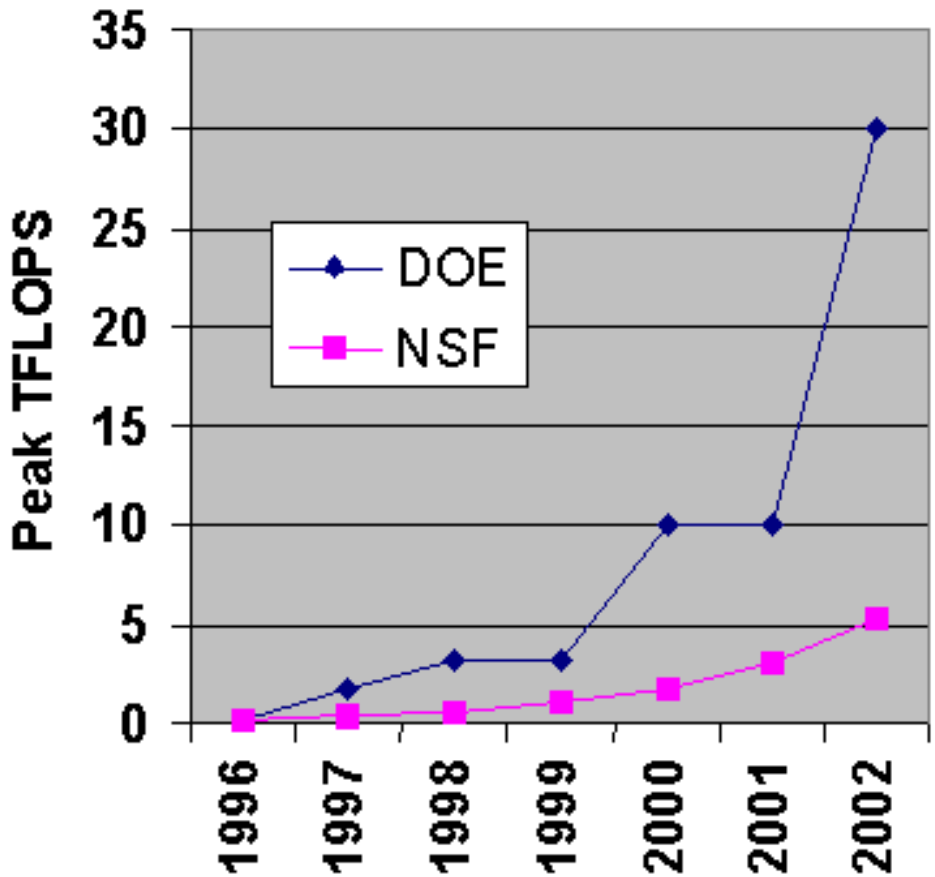




Simulation by Wilhelmson, et al.; Figure from Supercomputing and the Transformation of Science, Kaufmann and Smarr, Freeman, 1993

Accelerated Strategic Computing Initiative is Coupling DOE Defense Labs to Universities

- Access to ASCI Leading Edge Supercomputers
- Academic Strategic Alliances Program
- Data and Visualization Corridors

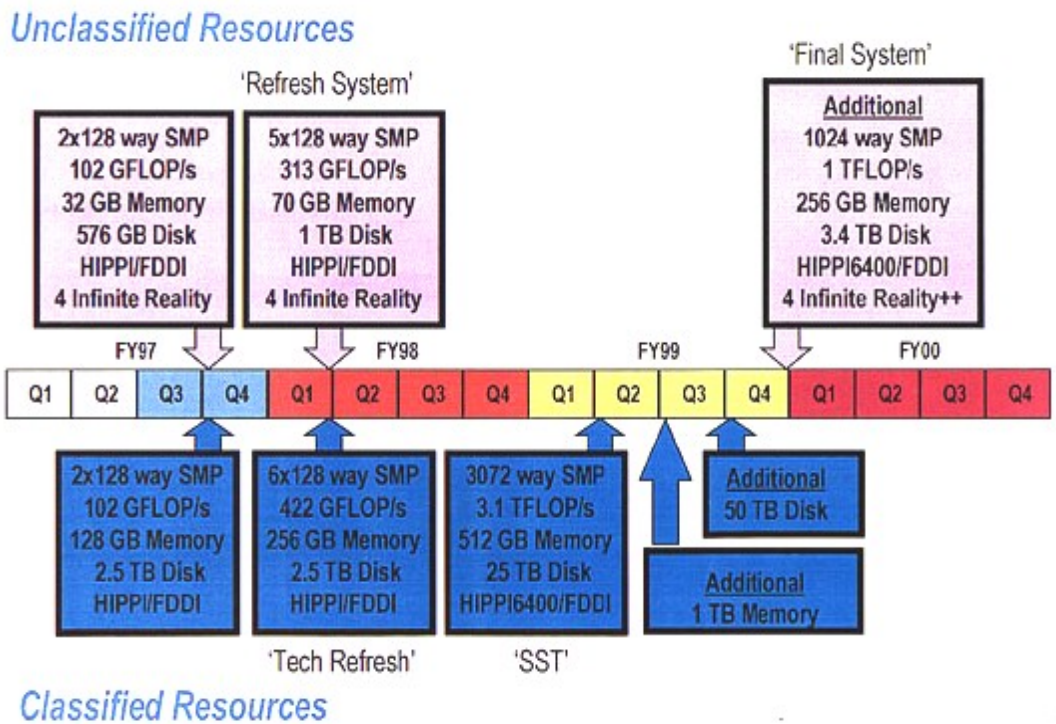




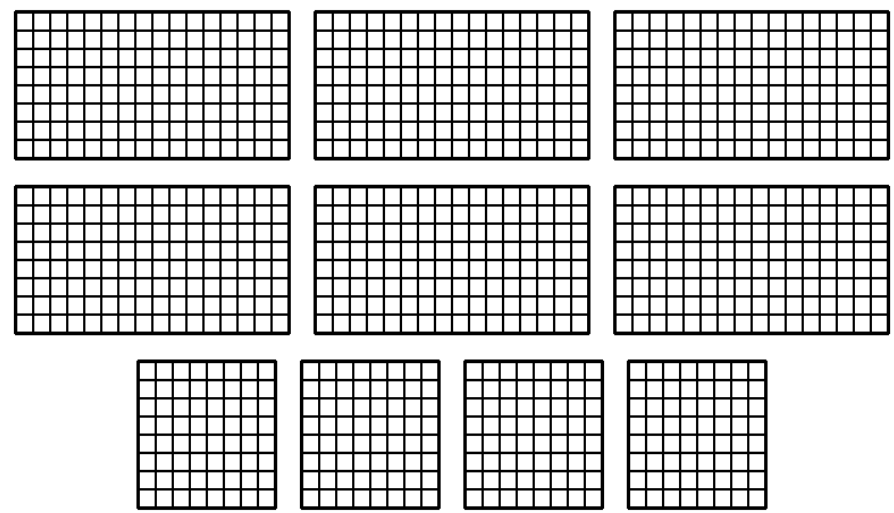
http://www.llnl.gov/asci-alliances/centers.html

