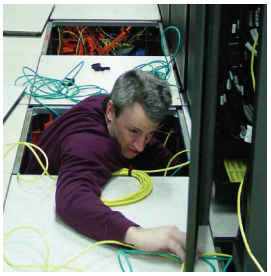
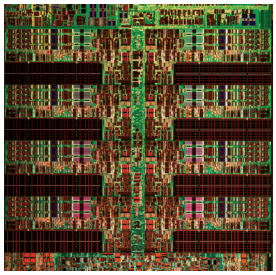
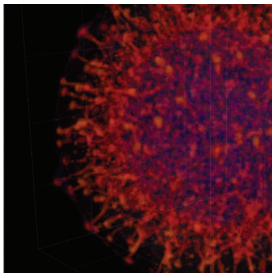





The World's Fastest Computer

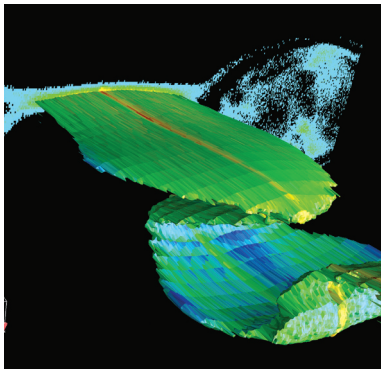
Roadrunner

First to break the "petaflop" barrier

At 3:30 a.m. on May 26, 2008, Memorial Day, the "Roadrunner" supercomputer exceeded a sustained speed of 1 petaflop/s, or 1 million billion calculations per second. The sustained performance makes Roadrunner more than twice as fast as the current number 1 system on the TOP500 list. The best sustained performance to date is 74.5% efficiency, 1.026 petaflop/s.

"Petaflop/s" is computer jargon—peta signifying the number 1 followed by 15 zeros (sometimes called a quadrillion) and flop/s meaning "double-precision floating point operations per second."

Los Alamos held the fastest supercomputer title in 1993 with the Thinking Machines CM-5, and inaugurated the supercomputer era, assisting in the development of the Cray-1 in 1976. The Laboratory and IBM go all the way back to the first card-programmable calculators, used at Los Alamos in 1949. Los Alamos also housed serial number 1 of the IBM 704 in 1956.



Recent VPIC simulation on Opteron only system. VPIC is a fully 3-D particle simulation code.

The Roadrunner supercomputer, developed by IBM in partnership with the Laboratory and the National Nuclear Security Administration, uses commercially available hardware, including aspects of commercial game console and graphics technologies. Because of its off-the-shelf components, the computer costs significantly less than a one-of-a-kind machine. It also uses a Linux operating system.

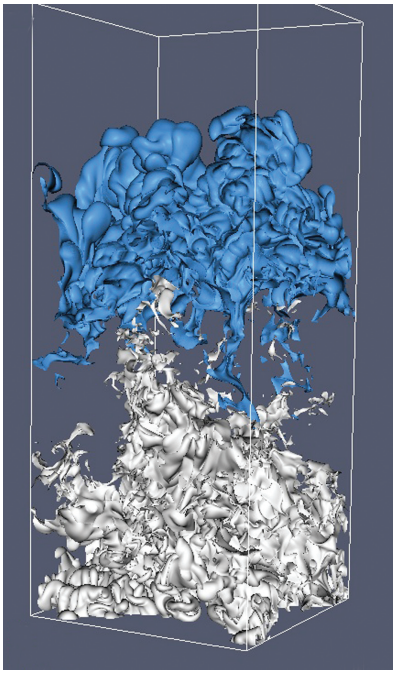
The secret to its record-breaking performance is a unique hybrid design. Each compute node in this cluster consists of two AMD Opteron™ dual-core processors plus four PowerXCell 8i™ processors used as computational

Photo by Leroy N. Sanchez LANL

accelerators. The accelerators used in Roadrunner are a special IBM-developed variant of the Cell processor used in the Sony PlayStation® 3. The node-attached Cell accelerators are what make Roadrunner different than typical clusters.

The Lab and IBM have been working on Roadrunner since 2006, but collaboration on Cell dates back to 2002. The first phase of the project included delivery of an initial Opteron-only cluster that operates at a speed of 71 teraflop/s. This initial system has been in full production at Los Alamos for almost a year, and Laboratory researchers are using this machine for classified weapons applications. The full-scale Roadrunner machine operates more than 10 times faster than the current installed system.

Phase 2 of the Roadrunner project was completed in October 2007. Two external assessments, one by NNSA headquarters and one by an independent team of high performance computing experts, evaluated the machine's potential use for Laboratory applications, the Laboratory's ability to successfully manage the computing system, IBM's ability to deliver the product, and whether computer programs could be adapted to the new system.



High-resolution simulations (30 billion cells) of Rayleigh-Taylor turbulence reveal details of the mixing layer between two fluids.

Based on the positive outcome of the assessments, the Laboratory and NNSA decided to pursue the final phase of the Roadrunner project.

The powerful cluster of nodes will process information enabling the Laboratory to use Roadrunner for advanced physics and predictive simulations of complex scientific processes. Weapons science applications that can be processed by Roadrunner are applicable to all three of the U.S. Department of Energy weapons laboratories. The machine will also be well equipped to tackle the intricacies of modeling processes, ranging from the biomolecular to the cosmological. In addition, Los Alamos intends to purchase additional Roadrunner resources to support open science and technology applications.

The full-scale Roadrunner system, named in honor of New Mexico's speedy state bird, broke the performance record at IBM's Poughkeepsie, New York, facility. The full machine will be moved to Los Alamos beginning in July and housed in the Nicholas Metropolis Center for Modeling and Simulation. The first computing applications are expected to begin running on the machine in January 2009.

The cost of all phases of the Roadrunner project is approximately $120 million. More than 200 Laboratory employees have been involved in this effort.

Cooling towers at the Los Alamos Metropolis Center for Modeling and Simulation dissipate the heat generated by the Laboratory's supercomputers.

For more information about Roadrunner at Los Alamos National Laboratory, see the Roadrunner website at http://www.lanl.gov/roadrunner

Los Alamos National Laboratory is operated for the Department of Energy's National Nuclear Security Administration by Los Alamos National Security, LLC, a team of Bechtel National, the University of California, The Babcock & Wilcox Company, and Washington Group International

LAUR-08-0000