Visit booth 540 to learn how NASA is contributing to and using high-end computing to advance the Vision for Space Exploration.
Welcome, SC2004 participants,

I am pleased to welcome you to the 16th annual Supercomputing Conference in Pittsburgh. The SC2004 conference theme, “Bridging Communities,” will bring together representatives from many technical communities to exchange ideas, share recent successes, and plan for the future of supercomputing.

This year, NASA's demonstrations and presentations represent work being done within each of the agency's four new Mission Directorates: Science, Aeronautics Research, Exploration Systems, and Space Operations. These NASA Mission Directorates were formed earlier this year in response to President Bush's charter to NASA to transform its organization in order to advance our nation's new Vision for Space Exploration.

An important part of NASA's transformation includes high-end computing. We are delighted to introduce a major new supercomputer called “Columbia,” a 10,240-processor system that increases NASA's computing capability ten-fold and revitalizes the agency's high-end computing efforts. Constructed in just four months, the newly completed Columbia is already being used to make major contributions to several key projects of the four Mission Directorates.

At SC2004, you will learn about work being conducted at seven of the NASA field centers. These projects include the design of NASA's X-43A scramjet-powered vehicle, which holds the Guinness World Record for the fastest air-breathing aircraft at Mach seven. High-performance computing contributed to this record-breaking flight. You will also hear how a climate model, the Finite Volume General Circulation Model (fvGCM), is currently being run on Columbia to improve hurricane track predictions. With this model, scientists are obtaining accurate hurricane forecasts five days ahead of time—three days sooner than other prediction tools.

Another NASA highlight at the conference is a computational framework for design and analysis of the entire fuel supply system of a liquid rocket engine, including high-fidelity unsteady turbopump flow analysis. We will present analysis results along with performance data of the simulation runs on Columbia. In addition, advances in the emerging field of nanophase thermal and structural composite materials will be presented. These materials are expected to revolutionize the capabilities of virtually every system for future robotic and human exploration missions of the moon and Mars.

We hope you have an opportunity to learn about these and other impressive supercomputing applications that are a part of the effort to support NASA’s four missions through high-end computing.

— Sean O'Keefe
Aeronautics Research Mission Directorate

The goal of the Aeronautics Research Mission Directorate is to pursue research and technology development that: Protects air travelers and the public, protects the environment; increases mobility, enhances national security; and pioneers revolutionary aeronautical concepts for science and exploration. The objective of the Aeronautics Research Mission Directorate is to pioneer and validate high-value technologies that enable new exploration and discovery, and improve the quality of life through practical applications.

X-43 Scramjet-Powered Vehicle

Design studies using computational fluid dynamics (CFD) methods, structural finite-element analysis methods, and the interaction between the two disciplines have been critical to the development of the X-43A scramjet-powered vehicle, which holds the Guinness World Record for the fastest air-breathing aircraft, at Mach seven. High-performance computers were employed to develop the aerodynamic database for the flight hardware at conditions where wind tunnel testing capability was not available.

An interactive three-dimensional (3D) computer graphics display was developed to visualize the performance of the vehicle during the flight. High-resolution terrain imagery, detailed 3D aircraft models, and high-performance network protocols are integrated to provide an informative real-time flight display, which allows the record-breaking flight events to be seen at a glance. The X-43 program is a partnership between Langley Research Center and Dryden Flight Research Center. More information can be found at: [http://www.nasa.gov/missions/research/x43-main.html](http://www.nasa.gov/missions/research/x43-main.html).

Advanced Combustion Modeling for Complex Turbulent Flows

The next generation of aircraft engines will need to pass stricter efficiency and emission tests. NASA's Ultra-Efficient Engine Technology (UEET) program has set an ambitious goal of a 70 percent reduction of NOx emissions and a 15 percent increase in fuel efficiency of aircraft engines. State-of-the-art combustion tools developed at Stanford's Center for Turbulence Research (CTR), as part of this program, will be demonstrated. In the last decade, CTR has spearheaded a multi-physics-based combustion modeling program. Key technologies have been transferred to the aerospace industry and are currently being used for engine simulations. In this demo, the next-generation combustion modeling tools that integrate a very high level of detailed physics into advanced flow simulation codes will be showcased.

