Cornell Theory Center

Thomas Coleman, Director

Linda Callahan, Executive Director

Anthony Ingraffea, Associate Director

Ron Elber, Associate Director

David Lifka, Associate Director

Paul Redfern, Associate Director

Jeffrey Silber, Associate Director

A Center of Excellence in High-Performance Computing and Interdisciplinary Research located at Cornell University

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Over 100 Cornell Projects from Diverse Fields

- ***Agricultural, Resource, and Managerial Economics***
- ***Animal Science***
-

Cluster Computing Today

The Good

- ***Price/Performance***
- ***Computing by the Slice***

The Bad

- ***TCO is more than just purchase price and maintenance costs.***
- ***Still struggling with the same problems we have been on MPPs and NOWs for the past 10 years.***
- ***Instead of converging on a clustering standard, our efforts are fragmented and do not interoperate.***

The Ugly!

- ***Still have not moved supercomputing out of the laboratory (research, engineering and other scientific disciplines) and onto Main street.***
- ***We have yet to make parallel programming easy!***

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1996 - The Little Engine that Could!

12 Dell PowerEdge Servers

- 6 Dual Pentium II 300 Mhz (SMP)
- 256 MB RAM/Node
- 12 GB Disk/Node
- 6 Dual Pentium II 450 Mhz (SMP)
- 512 MB RAM/Node
- 12 GB Disk/Node
- Switched Ethernet (100 Mb/second)

Intel Technology For Education 2000 Grant
http://www.cs.cornell.edu/tech2000/

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Key Components for Success

User Interfaces

- ***Telnet – Seattle Lab and Microsoft built in.***
- ***Cygwin, Interix – Unix tools + look and feel***
- ***Terminal Server – Remote access to Windows GUI***
- ***Citrix Terminal Server – Remote access to Windows GUI for non-MS platforms***
- ***X Windows***

Ease of Porting from Other Environments

- ***Compilers - MS, Compaq, Intel, PGI, Gnu***
- ***Cygwin – Unix shell support and Make***
- ***Debugging – Studio, Gnu***
- ***MPIPro, MPI Software Technology, Inc.***

Batch and Interactive Job Scheduling

- ***Cluster CoNTroller, MPI Software Technology, Inc.***

Reliable Servers, Software, and Storage

- ***Windows 2000 Advanced Server – Solid!***
- ***Dell Hardware – just works!***
- ***Scalable Storage using Microsoft DFS.***

System Management

- ***Windows Management Instrumentation***
- ***CTC Domain Monitoring Tools***
- ***Software Distribution and Remote Installation***

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Velocity 1 – 256 Processors

64 Dell PowerEdge 6350 Servers

- Quad Pentium III Xeon 500 Mhz (SMP)
- 4 GB RAM/Node
- 2 MB Cache/Processor
- 50 GB Disk/Node (Raid 0 Stripe Set)
- Emulex CLan Interconnect (100 MB/second)
- Switched Ethernet (100 Mb/second)

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Velocity 1 Plus Cluster - 128 Processors

64 Dell PowerEdge 2450 Servers

- Dual Pentium III 733 Mhz
- 2 GB RAM/Node
- 256 KB Cache/Processor
- 27 GB Disk (RAID 0)/Node
- Emulex CLan Interconnect (100 MB/second)
- Switched Ethernet (100 Mb/second)

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Special Purpose CTC Clusters

32 Dell PowerEdge 2450 Servers (Application Center - .Net)

- *Dual Processor Pentium III 933 Mhz*
- *256 KB Cache/Processor*
- *2 GB RAM/Node*
- *27 GB Disk (RAID 0)/Node*

8 Dell PowerEdge 1550 Servers (NASA/NYS Educluster)

- *Dual Processor Pentium III 1 Ghz*
- *256 KB Cache/Processor*
- *2 GB RAM/Node*
- *27 GB Disk (RAID 0)/Node*

8 Dell PowerEdge 1550 Servers Development Cluster, 16 processors

- *Dual Processor Pentium III 866 MHz*
- *256 KB Cache/Processors*
- *2 GB RAM/Node*
- *27 GB Disk (RAID 0)/Node*
- *Emulex CLan Interconnect (100 MB/second)*
- *15 Minute Job Limit*