Comparison of the DoE ASCI and the NSF PACI Origin Array Scale Through FY99

Los Alamos Origin System FY99
5-6000 processors

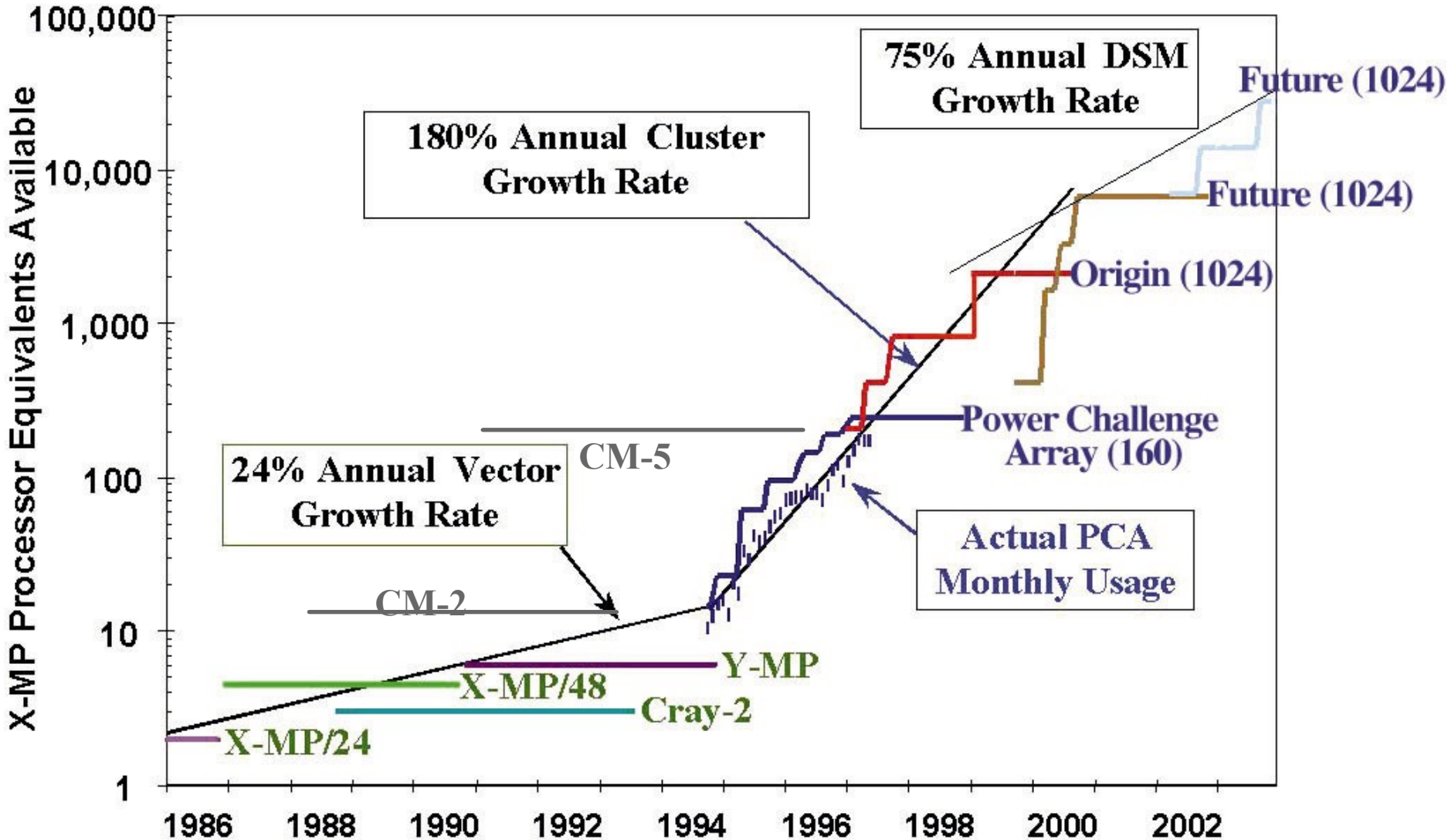


NCSA Proposed System FY99
6x128 and 4x64=1024 processors



www.lanl.gov/projects/asci/bluemtn/Hardware/schedule.html

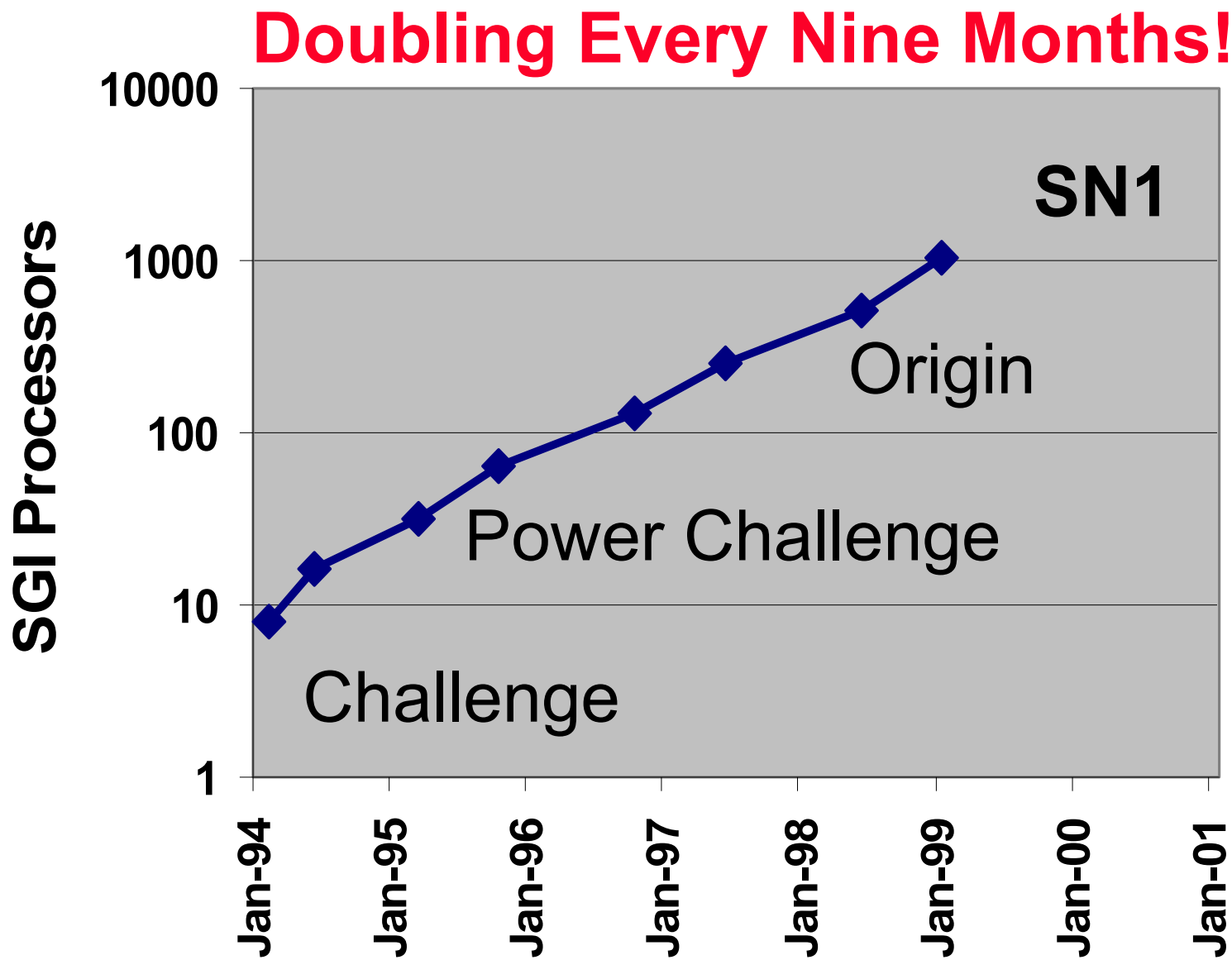
NCSA Combines Shared Memory Programming with Massive Parallelism



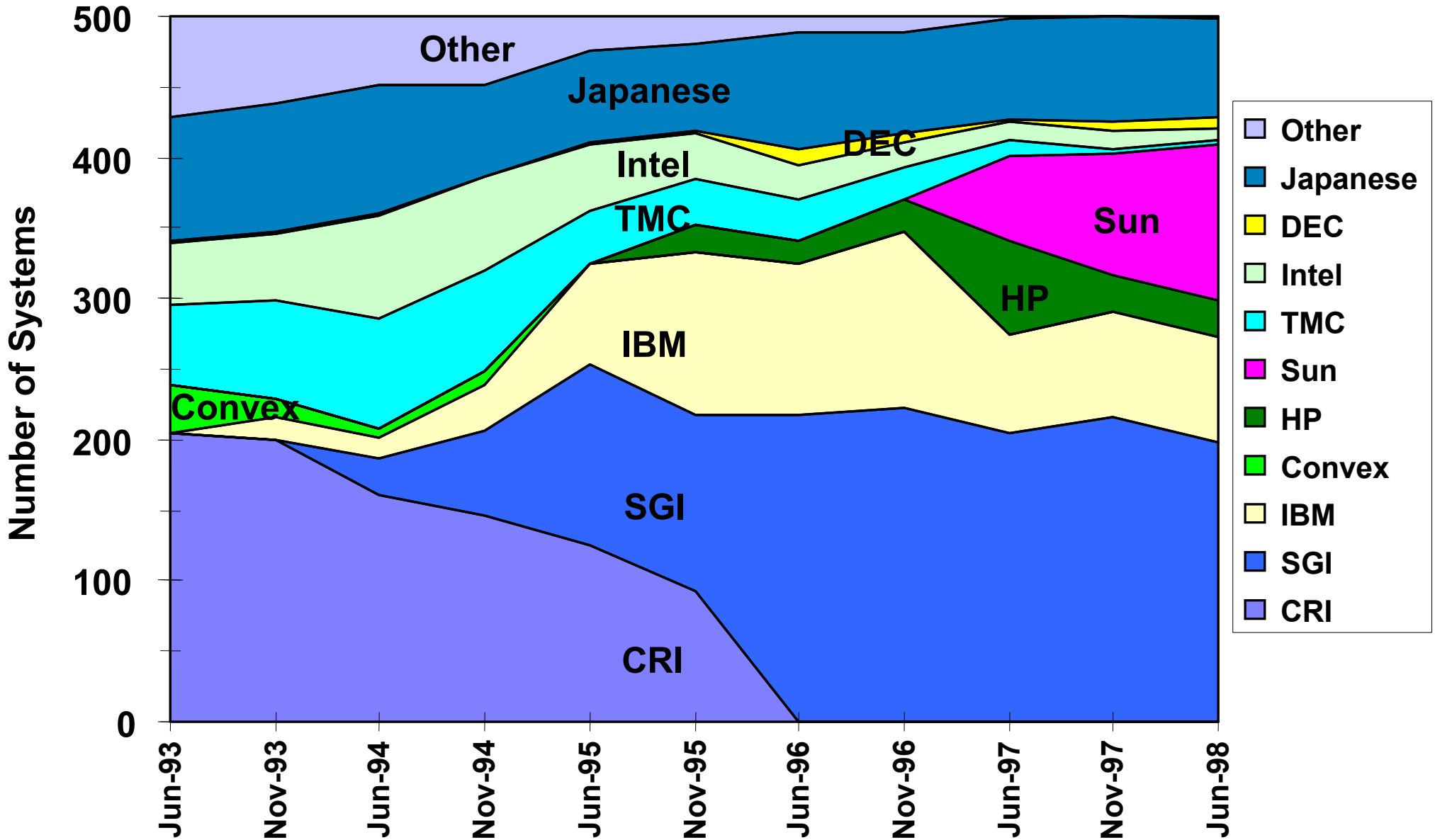
Future Upgrade Under Negotiation with NSF