Parallel Performance Characterization of Columbia

Using a collection of benchmark problems of increasing levels of realism and computational effort, the strengths and limitations of the 10,240-processor Columbia system to deliver supercomputing value to application scientists will be characterized. Scientists need to be able to determine if and how they can utilize Columbia to carry extreme workloads, either in terms of ultra-large applications that cannot be run otherwise (capability), or in terms of very large ensembles of medium-scale applications to populate response matrices (capacity). Existing application benchmarks that scale from a small number of processors to the entire machine, and that highlight different issues in running supercomputing-class applications, such as the various types of memory access, file I/O, inter- and intra-node communications and parallelization paradigms are selected. More information can be found at: [http://www.nas.nasa.gov/Software/NPB/](http://www.nas.nasa.gov/Software/NPB/).

Enabling Computations for Vehicle Systems

Computational methods that complement theory and experiment for the design of future aircraft within the NASA Vehicle Systems program are highlighted. Technologies are being developed for a range of vehicle sectors and will exploit new design concepts, such as active flow control, blended wing bodies, shaped supersonic booms, or slotted cruise wing sections, to enhance mobility and protect the environment. NASA and its partners are working together on simulations aimed at the discovery of new physical mechanisms, validation of engineering models, and evaluation and refinement of breakthrough concepts. This demonstration provides glimpses into selective aspects of such simulations, including holistic simulations of laminar-turbulent transition for advanced drag reduction concepts and adaptive analysis and design methods for large-scale configurations.

Blade-Out Simulations

A demonstration of a virtual reality post-processor for LSDYNA-based structural analysis will be given. Datasets shown include structural failures of turbine machinery blades. More information can be found at: [http://ballistics.grc.nasa.gov](http://ballistics.grc.nasa.gov).

Analysis of LDIMEMS Technology Using the National Combustion Code

The National Combustion Code (NCC) was used to evaluate the emissions performance of the current Lean Direct Injection with Micro Electro-Mechanical Systems (LDIMEMS) concept. The LDIMEMS concept uses 46 mini-radial swirlers, with fuel injection for each swirler. An assumption of periodicity made the problem more computationally realistic. Using two sets of translational periodic boundary conditions, a “single injector of many” computational model was created. This assumption was considered valid because a majority of the swirlers are in the core flow, away from the combustor walls. Steady-state complex test cases and show excellent agreement with experimental data.
conditions were assumed at operating pressures of fifteen atmospheres, at a fuel-air ratio of 0.0351. Two combustion models were used. The computational models ran on the SGI Origin 3000 and Altix 3000 clusters at NASA Ames Research Center utilizing 128 processors each. Results from NCC calculations show that the LDIMEMS is effective in reducing NOx emissions [Nitric oxide (NO) and nitrogen dioxide (NO₂)]. More information can be found at: http://www.grc.nasa.gov/WWW/RT2002/5000/5830iannetti.html.

Numerical Prediction of Non-Reacting and Reacting Flow in a Model Gas Turbine Combustor

The three-dimensional, viscous, turbulent, reacting and non-reacting flow characteristics of a model gas turbine combustor operating on air/methane are simulated via an unstructured and massively parallel Reynolds-Averaged Navier-Stokes (RANS) code called the National Combustion Code (NCC) developed at NASA Glenn Research Center. The goal of this work is to verify that the code correctly models real-world situations and can be helpful in designing gas turbine combustors that cleanly burn fuel, thus reducing the CO and NOx produced as a result. The code was run using approximately 2.5 million grid points, solving 10 partial differential equations, and utilizing a cluster of 400 processors (SGI Origin 3000 at NASA Ames Research Center). The results of the run were achieved in about 24 hours. Data shown in a 3D immersive environment will include the reacting flows and temperature contours of the air/methane mixture as it is being burned in the combustor.

Vertical Take-off Vehicle in Cross-Flow

This private industry-partnered effort utilizes the Information Power Grid (IPG) to study fluid flow phenomena for a Vertical Take-Off and Landing (VTOL) Vehicle. A simplified geometry is shown which allows quick exploration of hot gas ingestion, vortex size and dynamics, cross-flow, and jet-vortex-engine inlet interactions.