36 Dell PowerEdge Servers (Serial Nodes)

- *Pentium III 600+ MHz*
- *256 KB Cache/Processor*
- *1 GB RAM/Node*
- *27 GB Disk (RAID 0)/Node*

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Dedicated Clusters

ARS/USDA Cluster for Agricultural Bioinformatics, 48 processors

- *4 Dell PowerEdge 6300 Servers*
- *Quad Processor SMP 400 Mhz Pentium II Xeons, 1 GB Ram, 56 GB Disk*
- *8 Dell PowerEdge 6350 Servers*
- *Quad Processor SMP 550 Mhz Pentium III Xeons, 1 GB Ram, 54 GB Disk*
- *Gigabit switched Ethernet*
- *2 TB Dell Power Vault Storage Equipment*

Social and Economics Research Cluster, 32 processors

- *8 Dell PowerEdge 6350 Servers*
- *Quad Processor SMP 550 Mhz Pentium III Xeons*
- *1 GB RAM/Node*
- *54 GB Disk/Node*
- *Gigabit switched Ethernet*
- *3 TB Dell Power Vault Storage Equipment*

Tri-Institutional/Computational Materials Institute Cluster, 256 processors

- *128 Dell PowerEdge 1550 Servers*
- *Dual Processor Pentium III 1 Ghz*
- *2 GB RAM/Node*
- *27 GB Disk (RAID 0)/Node*
- *Emulex CLan Interconnect*

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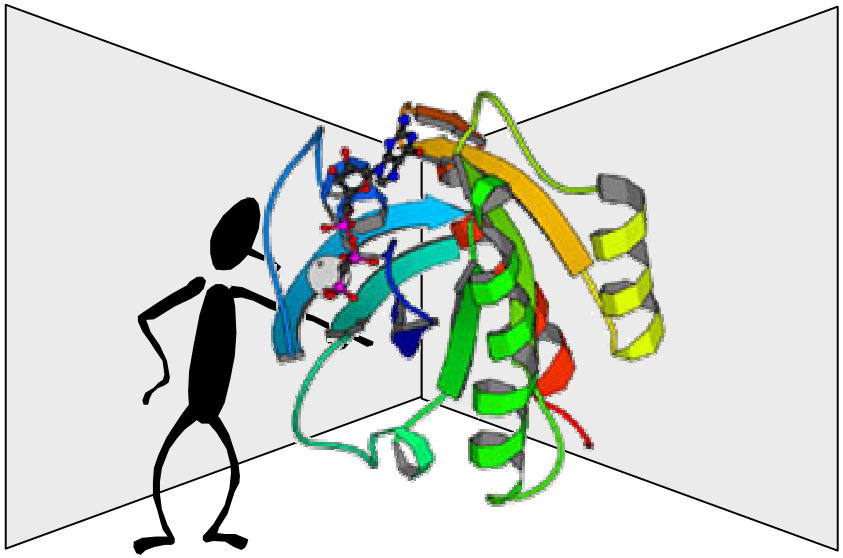
Windows Based CAVE



- *3 Dual Processor Dell Precision 620 Workstations*
- *Wildcat 4210 Graphics Adapters*
- *1 GB RAM/Workstation*
- *Emulex CLan Interconnect*

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Windows 2000 Cluster Management

Job Scheduling & Resource Management

- ***Cluster CoNTroller***
  - ***www.mpi-softtech.com/products/cluster_controller***

Resource Monitoring

- ***Windows Management Instrumentation***
  - ***msdn.microsoft.com/library/en-us/dnwmi/html/wmicim.asp***
- ***Microsoft Operations Manager***
  - ***www.microsoft.com/mom/***
- ***Perl & Python***
  - ***www.activestate.com***

System Installations

- ***Symantec Ghost***
  - ***enterprisesecurity.symantec.com/content/ProductJump.cfm?Product=3&PID=na***
- ***WinInstall LE***
  - ***www.microsoft.com/WINDOWS2000/techinfo/planning/management/veritas.asp***