National Computational Science Alliance

The Exponential Growth of NCSA's SGI Shared Memory Supercomputers



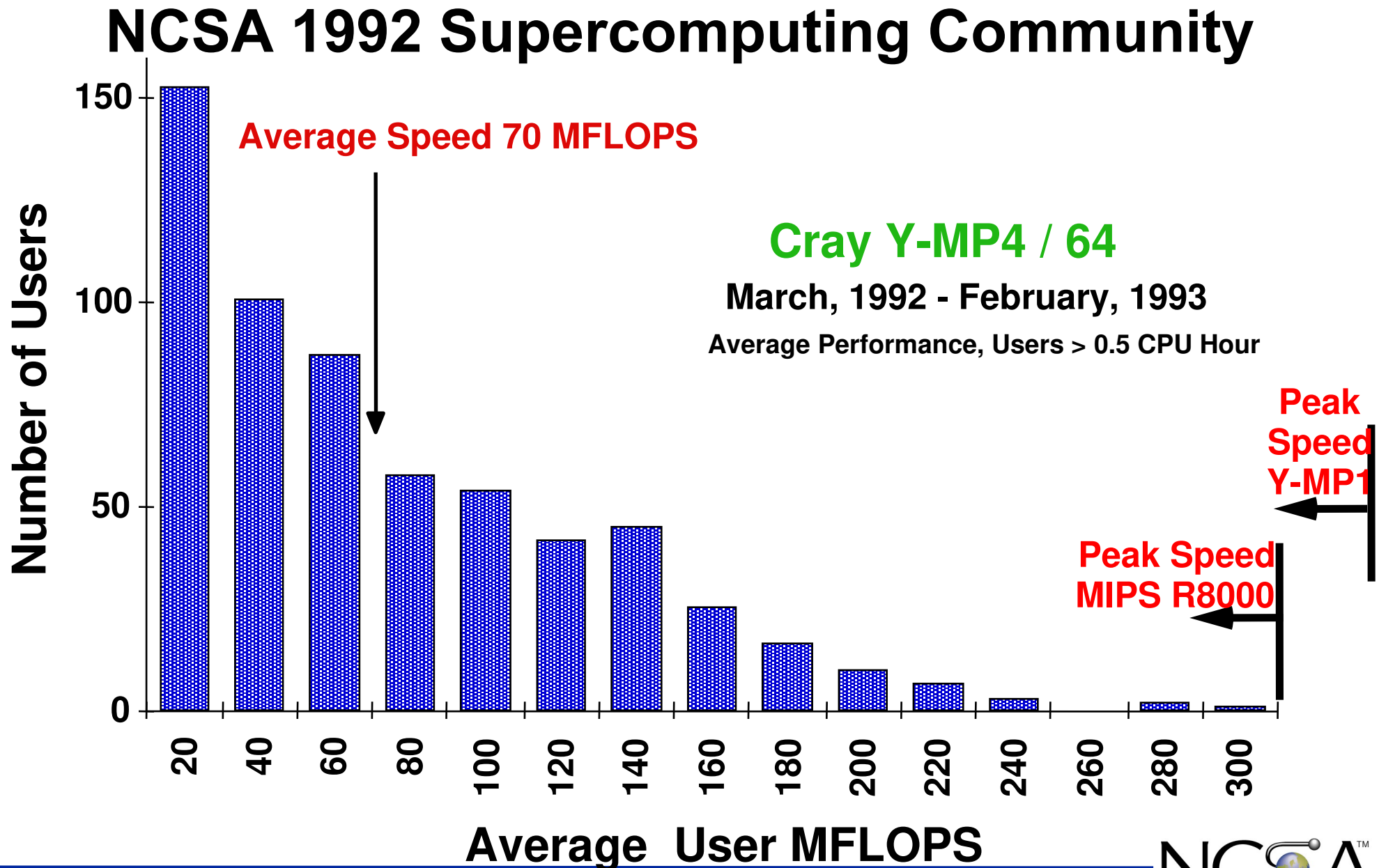
TOP500 Systems by Vendor



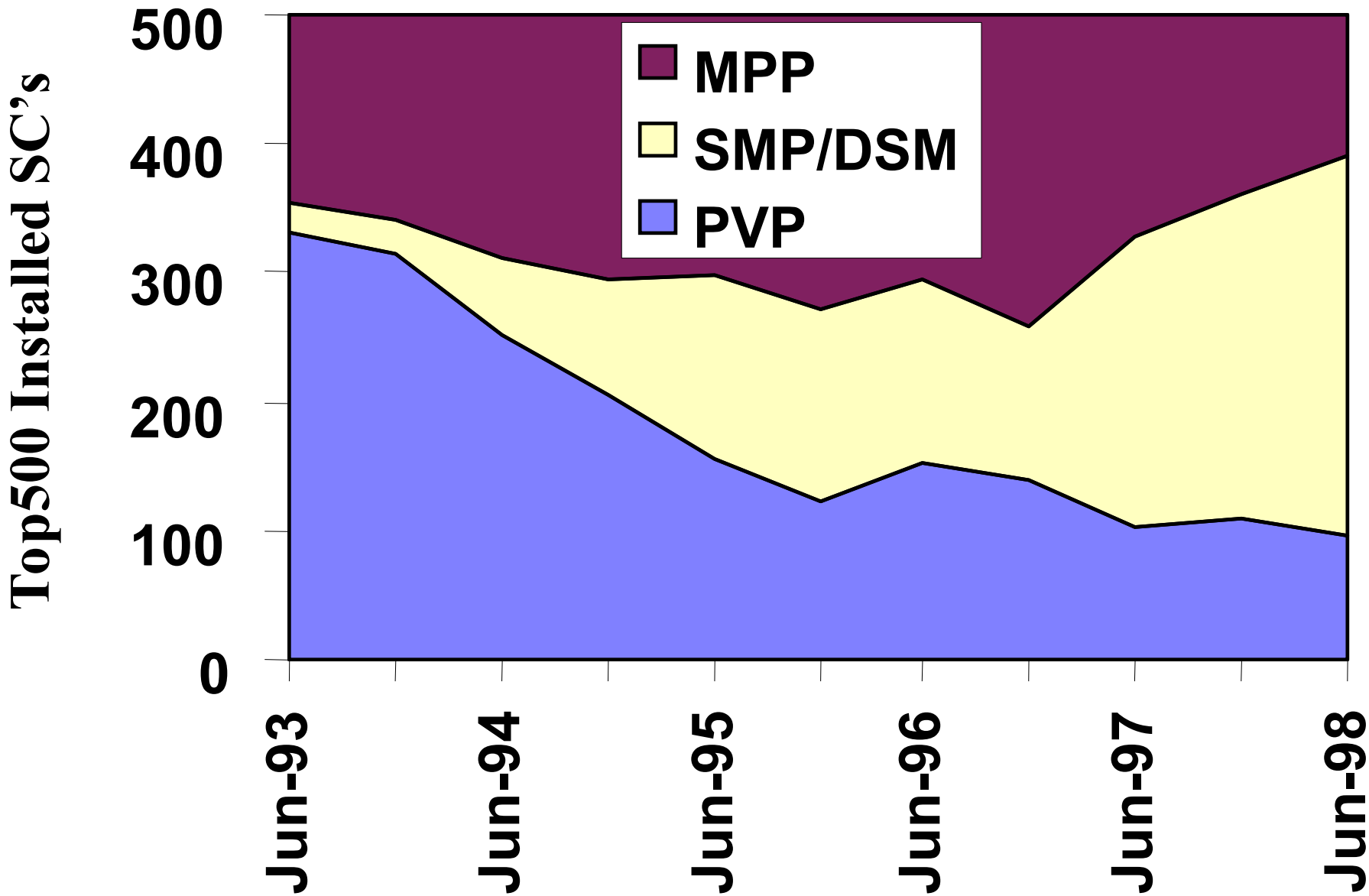
TOP500 Reports: http://www.netlib.org/benchmark/top500.html

National Computational Science Alliance

Why NCSA Switched From Vector to RISC Processors

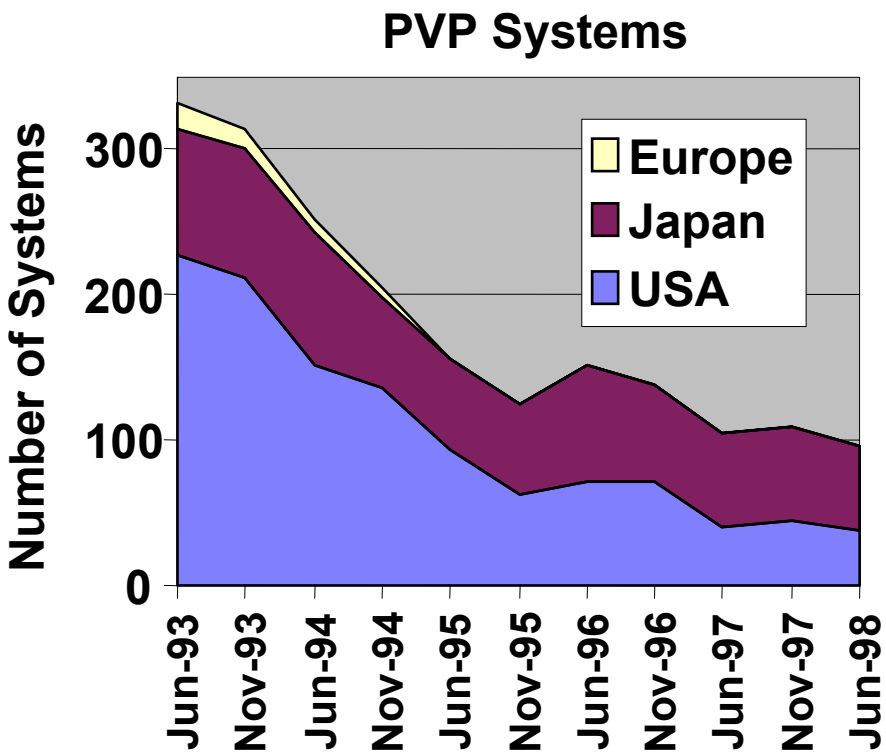


Replacement of Shared Memory Vector Supercomputers by Microprocessor SMPs

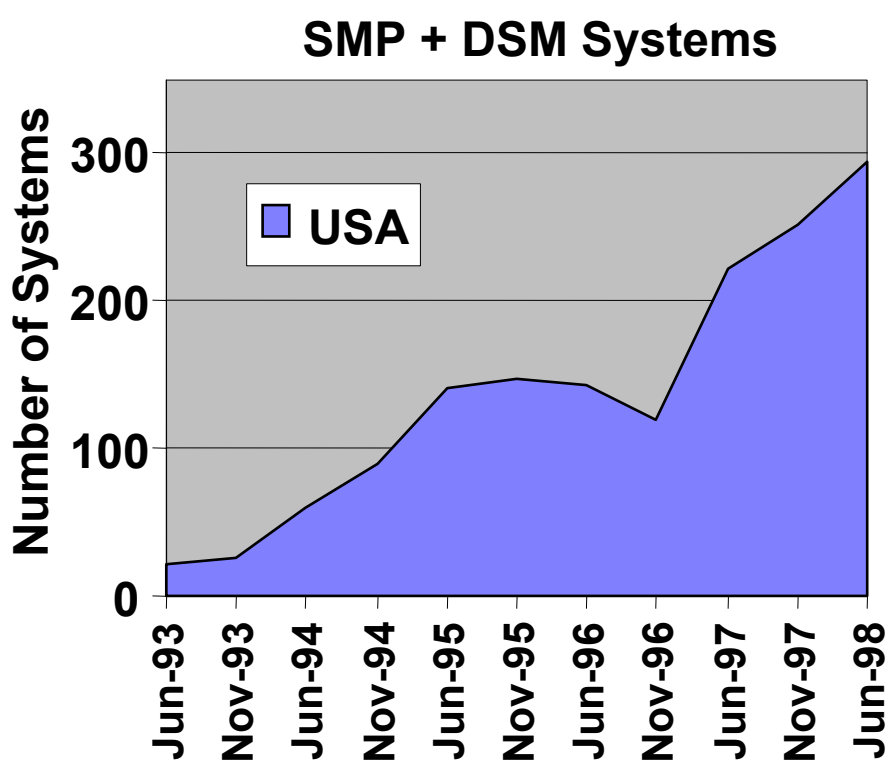


TOP500 Reports: http://www.netlib.org/benchmark/top500.html

Top500 Shared Memory Systems



Vector Processors

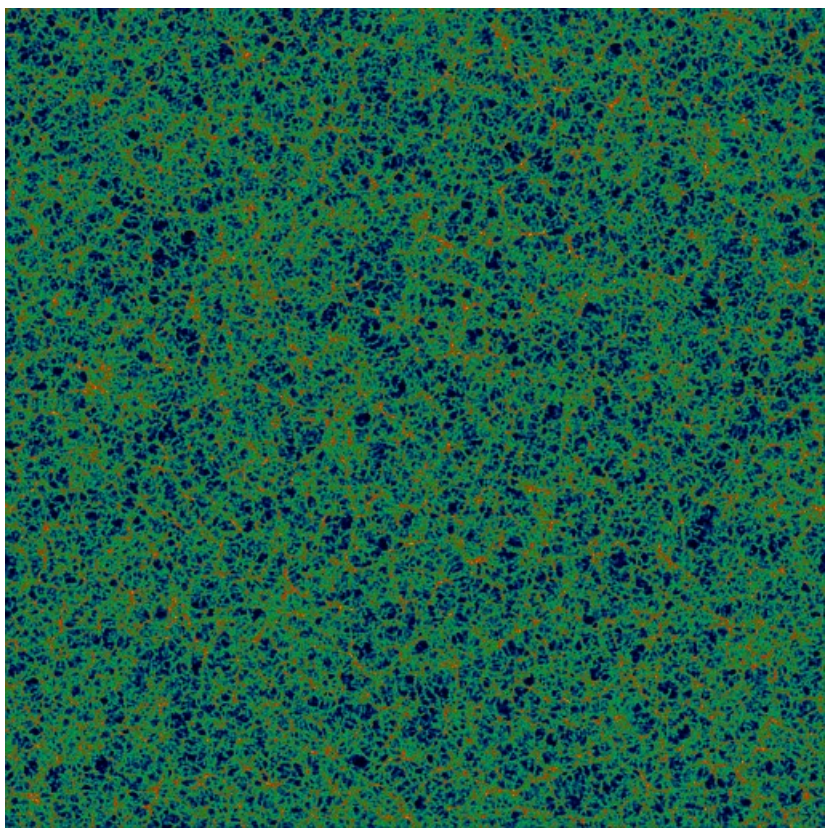


Microprocessors

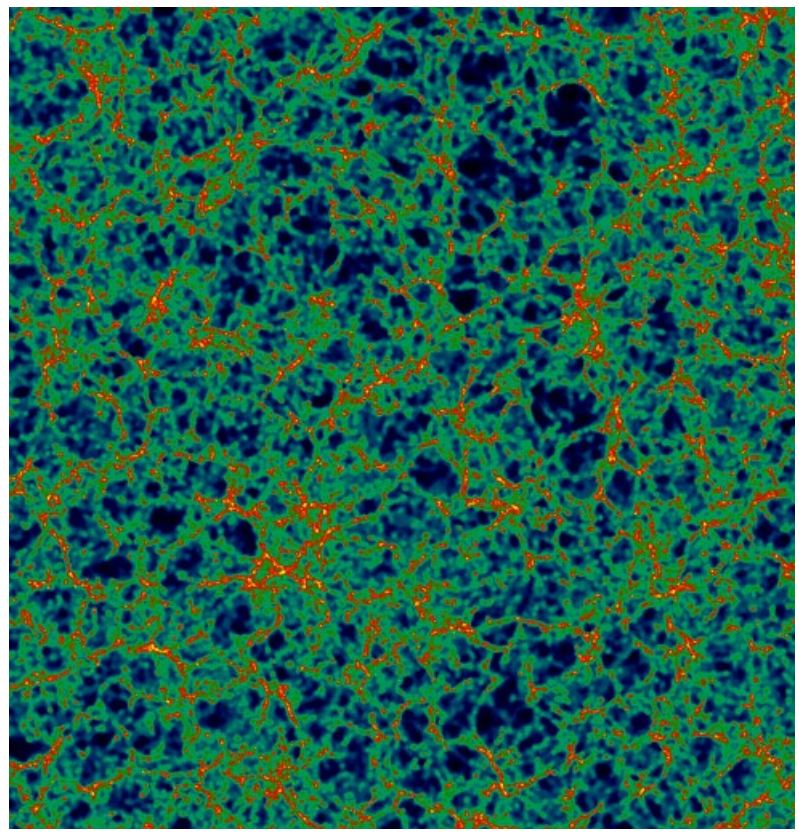
TOP500 Reports: http://www.netlib.org/benchmark/top500.html

Simulation of the Evolution of the Universe on a Massively Parallel Supercomputer