Advanced Aerospace Materials by Design

Advances in the emerging field of nanophase thermal and structural composite materials; materials with embedded sensors and actuators for morphing structures; lightweight composite materials for energy and power storage; and large surface area materials for in-situ resource generation and waste recycling, are expected to revolutionize the capabilities of virtually every system for future robotic and human exploration missions to the moon and Mars. This exhibit will describe the porting and scaling of multi-scale physics-based core computer simulation codes to NASA’s new 10,240-processor supercomputer, Columbia, for discovering and designing carbon nanotube-polymer composite materials for lightweight load-bearing structural and thermal protection applications. More information can be found at: http://people.nas.nasa.gov/~deepak/home.html.
Science Mission Directorate

The Science Mission Directorate carries out research, flight and robotic missions, and development of advanced technologies to expand our understanding of the Earth and the universe beyond. Activities include: Scientific exploration of the Earth, moon, Mars and beyond; Exploration of the origins and evolution of the solar system and of life within it; Transferring the knowledge gained from Earth studies to the exploration of the solar system, and vice versa; and Showcasing the amazing and unexpected discoveries we make every day to inspire the next generation of explorers.

Tool-Driven Optimization of an Astrophysics Application

This demonstration will show how Computer-Aided Parallelization and Optimizer (CAPO), a parallelization tool developed at the NASA Advanced Supercomputing Division, and Paraver, a performance tool from the European Center for Parallelism, were used to optimize an application code from the Science Mission Directorate. The target simulation was NIRVANA, a magnetohydrodynamic code used to study aspects of planet formation and accretion of gas onto the central star. Before using these tools, the application had been parallelized using compiler switches on the SGI Origin, producing a speed-up of only 1.4 when four processors were used, with almost no scalability past that. With the assistance of these tools, in one week, the code’s speed-up increased to 3.8 on 4 processors, 12 times on 16, and 35 times on 64 processors.

Solar Simulation

The objective of simulating the surface region and interior of the sun’s convection zone is to provide understanding of the tachocline at the base of the convection zone, the differential rotation generated by global convective motions, and the supergranules that are observed on the solar surface. Two large-scale simulation codes are used, one for the global dynamics in spherical coordinates, and another for the local surface events in Cartesian geometry. The NASA program, Living with a Star: Sun-Earth Connection, collaborates with the Helioseismic and Magnetic Imager instrument developers for the Solar Dynamics Observatory satellite on this work.

The NASA Finite Volume General Circulation Model (fvGCM)

The fvGCM is a global climate and weather prediction model traditionally used for long-term climate simulations at a coarse (~100 km) horizontal resolution. Recently, the fvGCM has been running on Columbia (an SGI Altix supercomputer at the NASA Advanced Supercomputing Division), producing real-time, high-resolution (~25 km) weather forecasts focused on improving hurricane track and intensity forecasts. The fvGCM has been remarkably successful during the active 2004 Atlantic hurricane season, providing landfall forecasts with an accuracy of ~100 km, up to five days in advance. This record marks an improvement in advanced warning beyond the typical two- to three-day lead time. Forecasts of hurricanes Charley, Frances, Ivan, and Jeanne will be featured, and current real-time weather forecasts will be displayed. More information can be found at: http://fvncep.gsfc.nasa.gov.

The Earth System Modeling Framework and its Applications

The Earth System Modeling Framework (ESMF) is a national-scale collaboration to build a software system that allows weather and climate model components from different researchers to operate together on parallel supercomputers. The ESMF team includes leading modeling efforts at NASA, the National Oceanic and Atmospheric Administration, the National Science Foundation, the Department of Energy (DOE), the Department of Defense, and academia. Their coupled modeling systems run on multi-teraflop-capable systems across the country. Goddard Space Flight Center researchers will show ESMF field tests that couple atmosphere models, ocean models, and data assimilation systems from several institutions, in entirely new configurations. They will also demonstrate prototypes combining ESMF with the DOE’s Common Component Architecture. More information can be found at: http://www.esmf.ucar.edu/.

Clemson University’s Parallel Architecture Research Laboratory

The Parallel Architecture Research Laboratory (PARL) mission is to provide science and engineering researchers and professionals that are not in high-performance computing (HPC) access to advanced HPC systems, including parallel and distributed systems. Software under development includes PVFS2, a next-generation parallel file system for Linux clusters that provides concurrent access to data distributed across a (possibly large) collection of servers. In addition, PARL is also enhancing its Coven problem-solving environment for development, execution, and maintenance of parallel applications. PARL developed BeoSim, a simulation tool used to study resource co-allocation in large parallel and distributed systems, including grids. More information can be found at: http://www.parl.clemson.edu.

