Durham University Cosmologists Use New Supercomputer To Tackle the Biggest Problem in Physics

November 13, 2007 -- Researchers from the Institute for Computational Cosmology (ICC) at Durham University are tackling what has been described as the biggest problem in physics by running simulations of the Universe on a massive upgrade to the Cosmology Machine supercomputer supplied by Sun Microsystems.

These calculations have been used by an international team which is competing to carry out a new space mission under the European Space Agency's ``Cosmic Vision'' programme.

Perhaps the most startling recent observation in cosmology is that the expansion of the universe appears to be speeding up rather than slowing down.

Two possible explanations have been put forward to explain this phenomenon: either the universe is filled with a mysterious fluid called Dark Energy, which exerts a repulsive force to overcome the gravitational pull of matter, or the very law of gravity itself is flawed and needs to be changed. Either way, physicists are excited by the prospect of understanding what is pulling the Universe apart, as this will lead to fundamental advances in the subject.

Prof Carlos S. Frenk FRS, Ogden Professor, Director of the ICC: “Dark energy is at the cutting-edge of science; cutting-edge science requires cutting-edge technology and this is precisely what Sun Microsystems provides us with.”

Cosmologists grapple with these problems by running huge computer simulations of the evolution of the universe. As part of Virgo Consortium, an international group of cosmologists who simulate the growth of cosmic structures, the group at Durham has used the local supercomputer called the Cosmology Machine (COSMA), to simulate more of the Universe than has ever been attempted before.

The Cosmology Machine is a unique installation in academia.

The Cosmology Machine is built up of a combination of UltraSPARC(R) IIIi and AMD Opteron nodes supplied by Sun Microsystems. The Cosmology Machine also uses Sun's Solaris(TM) Operating System (OS), compilers and internode communications software.

The latest upgrade in April 2006, which included Sun Fire(TM) X2100, Sun Fire X4100 and Sun Fire V40z servers, brought the system to 1300 CPUs, making it one of the largest supercomputers in Europe dedicated to academic research in one field.

Sun Microsystems are working closely with the ICC High Performance Computing manager,

Dr. Lydia Heck, to optimize the performance of the Cosmology Machine, which, due to the demands placed on it by the simulation codes, is a challenging and invaluable test-bed for Sun's software and hardware.

Researchers at the ICC recently ran a series of huge simulations to test a new method for measuring the dark energy in the Universe. These calculations give the definitive answer on how well future experiments will be able to constrain the nature of dark energy.

These calculations form a key part of an international bid to build a satellite called the SPectroscopic All-sky Cosmic Explorer (SPACE), a mission proposed to ESA under the Cosmic Vision programme.

The SPACE mission concept has beaten off many competitors to be shortlisted for the next round of selection. If successful, SPACE would launch round 2017 and would produce the largest ever map of the Universe, and will yield the best possible measurements of the dark energy. It has been announced by the ESA that SPACE has made it to the next round of assessment (http://www.esa.int/esaCP/SEM1IQAMS7F_index_0.html).

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The Virgo Consortium is an international collaboration of researchers from higher education institutes in the UK, Germany, the Netherlands, the USA, Canada and Japan. Virgo is the world leader in the field of cosmological simulations, with recent highlights including the Millennium Simulation which was featured on the front cover of Nature. Durham is the UK base of the Virgo Consortium. The director of the ICC, Professor Carlos Frenk, is the co-Principal Investigator of Virgo, along with Prof Simon White of the Max Planck Institut fuer Astrophysik, Garching Germany, is the co-lead of the project.

In April 2006 an 800 CPU system using Sun Fire X2100 and X4100 servers was installed by Sun Microsystems as an extension of COSMA, the Cosmology Machine. COSMA serves the computing needs of the researchers of Institute for Computational Cosmology (ICC) and those of researchers from other Virgo nodes. COSMA now comprises more than 1,300 CPUs of which over 500 are 1Ghz UltraSPARC IIIi and more than 800 are AMD Opteron(TM) processors with clock speeds of 2.2 GHz and 2.6 GHz. The maximum peak floating point performance is approximately 4 TFlops. The operating system is exclusively Solaris 10.. The AMD Opteron based part is partly configured using dual gigabit and partly using Myrinet.

Sun Microsystems is collaborating with the Durham High Performance Computing manager Dr Lydia Heck to optimally configure the system. Researchers are also using an 8 CPU UltraSPARC IV+ system with 64 GByte of RAM for researchers to post-process large amounts of simulation data using software packages such as IDL. Users also utilise the Sun Studio compilers, and recently these have been upgraded to Sun Studio 12 software.

The choice for an all Solaris OS system was made because of the superior performance of NFS4, autofs and other essential software tools. In addition the Solaris OS offers such tools as DTrace to examine system performance and user code performance. The job load on the system is managed by Sun Grid Engine software.

The collaboration between the ICC and Sun Microsystems started when COSMA was first installed in 2001. Phase 1 comprised 1 Sun Fire 6800 server with 24 CPUs and 48 GBytes of RAM and 64 Sun Blade 1000 workstations s with a total of 128 CPUs and 64 GByte of RAM connected via Myrinet. The 64 Sun Blade workstations were donated by the ICC to the Kigali Institute of Science and Technology (KIST) in Kigali, the capital of Rwanda.

Phase 2 of COSMA was installed in February 2004 with 259 Sun Fire V210 servers which are still going strong and which have recently been upgraded to Solaris 10.

The main data storage on the system is hosted by two AMD Opteron-based servers running Solaris 10 which serve a total of 90 TByte of storage. An additional 30 TByte are served by Linux based servers. However preparations are underway to migrate to Solaris 10.

SPACE, the SPectroscopic All-sky Cosmic Explorer, was proposed by an international consortium headed by Prof. Andrea Cimatti of the University of Bologna, Italy and by Dr. Massimo Robberto, of the Space Telescope Science Institute, in Baltimore, USA. Further information can be found at: http://urania.bo.astro.it/cimatti/space/

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