12 Billion Light Years



4 Billion Light Years

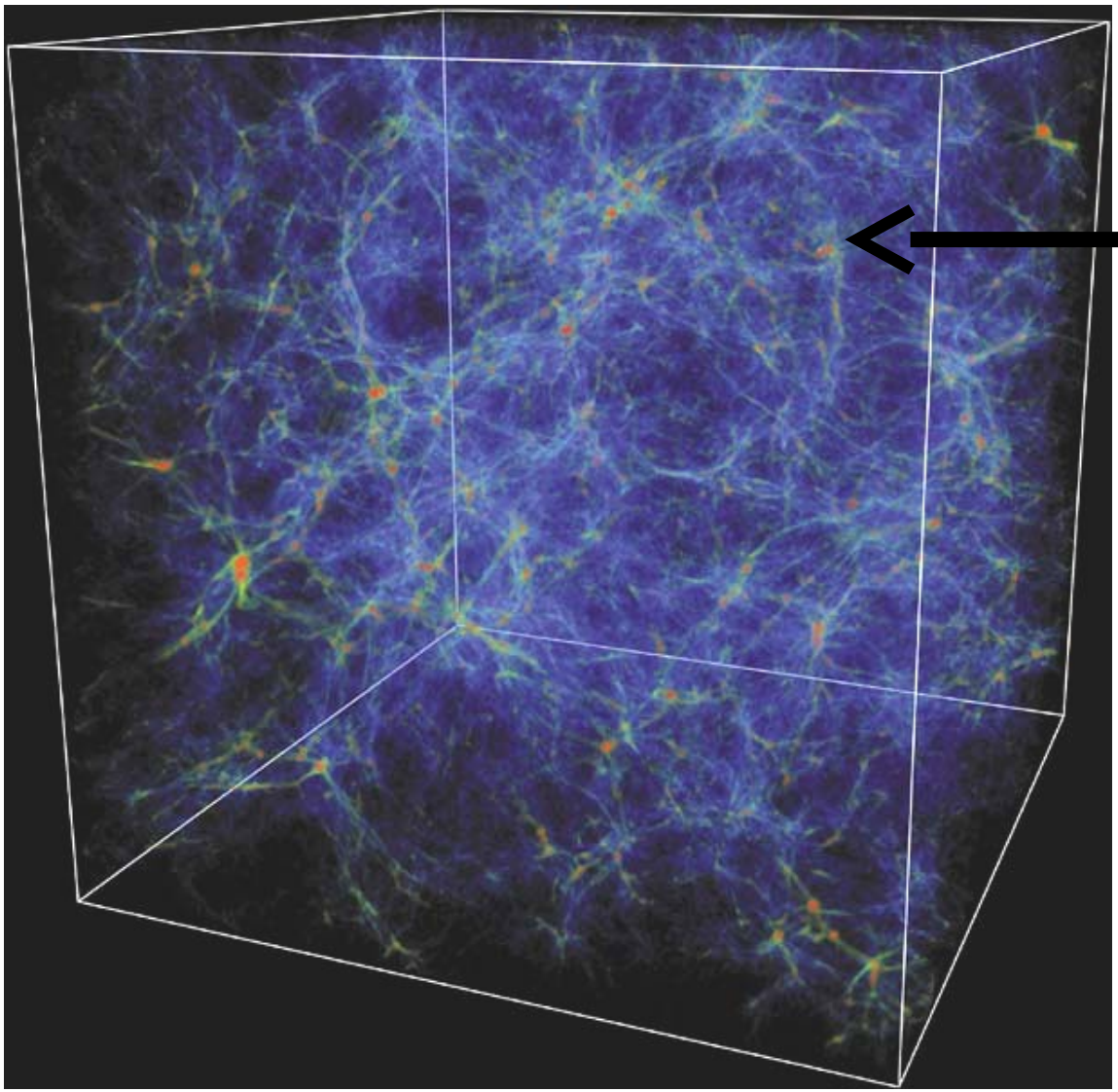


Virgo Project - Evolving a Billion Pieces of Cold Dark Matter in a Hubble Volume - 688-processor CRAY T3E at Garching Computing Centre of the Max-Planck-Society

http://www.mpg.de/universe.htm

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Limitations of Uniform Grids for Complex Scientific and Engineering Problems

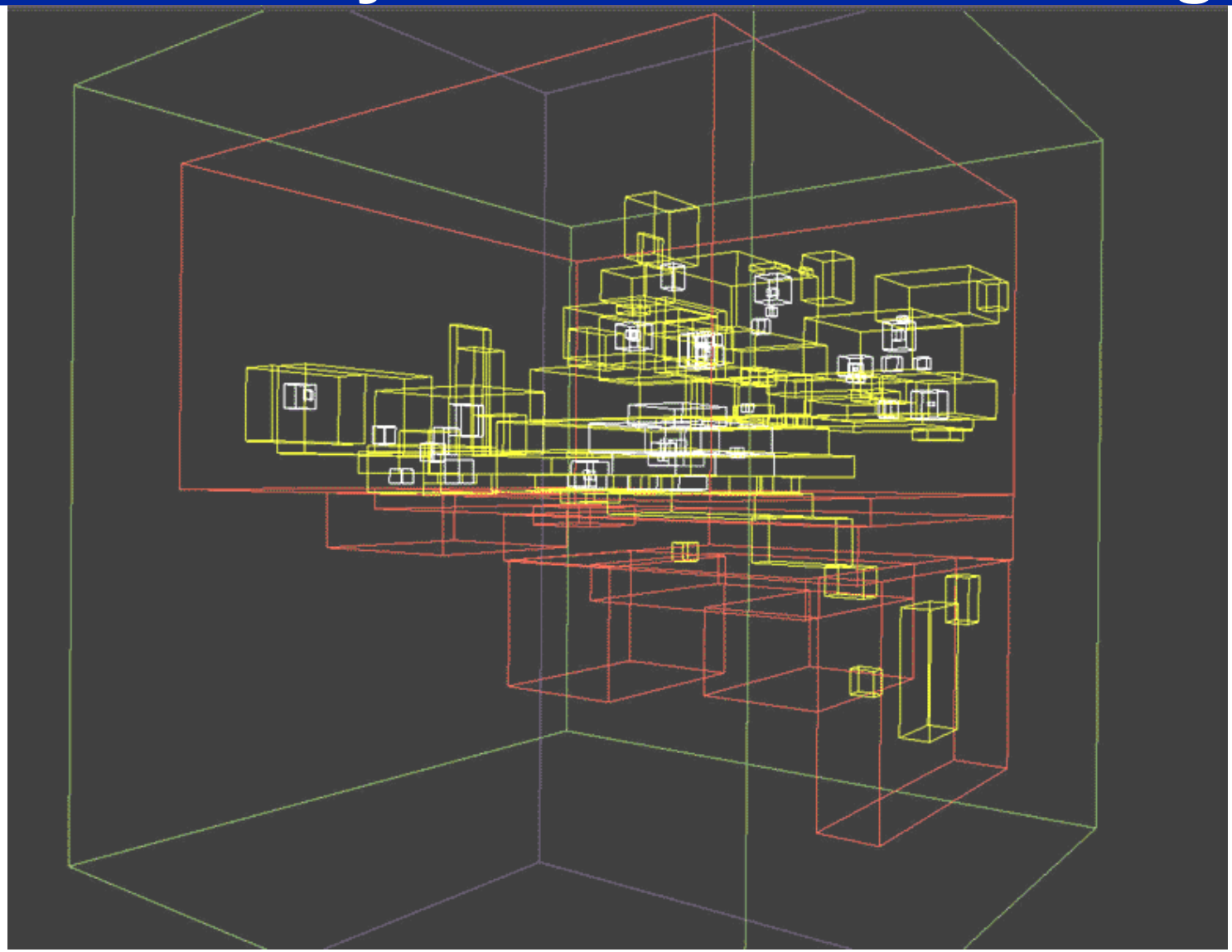


512x512x512 Run on 512-node CM-5

Gravitation Causes Continuous Increase in Density Until There is a Large Mass in a Single Grid Zone

Source: Greg Bryan, Mike Norman, NCSA

Use of Shared Memory Adaptive Grids To Achieve Dynamic Load Balancing

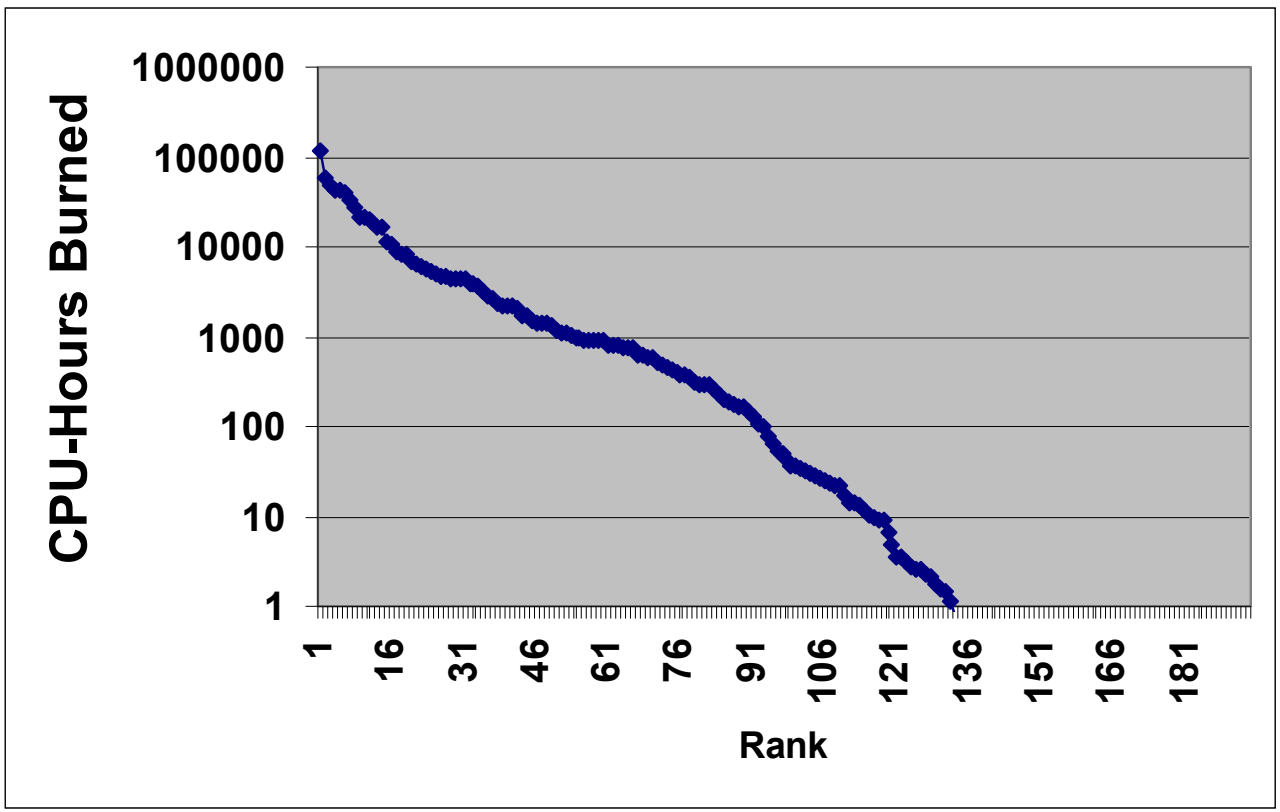


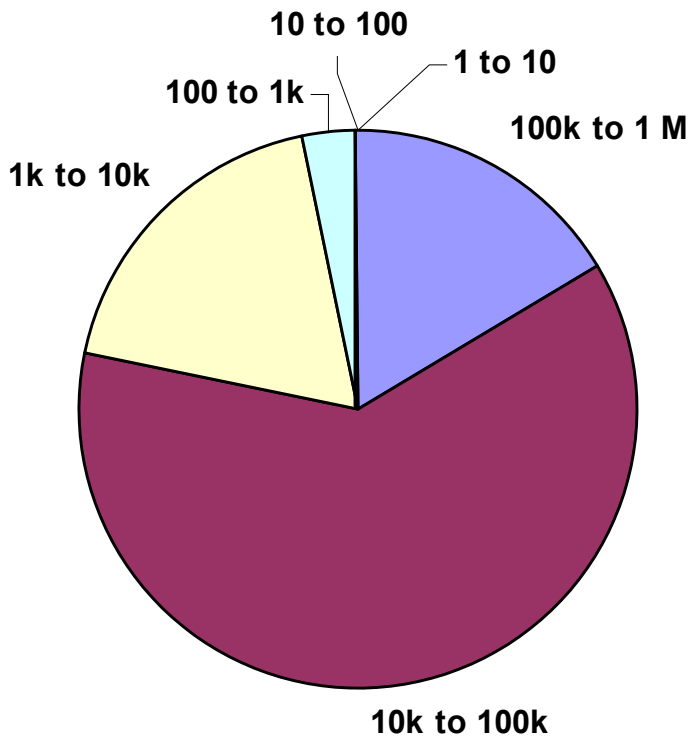
64x64x64 Run with Seven Levels of Adaption on SGI Power Challenge, Locally Equivalent to 8192x8192x8192 Resolution