Chombo Framework for Block-Structured AMR Applications

With NASA funding, Lawrence Berkeley National Laboratory scientists are developing the Chombo software framework for implementing block-structured adaptive mesh refinement (AMR) algorithms for the solution of computationally intensive problems in star formation, microgravity research, and space physics. Algorithm components in development include finite-volume techniques for representing irregular geometries and multi-fluid interfaces, along with techniques for particles
in incompressible fluids. All Chombo libraries and applications are developed on parallel supercomputers, with scalability to 1,000 processors. Scientists will show results using the ChomboVis tool, which provides an interpretive environment for manipulating and visualizing AMR data. More information can be found at: http://davis.lbl.gov/NASA.

**IBEAM: Developing an AMR Framework for Astrophysical Modeling**

Interoperability Based Environment for Adaptive Meshes (IBEAM) is an object-oriented, component-based framework for adaptive mesh simulations of astrophysical phenomena on massively parallel architectures. The project is a cooperative venture involving Goddard Space Flight Center, the University of Illinois at Urbana-Champaign, the University of Chicago, the State University of New York at Stony Brook, and Marshall Space Flight Center/Universities Space Research Association. IBEAM components will provide the capability to simulate hydrodynamics, radiation transport, self-gravity, and a variety of other physical processes. The testbed problem used is the modeling of light curves from gamma ray bursts observed by NASA's Compton Gamma Ray Observatory. This high-performance computing challenge necessitates representing matter moving at ultrarelativistic speeds (greater than 99 percent of the speed of light). More information can be found at: http://www.ibeam.org.

**Exploring the Circulation and Climate of the Ocean**

Researchers from the NASA Advanced Supercomputing Division, Jet Propulsion Laboratory, and the Massachusetts Institute of Technology (MIT) have partnered to dramatically accelerate development of a global eddy-resolving ocean and sea-ice reanalysis. Estimates of time-evolving ocean and sea-ice circulations are obtained by constraining the MIT general circulation model with satellite and in-situ observations such as sea level, sea-ice extent, and hydrographic profiles. Scientists use these realistic, full-ocean-depth circulation estimates to understand how ocean currents and sea-ice affect climate, to study air-sea exchanges, to improve seasonal and long-term climate predictions, and for many other applications. This is a contribution to the consortium for Estimating the Circulation and Climate of the Ocean (ECCO). More information can be found at: http://ecco.jpl.nasa.gov/cube_sphere/.

**Modeling Black Holes and Neutron Stars on Supercomputers**

The direct detection of gravitational waves will open a new window on the universe and will birth an entirely new branch of observational astronomy. Ground- and space-based detectors of gravitational waves currently under construction are the first generation of gravitational wave observatories, allowing scientists to study the inner workings of exotic objects such as black holes and neutron stars. However, one must be able to calculate the gravitational wave signal from these exotic objects before gravitational wave detectors may be used as gravitational wave observatories. The equations that govern these gravitational processes are some of the most complicated nonlinear equations in all of classical physics: the Einstein field equations. Analytically intractable, these equations must be solved on large supercomputers. Some of the difficulties in solving the Einstein field equations on a computer will be described, and the latest results of binary neutron star coalescence simulations will be presented.

**QuakeSim - Active Tectonics Simulations of the LA Basin**

The QuakeSim Project represents development of a Solid Earth framework for accurate modeling of active tectonic and earthquake processes. One of the principal codes in QuakeSim is the Geophysical Finite Element Simulation Tool (GeoFEST), used to simulate Earth's crustal deformation, in addition to other geologic processes. This demonstration will describe how GeoFEST was parallelized with the PYRAMID AMR library and ported to Project Columbia, as well as other systems. Simulations of earthquake processes, such as the Landers faults and the Los Angeles Basin will be demonstrated. More information can be found at: http://quakesim.jpl.nasa.gov/.

