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Scientists use world's fastest supercomputer to model origins of the unseen universe

1 of the largest-ever computer models explores dark matter and dark energy, 2 cosmic constituents that remain a mystery

LOS ALAMOS, New Mexico, October 26, 2009— Understanding dark energy is the number one issue in explaining the universe, according to Salman Habib, of the Laboratory's Nuclear and Particle Physics, Astrophysics and Cosmology group.

"Because the universe is expanding and at the same time accelerating, either there is a huge gap in our understanding of physics, or there is a strange new form of matter that dominates the universe – 'dark energy' – making up about 70 percent of it," said Habib. "In addition, there is five times more of an unknown 'dark matter' than there is ordinary matter in the universe, and we know it's there from many different observations, most spectacularly, we've seen it bend light in pictures from the Hubble Space Telescope, but its origin is also not understood."

Even though it's looking at only a small segment of the "accessible" universe, Habib's "Roadrunner Universe" model requires a petascale computer because, like the universe, it's mind-bendingly large. The model's basic unit is a particle with a mass of approximately one billion suns (in order to sample galaxies with masses of about a trillion suns), and it includes 64 billion and more of those particles.

The model is one of the largest simulations of the distribution of matter in the universe, and aims to look at galaxy-scale mass concentrations above and beyond quantities seen in state-of-the-art sky surveys.

"We are trying to really understand how to more completely and more accurately describe the observable universe, so we can help in the design of future experiments and interpret observations from ongoing observations like the Sloan Digital Sky Survey-III. We are particularly interested in the Large Synoptic Survey Telescope (LSST) in Chile, in which LANL is an institutional member, and DOE and NASA's Joint Dark Energy Mission (JDEM)," said Habib. "To do the science in any sort of reasonable amount of time requires a petascale machine at the least."

The Roadrunner Universe model relies on a hierarchical grid/particle algorithm that best matches the physical aspects of the simulation to the hybrid architecture of Roadrunner. Habib and his team wrote an entirely new computer code that aggressively exploits Roadrunner's hybrid architecture and makes full use of the PowerXCell 8i computational accelerators. They also created a dedicated analysis and visualization software framework to handle the huge simulation database.

"Our effort is aimed at pushing the current state of the art by three orders of magnitude in terms of computational and scientific throughput," said Habib. I'm confident the final database created by Roadrunner will be an essential component of dark universe science for years to come."

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About Roadrunner, the world's fastest supercomputer, first to break the petaflop barrier

On Memorial Day, May 26, 2008, the "Roadrunner" supercomputer exceeded a sustained speed of 1 petaflop/s, or 1 million billion calculations per second. "Petaflop/s" is computer jargon—peta signifying the number 1 followed by 15 zeros (sometimes called a quadrillion) and flop/s meaning "floating point operation per second." Shortly after that it was named the world's fastest supercomputer by the TOP500 organization at the June 2008 International Supercomputing Conference in Dresden Germany.

The Roadrunner supercomputer, developed by IBM in partnership with the Laboratory and the National Nuclear Security Administration, will be used to perform advanced physics and predictive simulations in a classified mode to assure the safety, security, and reliability of the U.S. nuclear deterrent. The system will be used by scientists at the NNSA's Los Alamos, Sandia, and Lawrence Livermore national laboratories.

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 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.

Roadrunner is still currently the world's fastest with a speed of 1.105 petaflop/s per second, according to the TOP500 announcement at the November 2008 Supercomputing Conference in Austin Texas, and it again retained the #1 position at the June ISC09 conference.

About Los Alamos National Laboratory (www.lanl.gov)

Los Alamos National Laboratory, a multidisciplinary research institution engaged in strategic science on behalf of national security, is operated by Los Alamos National Security, LLC, a team composed of Bechtel National, the University of California, The Babcock & Wilcox Company, and the Washington Division of URS for the Department of Energy's National Nuclear Security Administration.

Los Alamos enhances national security by ensuring the safety and reliability of the U.S. nuclear stockpile, developing technologies to reduce threats from weapons of mass destruction, and solving problems related to energy, environment, infrastructure, health, and global security concerns.