Source: Greg Bryan, Mike Norman, John Shalf, NCSA

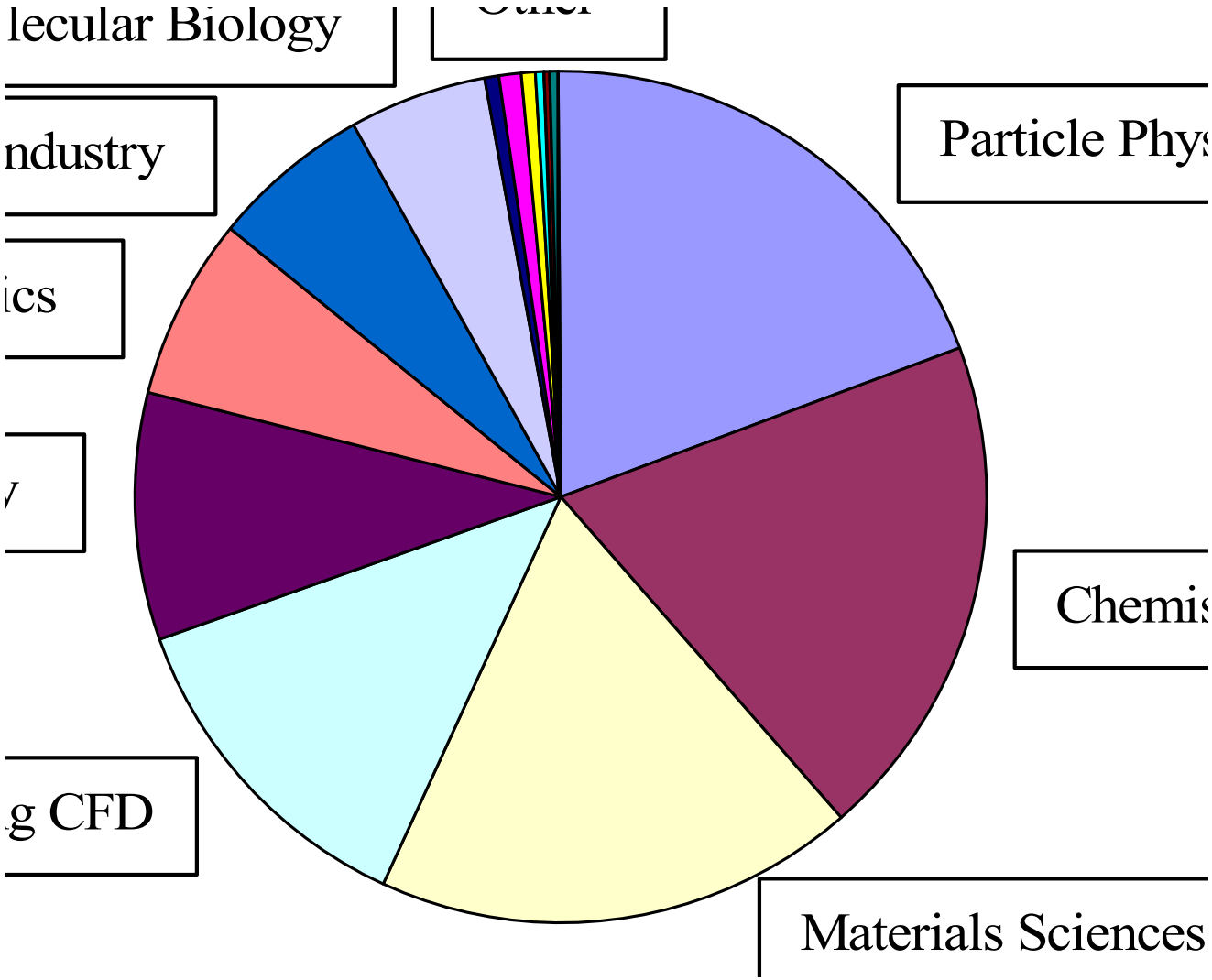
Extreme and Large PIs
Dominant Usage of NCSA Origin

January thru April, 1998

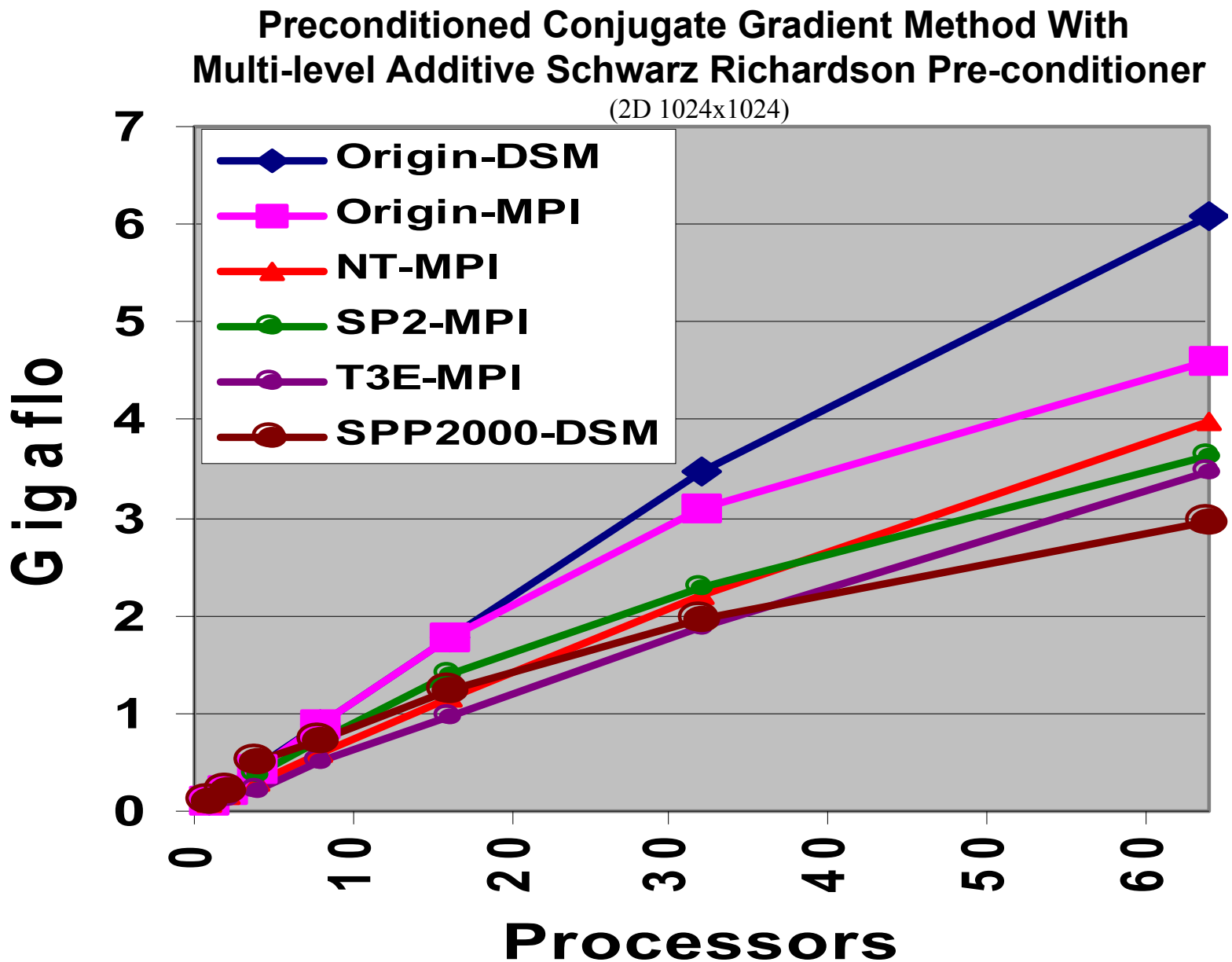




Disciplines Using the NCSA Origin 2000
CPU-Hours in March 1995



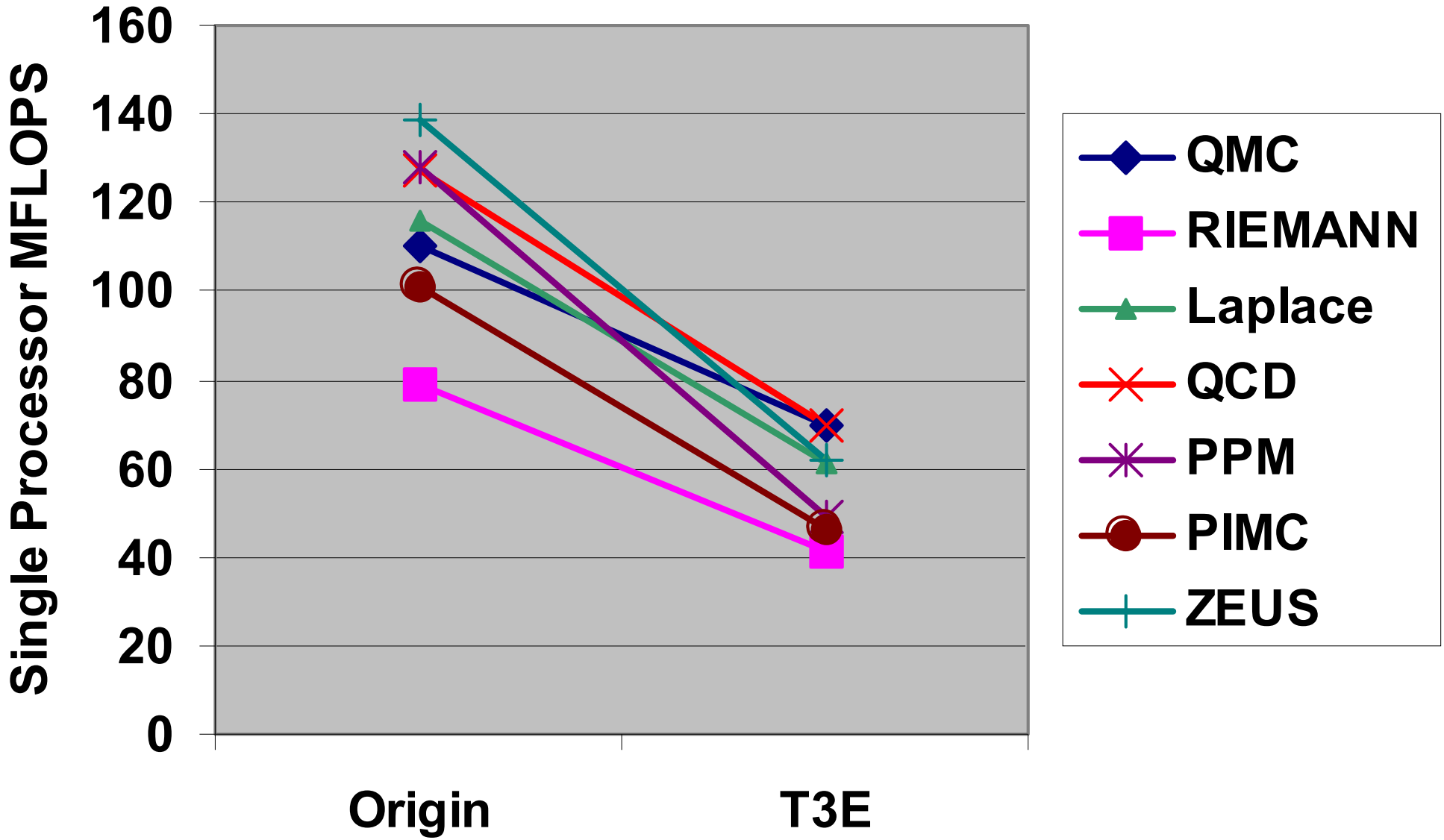
Solving 2D Navier-Stokes Kernel - Performance of Scalable Systems