**Interaction of the Solar System with the Interstellar Medium**

Traveling through interstellar medium, the sun creates a bubble of solar wind called the heliosphere. Observations show Voyager 1 beyond 90 astronomical units, in a region unlike any encountered in 26 years. Current controversy over whether Voyager 1 has already crossed the termination shock (first boundary of the heliosphere) is based on conflicting observations from instruments, and fueled by poor understanding of this region. Within a few years, the first in-situ measurements of the region will be made, and since the magnetic field is a major player, including theoretical modeling is fundamental. A movie presenting simulation results including, for the first time, the solar magnetic field (the Parker Spiral) being deflected backwards by the interstellar wind will be shown, in addition to the Heliosheath, presenting remarkable dynamics. To carry out investigations, the sophisticated BAT'S-R-US adaptive grid three-dimensional magnetohydrodynamic code running on parallel supercomputers was used—unprecedented spatial resolution using adaptive mesh refinement was obtained. More information can be found at: http://butch.engin.umich.edu/~merav/.

**Montage Demonstration**

Montage, software written for astronomical image mosaicking, will be demonstrated. This software is/will be used by two of the six Spitzer legacy teams, and has other customers within both NASA and non-NASA astronomy groups. Montage is a series of executables which can be run on a single workstation, but also can be run using grid tools such as Pegasus/Condor on arbitrary grids, and can be run using Message Passing Interface (MPI) on a single parallel machine. Montage runs vary from a few seconds on a PC to a few hours on 128 processors of the
TeraGrid, and single output images can easily be multiple gigabytes in size. Input datasets for Montage are typically network-accessible archives consisting of tens of terabytes, stored in multiple locations around the world. Montage is a collaboration between NASA’s Jet Propulsion Laboratory, NASA’s Infrared Processing Analysis Center, and Caltech, with some additional work done by Information Sciences Institute. More information can be found at: http://montage.ipac.caltech.edu/.

New Applications for the Testing and Visualization of Wireless Networks

Local Mars and moon field analysis will require robust localized wireless networks to enable quick and accurate calculations. GPSIPerf and GPSIPerfView are two new tools that will be demonstrated for use in mission-based wireless networks. GPSIPerf combines measurements of TCP throughput using Global Positioning System (GPS) coordinates to map bandwidth for wireless networks. GPSIPerfView provides high-resolution digital elevation maps (DEMs) to visualize and access the impact of elevation features utilizing wireless networks.

Space Operations Mission Directorate

The Space Operations Mission Directorate supports NASA’s science, research, and exploration achievements by providing many critical enabling capabilities such as direct space flight operations, launches, and communications, as well as the operation of integrated systems in low-Earth orbit and beyond. These goals are accomplished through the following programs: the International Space Station program, the Space Shuttle program, and the Flight Support program.

Return to Flight Analysis - Shuttle Debris Transport

This demonstration will review the findings of the Shuttle’s Debris Transport analysis, focusing on aero analysis of the entire vehicle in ascent (orbiter, solid rocket booster, and external tank together at low Mach number) for debris transport and determining maximum allowable debris sizes from various sources. Analysis results will be presented, along with performance data of the simulation runs on supercomputers such as Columbia. More information can be found at: http://people.nas.nasa.gov/~aftosmis/cart3d/.

Return to Flight Analysis - Propulsion/Flowliner

The objective of the current task is to provide a computational framework for design and analysis of the entire fuel supply system of a liquid rocket engine, including high-fidelity unsteady turbopump flow analysis. Time-accurate results obtained from shuttle fuel flowliner analysis using 66 million grid points with 262 overlapped zones will be shown. Analysis results, along with performance data of the simulation runs on supercomputers such as Columbia will also be presented.

Return to Flight 3D Simulation

For a Return to Flight presentation to the NASA Engineering and Safety Center (NESC), NASA Glenn’s Milind Bakhle examined flow unsteadiness as a possible cause of cracking problems in the Space Shuttle Main Engine (SSME) liquid hydrogen feedline flowliner.
Presentations

NASA scientists and managers will be on hand to answer questions and give the following presentations in the NASA booth.

Columbia Project at NAS

The Columbia Project at the NASA Advanced Supercomputing (NAS) Facility involves the construction and utilization of one of the world’s most powerful computer resources. With 10,240 processors spread across twenty 512-processor nodes, this system provides NASA with an unparalleled capacity for capability processing. This demonstration will focus on describing the process of fielding this system while providing the NAS community with an ever-increasing capability during construction.