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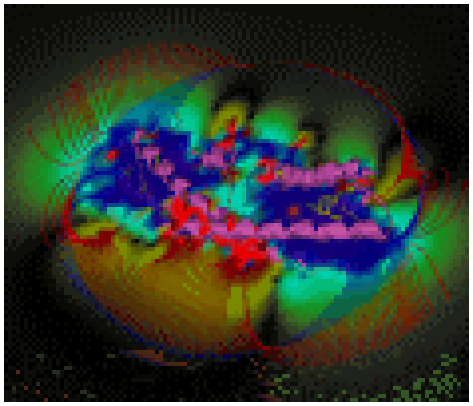
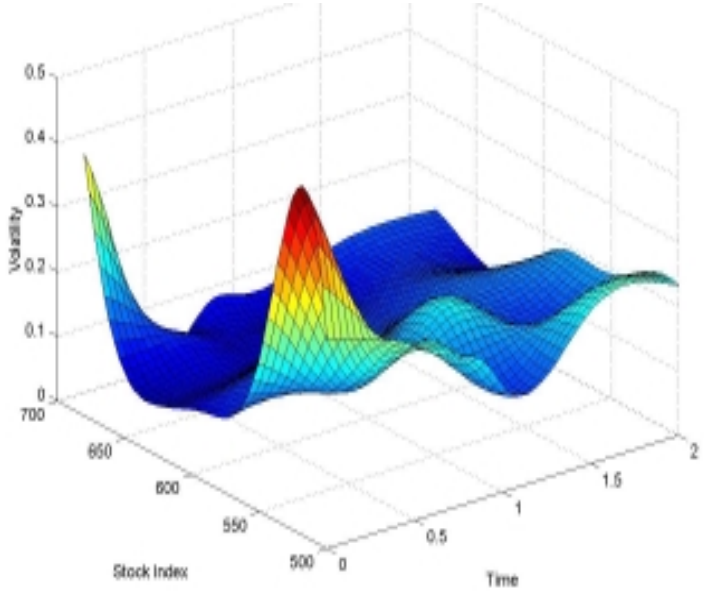
Strategic Applications

Bioinformatics



Computational Finance



Engineering Design and Analysis On Demand

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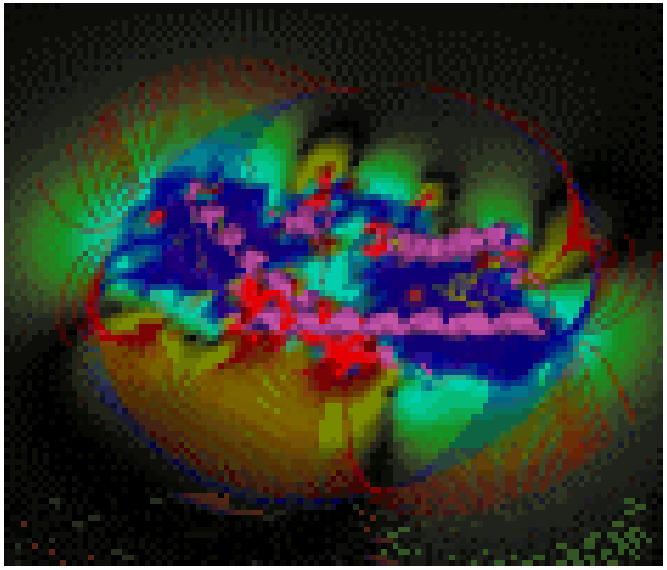
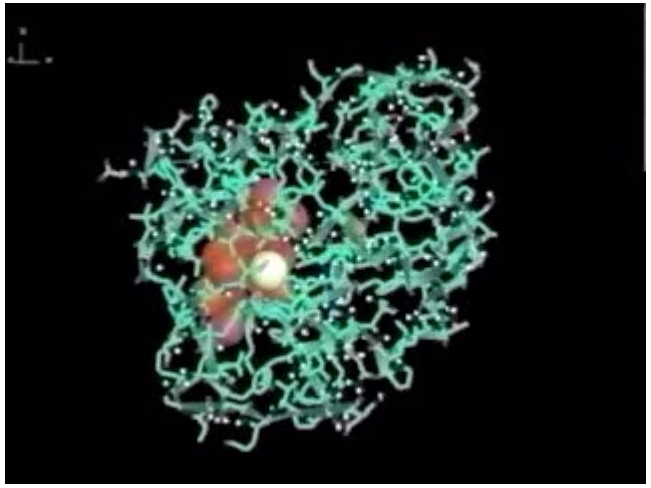
Protein Folding/Structural Biology

Ron Elber, Harold Scheraga



Collaborators at Hauptman-Woodward Medical Research Institute; Mt. Sinai School of Medicine, U. Rochester