Source: Danesh Tafti, NCSA

National Computational Science Alliance

A Variety of Discipline Codes - Single Processor Performance Origin vs. T3E



Alliance PACS Origin2000 Repository



Kadin Tseng, BU, Gary Jensen, NCSA, Chuck Swanson, SGI
John Connolly, U Kentucky Developing Repository for HP Exemplar

http://scv.bu.edu/SCV/Origin2000/

High-End Architecture 2000- Scalable Clusters of Shared Memory Modules

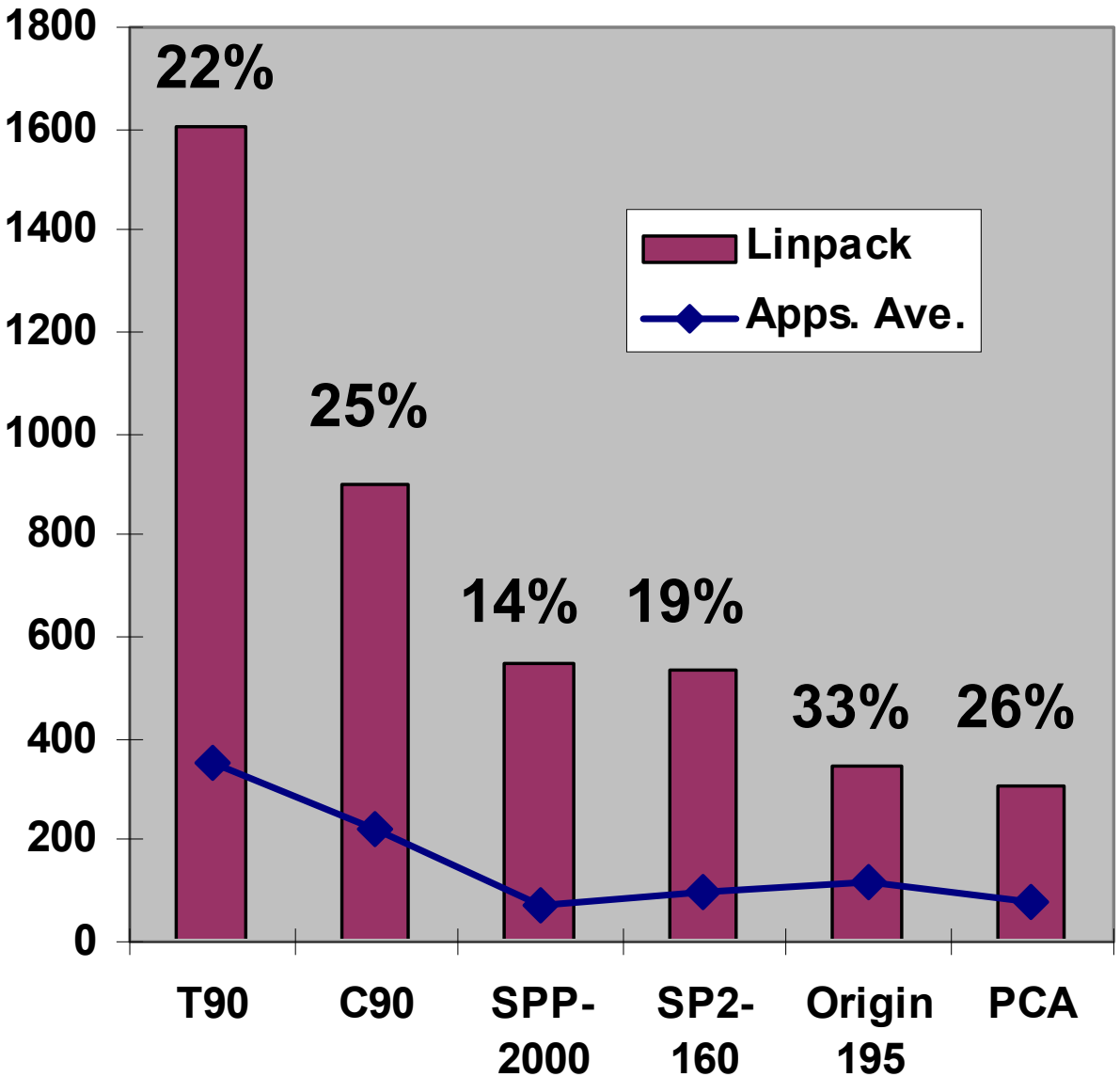
Each is 4 Teraflops Peak

- **NEC SX-5**
  - 32 x 16 vector processor SMP
  - 512 Processors
  - 8 Gigaflop Peak Processor
- **IBM SP**
  - 256 x 16 RISC Processor SMP
  - 4096 Processors
  - 1 Gigaflop Peak Processor
- **SGI Origin Follow-on**
  - 32 x 128 RISC Processor DSM
  - 4096 Processors
  - 1 Gigaflop Peak Processor

Emerging Portable Computing Standards

- HPF
- MPI
- OpenMP
- Hybrids of MPI and OpenMP

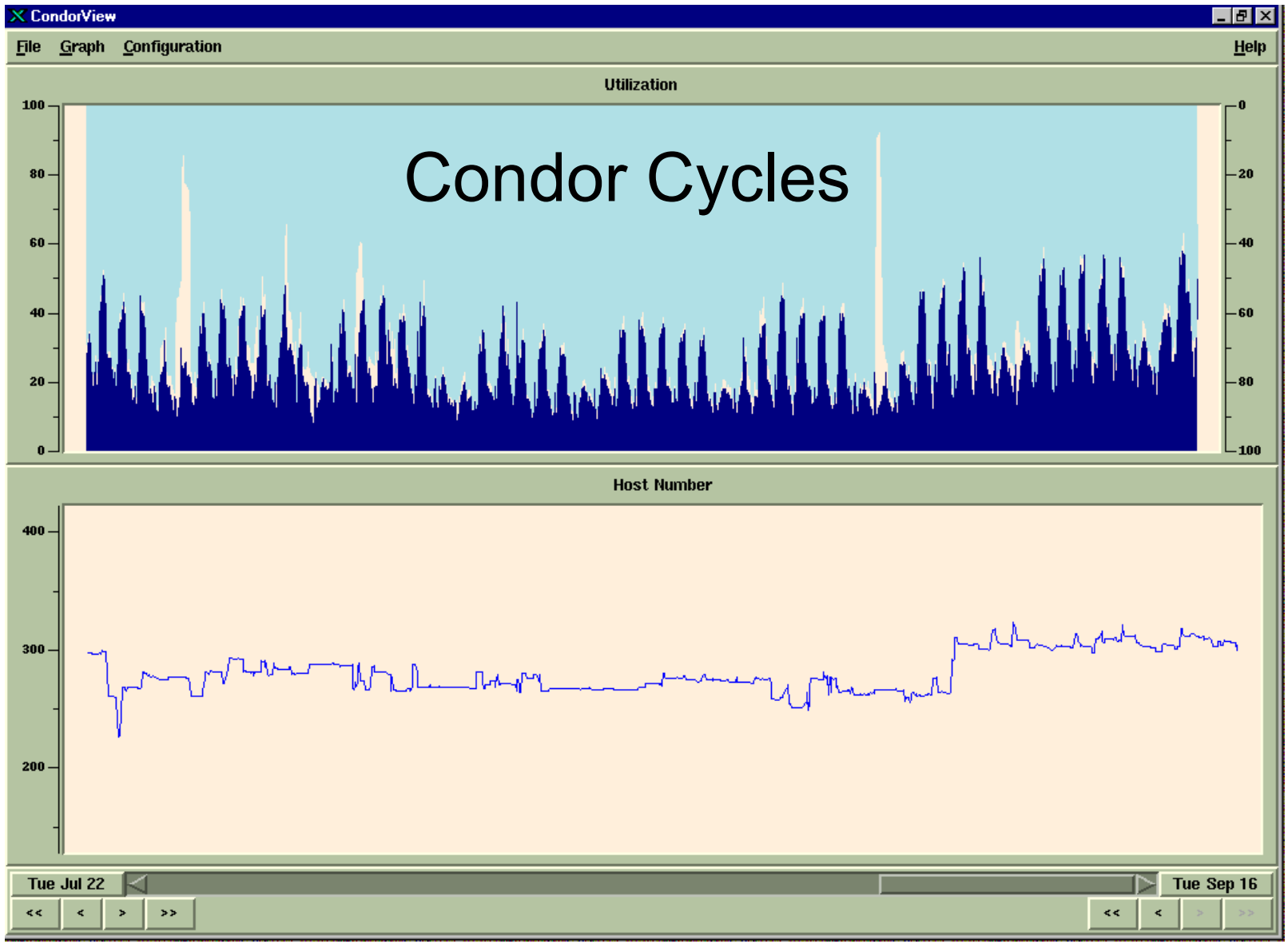
Basket of Applications Average Performance as Percentage of Linpack Performance



Applications Codes:

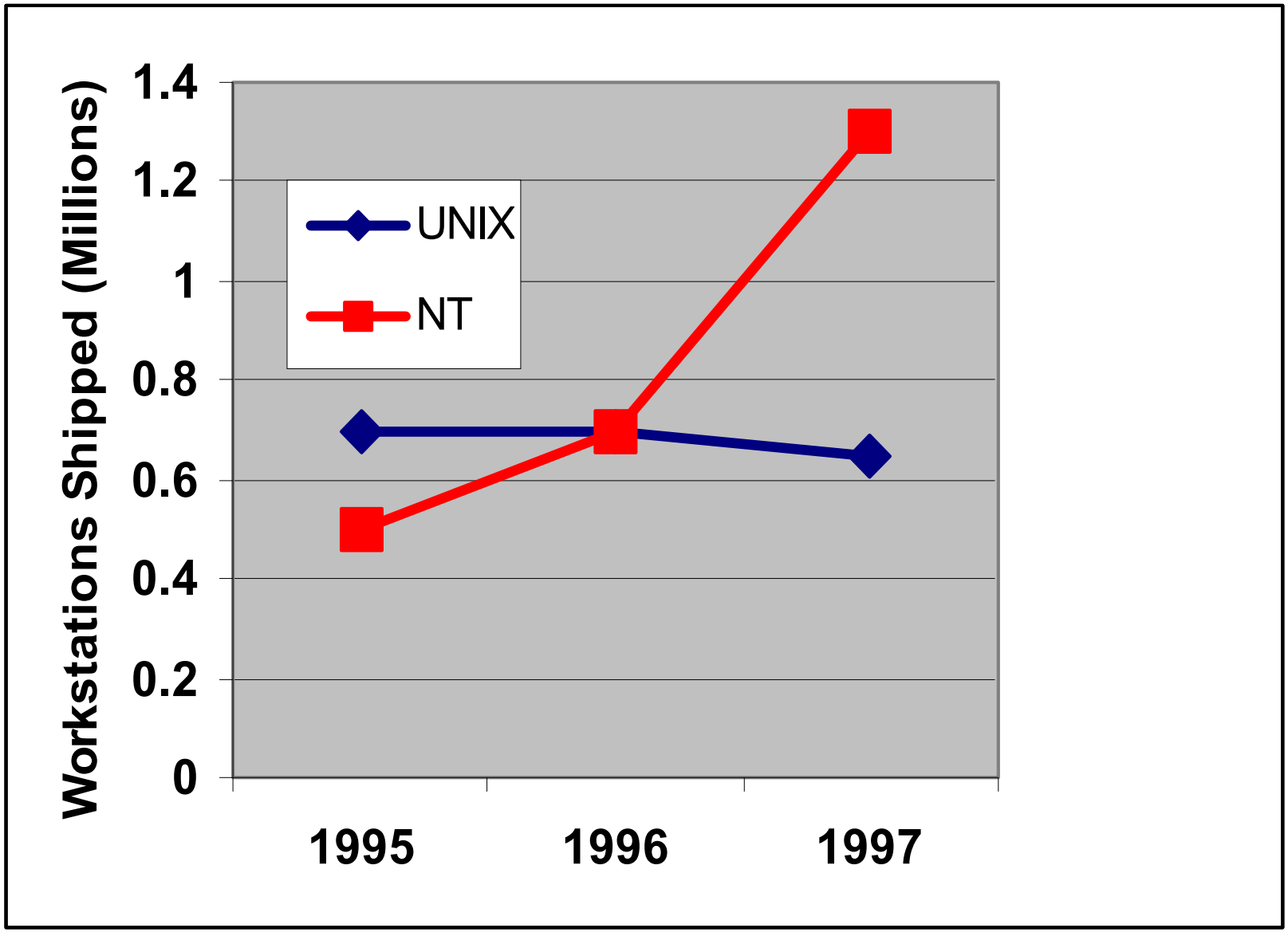
CFD
Biomolecular
Chemistry
Materials
QCD