Computer Simulation Performed for Columbia Project Cooling System

This demonstration shows a high-fidelity simulation of the airflow in the main computer room at the NASA Advanced Supercomputing (NAS) Facility housing the Columbia (10,240 Intel Itanium processors) system. The simulation assesses the performance of the cooling system and identifies deficiencies, and recommended modifications to eliminate them. It uses two in-house software packages: Chimera Grid tools, to generate a geometric model of the computer room, and the OVERFLOW-2 code, for fluid and thermal simulation. This state-of-the-art technology can be easily extended to provide a general capability for airflow analyses on any modern computer room.

High-End Computing Applications on Columbia Project

NASA’s Columbia system consists of a cluster of twenty 512-processor SGI Altix systems. Each system is three TFLOP/s in peak performance—approximately the same as the entire computer capability at the NASA Advanced Supercomputing (NAS) Facility just one year ago. Each 512-processor system is a single-system image machine with one Linux operating system, one high-performance file system, and one globally shared memory. The NAS Terascale Applications Group (TAG) is chartered to assist in scaling NASA’s mission-critical codes to at least 512 processors in order to significantly improve emergency response during flight operations, as well as provide significant improvements in the codes, and rate of discovery across the scientific disciplines within NASA’s Missions. Recent accomplishments include: 4x improvements to codes in the ocean modeling community, 10x performance improvements in a number of computational fluid dynamics codes used in aero-vehicle design, and 5x improvements in a number of space science codes dealing in extreme physics. The TAG group will continue its scaling work to 2,048 processors and beyond (up to 10,240 processors) as the Columbia system becomes fully operational and the upgrades to the SGI NUMAlink memory fabric are in place. The NUMAlink upgrades dramatically improve system scalability for a single application. These upgrades will allow a number of codes to execute faster, and at higher fidelity than ever before on any other system, thus increasing the rate of scientific discovery even further.

Mini hyperwall

Using applications from all NASA Mission Directorates, analysis and visualization capabilities that exploit a 3x3 array of LCD displays, driven by a Beowulf-style cluster, will be demonstrated. In addition to distributing a single, large image across an aggregate 17-million pixel display wall, the setup allows one to logically lay out and link multiple related views, to directly visualize parameterized datasets, and to usefully decompose and interact with multi-dimensional, multi-variate, and multi-scale data.

Montage: Experiences in Astronomical Image Mosaicking on the TeraGrid

NASA’s Montage project has used the TeraGrid to generate large astronomical image mosaics by composing multiple small images. The modules in the Montage suite can be run on a single-processor computer using a simple shell script, and can be run using a combination of parallel approaches. These include running Message Passing Interface versions of some modules, and using standard grid tools. In the latter case, processing workflows are automatically generated, and appropriate data sources are located and transferred to a variety of parallel processing environments (including TeraGrid) for execution. As a result, it is now possible to generate large-scale mosaics on demand, in timescales that support iterative, scientific exploration. More information can be found at: http://montage.ipac.caltech.edu/.

Nanoscale Bio-Engineering Solutions for Space Exploration: The Nanopore Sequencer

Characterization of biological systems at the molecular level and extraction of essential information for nano-engineering design to guide the nano-fabrication of solid-state sensors and molecular identification devices is a computational challenge. The alpha hemolysin protein ion channel is used as a model system for structural analysis of nucleic acids like DNA. Applied voltage draws a DNA strand and surrounding ionic solution through the biological nanopore. The subunits in the DNA strand block ion flow by differing amounts. Atomistic scale simulations are employed using NASA supercomputers to study DNA translocation, with the aim of enhancing single DNA subunit identification. Compared to protein channels, solid-state nanopores offer better temporal control of the translocation of DNA and the possibility to easily tune its chemistry to increase the signal resolution. Potential applications for NASA missions, besides real-time genome sequencing include astronaut health, life detection, and decoding of various genomes. For additional information, visit http://phenomorph.arc.nasa.gov/index.php.
Reinvigorating High-End Computing at NASA

This talk will review the focus on NASA’s advances in single-system image (SSI) supercomputing technology over the last four years, the development of the world’s largest SGI Origins, the progression of the cooperative program that led to the development of the CRAY and SGI systems in FY03, and the efforts that led to the formulation and approval of the NASA Advanced Simulation program and Columbia Project. Finally, a projection of the R&D and operations focus in high-end computing for the next three to five years will be covered.