Cornell Faculty from Computer Science, Chemestry, and Biochemestry



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Protein Folding Per/Processor Performance

Results on different computers for a protein structures:

Machine	System	CPU	CPU speed [MHz]	compiler	Energy evaluations per second
Blue Horizon (SP San Diego)	AIX 4	Power3	222	xlf	44.3
Linux cluster	Linux 2.2	PentiumIII	650	PGF 3.1	59.1
Velocity (CTC)	Win 2000	PentiumIII Xeon	500	df v6.1	46.0
Velocity+ (CTC)	Win 2000	PentiumIII	733	df v6.1	59.2

Results on different computers for (a /b or b proteins):

Machine	System	CPU	CPU speed [MHz]	compiler	Energy evaluations per second
Blue Horizon (SP San Diego)	AIX 4	Power3	222	xlf	15.0
Linux cluster	Linux 2.2	PentiumIII	650	PGF 3.1	21.0
Velocity (CTC)	Win 2000	PentiumIII Xeon	500	df v6.1	16.9
Velocity+ (CTC)	Win 2000	PentiumIII	733	df v6.1	22.4

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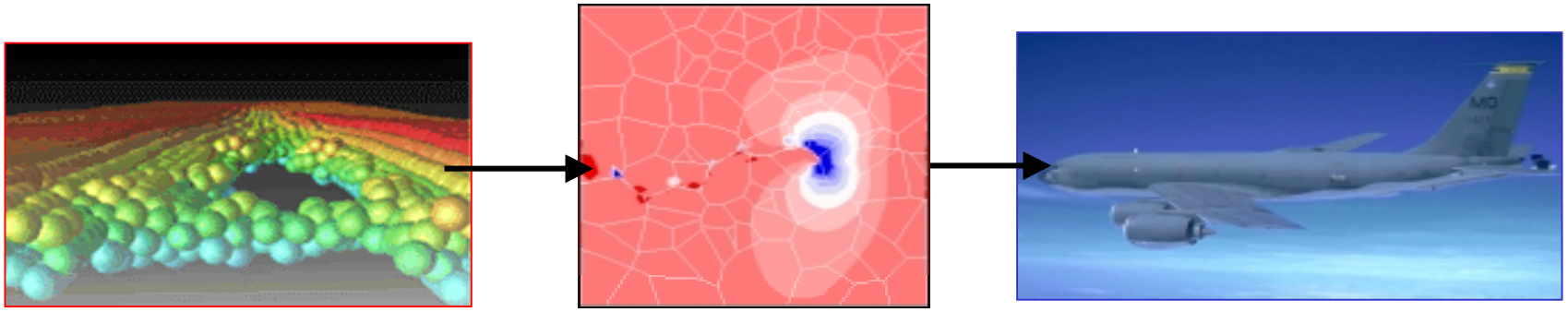
Computational Materials Institute

Anthony Ingraffea, Keshav Pingali



10^{-10} m 10^{-5} m 10^{2} m

Mission:

- ***Connect nano-scale and intermediate scale understanding of "old" materials to new designs and life-extension of existing designs;***
- ***Create simulation tools that support virtual design and testing of new materials;***
- ***Compliment the theoretical/experimental activities of the Cornell Center for Materials Research.***

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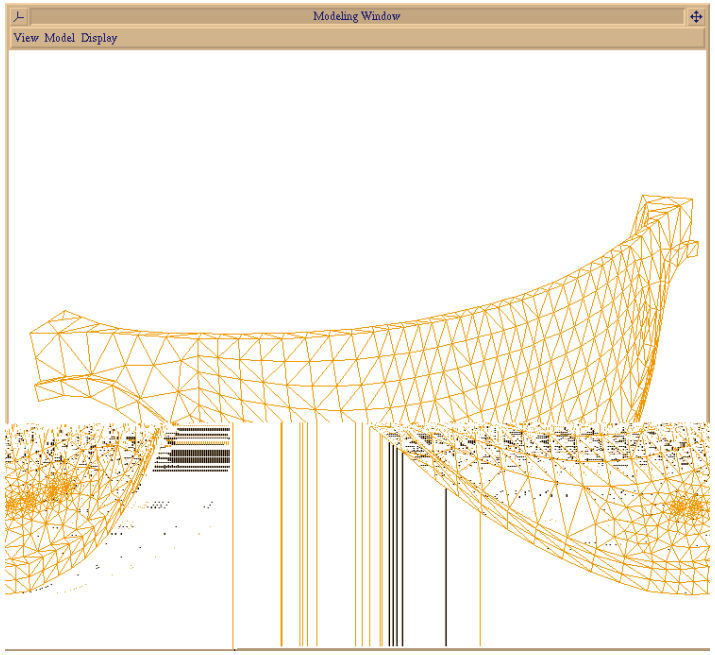
Concrete Dam