Harnessing Distributed UNIX Workstations - University of Wisconsin Condor Pool



CondorView, Courtesy of Miron Livny, Todd Tannenbaum(UWisc)

NT Workstation Shipments Rapidly Surpassing UNIX



Source: IDC, Wall Street Journal, 3/6/98

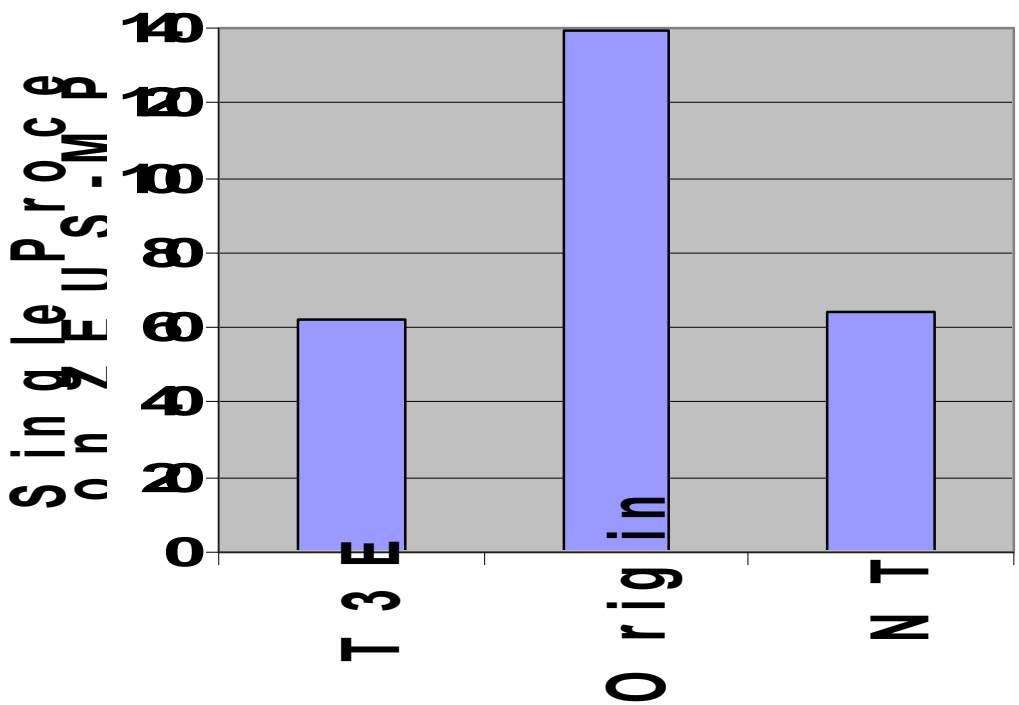
First Scaling Testing of ZEUS-MP on CRAY T3E and Origin vs. NT Supercluster

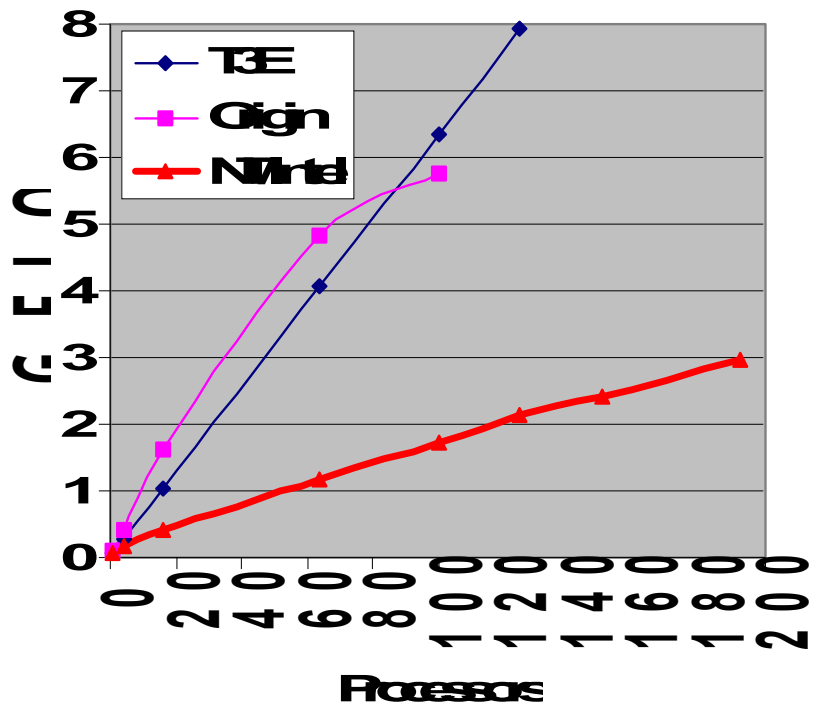
"Supercomputer performance at mail-order prices"-- Jim Gray, Microsoft

access.ncsa.uiuc.edu/CoverStories/SuperCluster/super.html

Zeus-MP Hydro Code Running Under MPI

- Alliance Cosmology Team
- Andrew Chien, UIUC
- Rob Pennington, NCSA



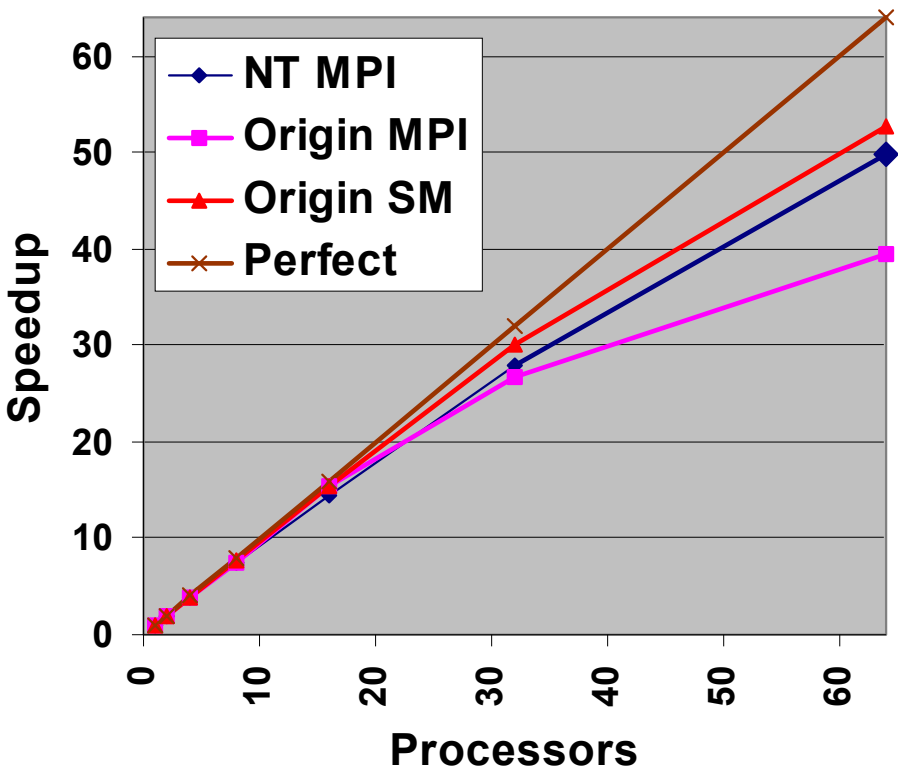


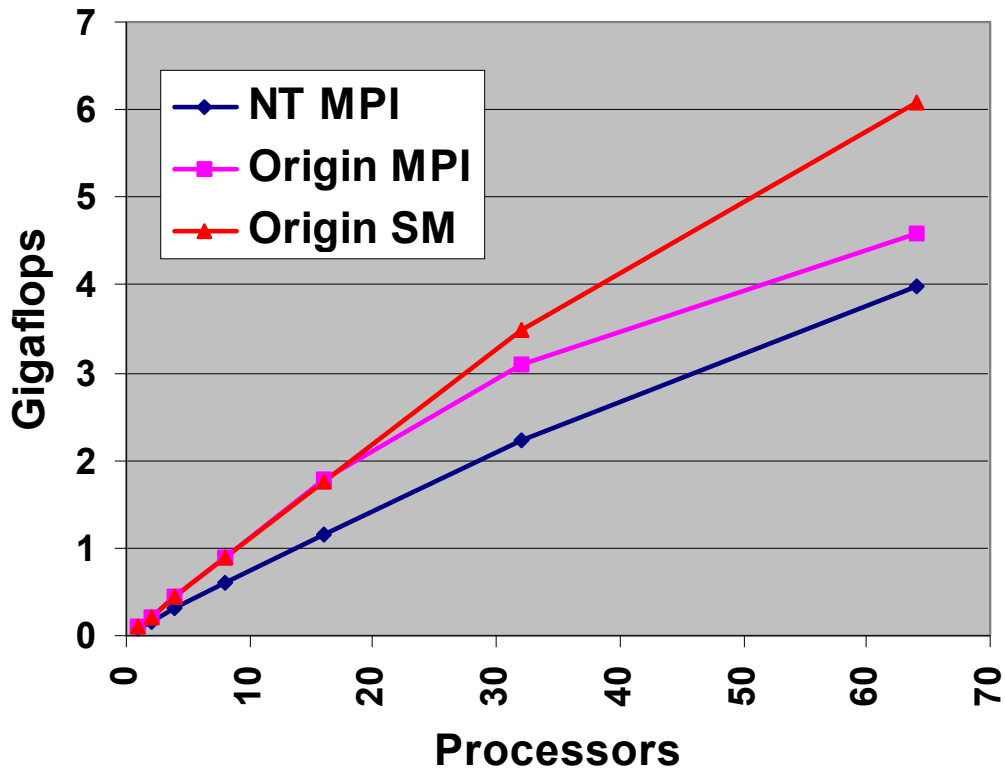
NCSA NT Supercluster
Solving Navier-Stokes Kernel

Single Processor Performance:

MIPS R10k **117 MFLOPS**

Intel Pentium II **80 MFLOPS**





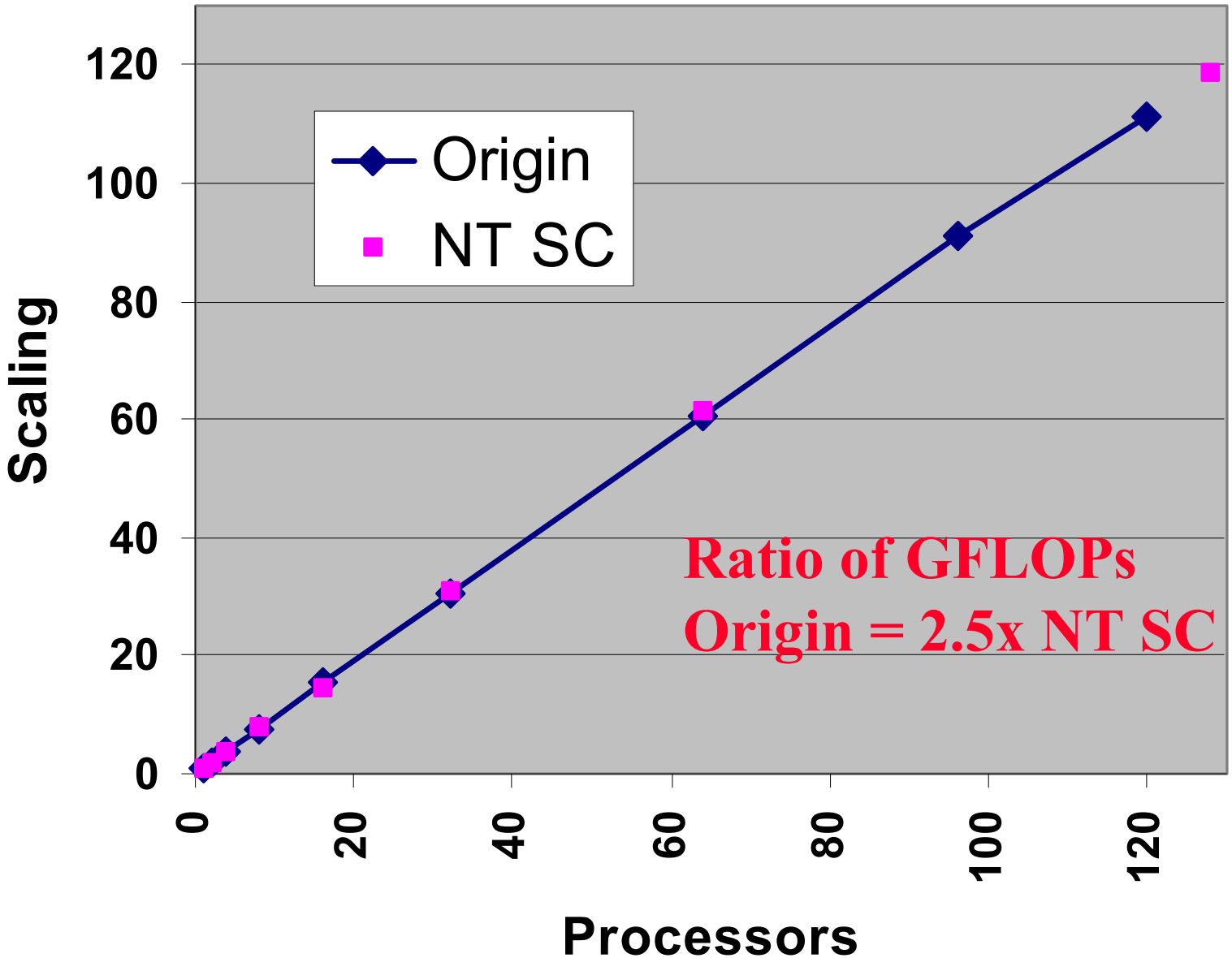
Preconditioned Conjugate Gradient Method With Multi-level Additive Schwarz Richardson Pre-conditioner

(2D 1024x1024)

Danesh Tafti, Rob Pennington, Andrew Chien NCSA

NCSA™ National Computational Science Alliance

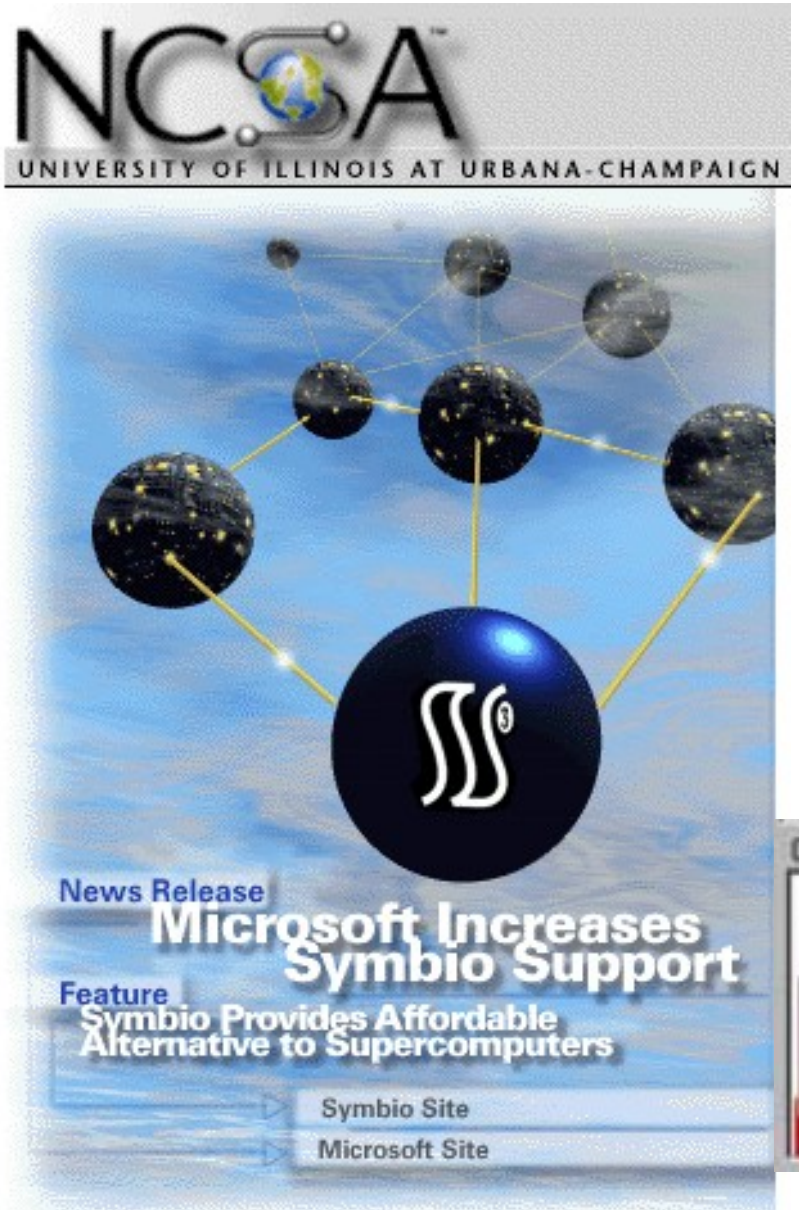
Near Perfect Scaling of Cactus - 3D Dynamic Solver for the Einstein GR Equations



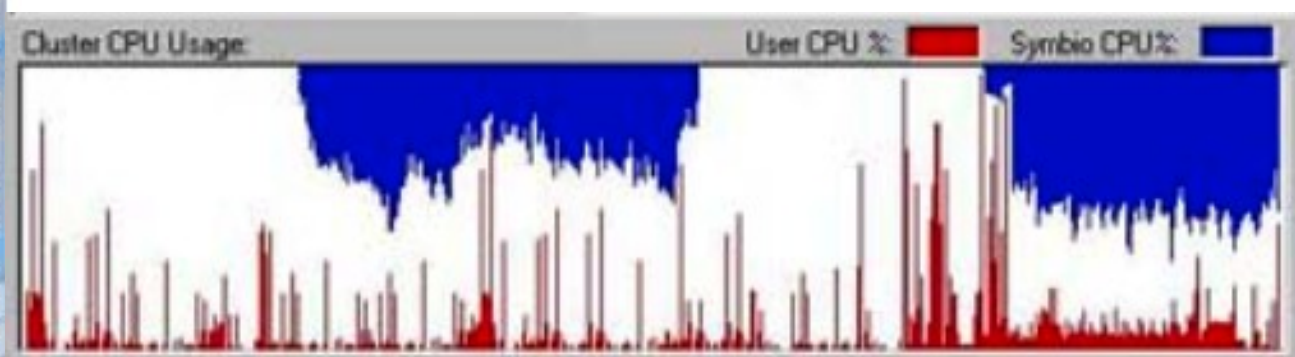
Cactus was Developed by Paul Walker, MPI-Potsdam UIUC, NCSA

Danesh Tafti, Rob Pennington, Andrew Chien NCSA

NCSA Symbio - A Distributed Object Framework Bringing Scalable Computing to NT Desktops



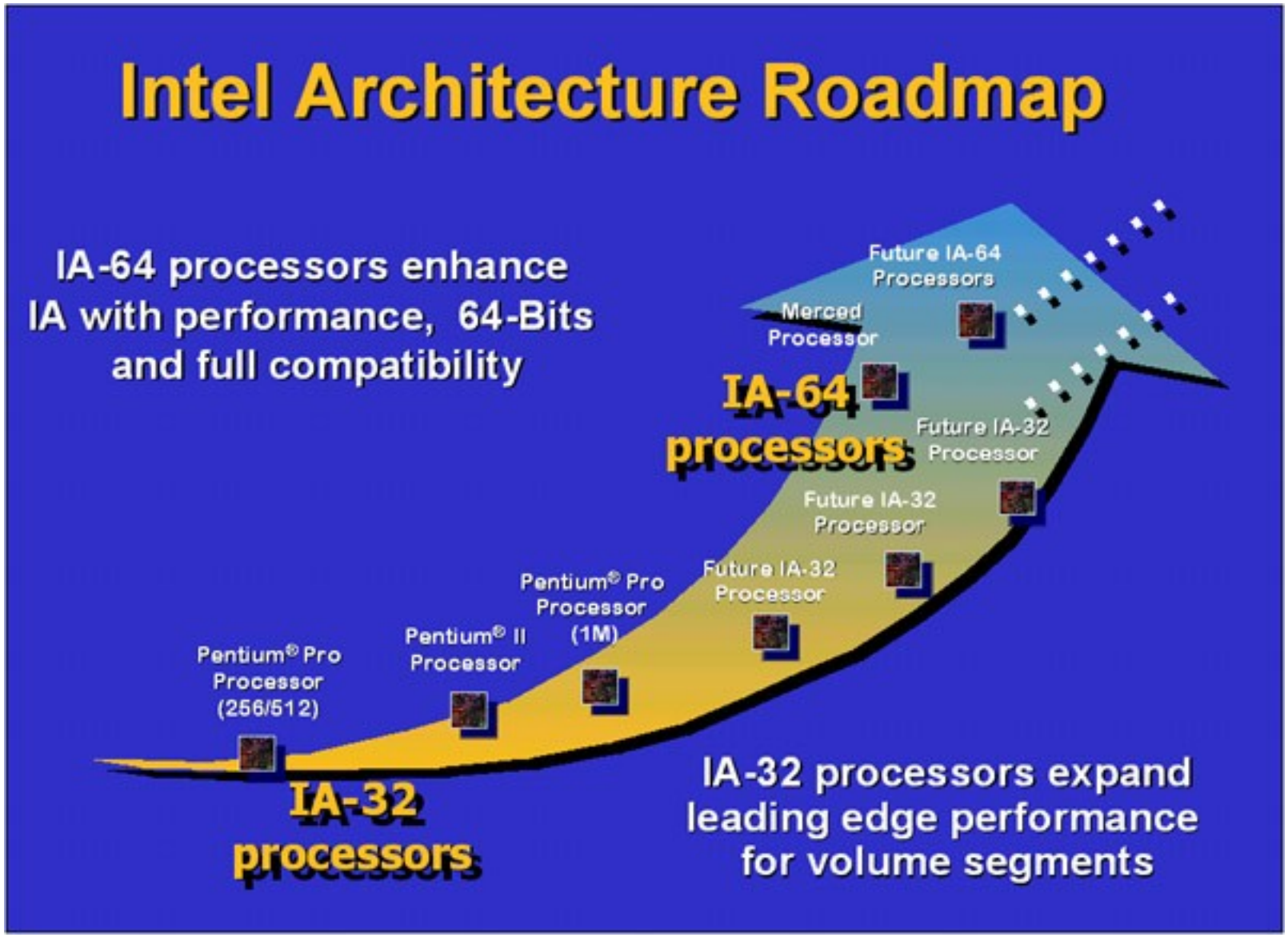
- **Parallel Computing on NT Clusters**
  - Briand Sanderson, NCSA
  - Microsoft Co-Funds Development
- **Features**
  - Based on Microsoft DCOM
  - Batch or Interactive Modes
  - Application Development Wizards
- **Current Status & Future Plans**
  - Symbio Developer Preview 2 Released
  - Princeton University Testbed



http://access.ncsa.uiuc.edu/Features/Symbio/Symbio.html

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The Road to Merced



http://developer.intel.com/solutions/archive/issue5/focus.htm#FOUR