Part of NASA’s involvement in SC2004 includes the participation of several NASA scientists and collaborators in some of the conference’s birds-of-a-feather sessions, paper presentation, tutorials, and special sessions.

BIRDS-OF-A-FEATHER (BoF)

Session/Title: NASA’s 60 Teraflop Columbia Project
Chair: David Barkai (Intel)
Date/Time: Wednesday, November 10, 12:15-1:15 p.m.
Room: 302
Speaker(s)/Author(s): Dave Parry (SGI), David Barkai (Intel), Walt F. Brooks and James Taft (both of NASA Ames Research Center)
Description: A new, very large system has been built at NASA Ames Research Center—a cluster of 20 nodes, 512 processors each. The system, called Columbia, will be used for a variety of applications including fluid dynamics, engine design, and weather and climate modeling. In this BoF, big science applications that can benefit from this unique system will be discussed.

Session/Title: Customer Experiences Using the SGI Altix™ Supercluster
Chair: Walt F. Brooks (NASA Ames Research Center)
Date/Time: Wednesday, November 10, 5:30-7:00 p.m.
Room: 317/318
Speaker(s)/Author(s): Walt F. Brooks (NASA Ames Research Center), Gary A. Jensen (SGI User Group)
Description: SGI Altix Supercluster users discuss developing and running highly complex data-intensive applications, solving huge CPU-intensive research problems, model simulations, modeling significant discoveries, and running repetitive, but difficult production models. These users discuss their reasons for choosing a modular, scalable, global shared-memory design, an enhanced, industry-standards-based hardware platform, and the Linux open-source operating system. The discussion may include actual parallel and scalar performance, and updates on data access, management, migration, and shared file systems on storage area networks.

This BoF is organized by the SGI Worldwide User Group and is hosted by Walt Brooks, chief of the NASA Advanced Supercomputing Division and president of the SGI User Group; and Paul White, HPC Systems Manager Computer Services for Academic Research, CSC Supercomputing, Farnborough, UK and Director for Altix and Linux at the SGI User Group. Panel members to be announced.

TUTORIALS

Session: M03: Component Software for High-Performance Computing
Title: Component Software for High-Performance Computing: Using the Common Component Architecture
Chair: David Edward Bernholdt (Oak Ridge National Laboratory)
Date/Time: Monday, November 8, 8:30 a.m.-5:00 p.m.
Room: TBA
Speaker(s)/Author(s): David E. Bernholdt, Wael R. Elwasif, and James A. Kohl (all of Oak Ridge National Laboratory), Robert C. Armstrong and Jaideep Ray (both of Sandia National Laboratories), Lori Freitag Diachin and Gary Kumfert (both of Lawrence Livermore National Laboratory),
Madhusudhan Govindaraju (Binghamton University, State University of New York), Ragib Hasan (University of Illinois at Urbana-Champaign), Daniel S. Katz (Jet Propulsion Laboratory, California Institute of Technology), Lois Curfman McInnes and Boyana Norris (both of Argonne National Laboratory), Craig E. Rasmussen (Los Alamos National Laboratory), Sameer Shende (University of Oregon), and Shujia Zhou (Northrop Grumman/TASC).

Description: This full-day tutorial will introduce participants to the Common Component Architecture (CCA) at both conceptual and practical levels. Component-based approaches to software development increase software developer productivity by helping manage the complexity of large-scale software applications and facilitating the reuse and interoperability of code. The CCA was designed specifically with the needs of high-performance scientific computing in mind. The concepts of components will be covered—in particular, the tools provided by the CCA environment, the creation of CCA-compatible components, and their use in scientific applications. A combination of traditional presentation and hands-on experience (computer with network access and ssh client required; X11 client desirable) will be used during the tutorial.