Vertices : 86,325 Tetrahedra : 401,124 dof



Machine	Processors	Time/Iteration
SP2	16x1	0.48
Velocity	4x4	0.53
Velocity	8x2	0.43
Velocity	16x1	0.39
SP2	32x1	0.27
Velocity	8x4	0.27
Velocity	16x2	0.22
Velocity	32x1	0.2
SP2	64x1	0.16
Velocity	16x4	0.15
Velocity	32x2	0.12
Velocity	64x1	0.12

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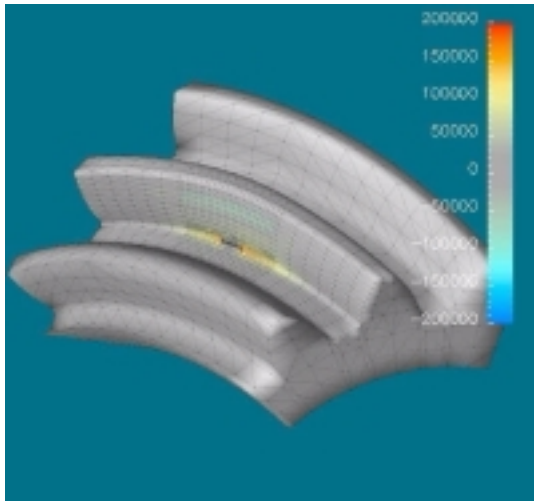
Fatigue Cracks in Spiral Bevel Power Transmission Gear

Vertices : 344,777 Tetrahedra : 1,535,943 dof



Machine	Processors	Time/Iteration
Velocity	16x1	1.54
Velocity	16x2	0.87
Velocity	32x1	0.78
Velocity	16x4	0.55
Velocity	32x2	0.44
Velocity	64x1	0.4
Velocity	20x4	0.43
Velocity	40x2	0.36
Velocity	64x2	0.23

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E-Science & Finance

Today

Serloopp

www.tc.cornell.edu/Research/Biomed/Dissemination/web.computing.asp

Fracture mechanics

Computational finance

Tomorrow

.Net! www.microsoft.com/net/

Application Center www.microsoft.com/applicationcenter/

Data Center www.microsoft.com/windows2000/guide/datacenter/overview/default.asp

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Reliability

Some Business Applications

- ***Barnes&Noble.com 99.98%***
- ***CBSMarketWatch.com 99.98%***
- ***Buy.com 99.98%***
- ***NASDAQ.com 99.97%***
- ***FreeMarkets.com 99.999%***

CTC HPC Experience

- ***99.9986% the first three months we ran Windows 2000***
- ***99.99999% the past two months!***
- ***Working on a Standard Reliability Benchmark***

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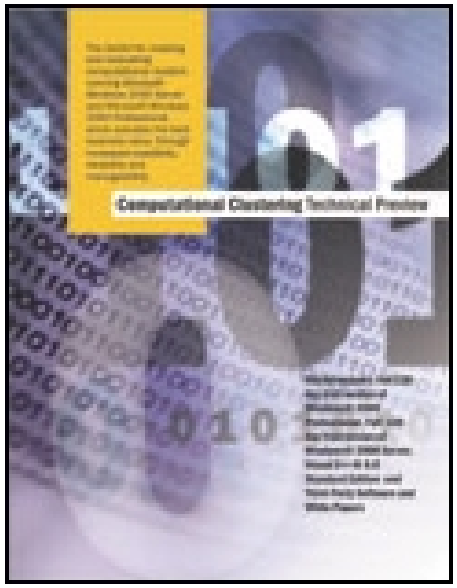
Microsoft
High-Performance
Computing



- ***Microsoft HPC - From Classics to Clusters***
  http://www.microsoft.com/windows2000/hpc

- ***Microsoft HPC Resource Kit***
  https://microsoft.order-1.com/cctp/

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