Session: M04: Hot Chips and Hot Interconnects for High End Computing Systems
Title: Hot Chips and Hot Interconnects for High End Computing Systems
Chair: Subhash Saini (NASA Ames Research Center)
Date/Time: Monday, November 8, 8:30 a.m.-5:00 p.m.
Room: TBA
Speaker(s)/Author(s): Subhash Saini (NASA Ames Research Center)

Description: Several processors will be discussed: 1) the Cray proprietary processor, which is used in the Cray X1; 2) the IBM Power 3 and Power 4, which are used in an IBM SP 3 and IBM SP 4 systems; 3) the Intel Itanium and Xeon, which are used in the SGI Altix systems and clusters respectively; 4) IBM System-on-a-Chip, which is used in IBM BlueGene/L; 5) HP Alpha EV68 processor, which is used in DOE ASCI Q cluster; 6) SPARC64 V processor, which is used in the Fujitsu PRIMEPOWER HPC2500; 7) an NEC proprietary processor, which is used in NEC SX-6/7; 8) Power 4+ processor, which is used in Hitachi SR11000; and 9) NEC proprietary processor, which is used in the Earth Simulator. The architectures of these processors will first be presented, followed by interconnection networks and a description of high-end computer systems based on these processors and networks. The performance of various hardware/programming model combinations will then be compared, based on latest NASA Advanced Supercomputing (NAS) Parallel Benchmark results (MPI, OpenMP/HPF and hybrid (MPI + OpenMP). The tutorial will conclude with a discussion of general trends in the field of high-performance computing, (quantum computing, DNA computing, cellular engineering, and neural networks).
Top row (from left):
X-43 in flight. *Langley Research Center* and
*Dryden Flight Research Center*

Radiation research on DNA bases. *Ames Research Center*

Unsteady computations for the space shuttle orbiter LH2 feedline flowliner. *Ames Research Center*

10,240-processor supercomputer, *Columbia*.

Shuttle ascent simulation and modeling. *Ames Research Center*

Center row (from left, continued):
The future of DNA sequencing. *Ames Research Center*

Surface Speed of the ocean (cube). *Jet Propulsion Laboratory and Ames Research Center*

Bottom Row (from left):
Climate modeling. *Goddard Space Flight Center and Massachusetts Institute of Technology*

Surface speed of the atmosphere. *Goddard Space Flight Center and Ames Research Center*

Artist’s concept of NASA Mars exploration rover. *Jet Propulsion Laboratory*

Mars landscape photographed by “Opportunity.” *Jet Propulsion Laboratory*

Center row (from left, continued):

Microgravity fluid flow simulation. *Goddard Space Flight Center and Lawrence Berkeley National Laboratory*

Quiet aircraft technology. *Glenn Research Center*

Ultra efficient engine technology. *Glenn Research Center*
Aeronautics Research Mission Directorate

3 • X-43 Scramjet-Powered Vehicle
• Enabling Computations for Vehicle Systems

4 • Advanced Combustion Modeling for Complex Turbulent Flows
• Parallel Performance Characterization of Columbia

I-DESK
• Blade-Out Simulations
• Analysis of LDIMEMS Technology Using the National Combustion Code
• Numerical Prediction of Non-Reacting and Reacting Flow in a Model Gas Turbine Combustor
• Vertical Take-off Vehicle in Cross-Flow

Science Mission Directorate

5 • Tool-Driven Optimization of an Astrophysics Application
• Solar Simulation
• The NASA Finite Volume General Circulation Model (fvGCM)

6 • The Earth System Modeling Framework and its Applications
• Clemson University’s Parallel Architecture Research Laboratory

7 • Chombo Framework for Block-Structured AMR Applications
• IBEAM: Developing an AMR Framework for Astrophysical Modeling

8 • Exploring the Circulation and Climate of the Ocean
• Modeling Black Holes and Neutron Stars on Supercomputers
• QuakeSim - Active Tectonics Simulations of the LA Basin
• Interaction of the Solar System with the Interstellar Medium
• Montage Demonstration

I-DESK • New Applications for the Testing and Visualization of Wireless Networks

Presentation Area:
• Columbia Project at NAS
• Computer Simulation Performed for Columbia Project Cooling System
• High-End Computing Applications on Columbia Project
• Montage: Experiences in Astronomical Image Mosaicking on the TeraGrid
• Nanoscale Bio-Engineering Solutions for Space Exploration: The Nanopore Sequencer
• Revitalizing High-End Computing at NASA
• Visualization Highlights on the mini hyperwall