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Helping HPC Applications Unravel the Universe's Origins

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>
> **Dr. James Murray**
> **Astronomer and System Administrator**
> **Swinburne Centre for Astrophysics and Supercomputing**

High performance computing applications require fast compilers

Today's high performance computing (HPC) applications, running on clusters of high performance supercomputers, require fast compilers that are optimized for the multiprocessing capabilities of high-end processors. Traditionally, clustered supercomputers used in HPC applications were based on proprietary RISC-based systems. Most of the newer, cutting-edge supercomputer clusters use Intel® Xeon™ processors for highly complex, scientific computing applications due to cost effectiveness and greater availability of software tools and applications.

Intel® compilers optimize application performance

The Intel® Fortran Compiler for Linux* supports Fortran 77, 90, and 95 standards. The compiler provides threaded application support, compatibility with leading tools and standards, and features that take advantage of Hyper-Threading Technology. Providing advanced optimization features, the compiler takes advantage of the performance features offered by Intel® Pentium® 4, Intel Xeon, and Intel® Itanium® 2 processors.

Hubble Space Telescope image resulting from 123-orbit HST program to determine the age of the universe to a precision of less than 3%. Faintest "white dwarf" stars are 13 billion years old.
Courtesy H. Richer, B. Gibson

THE APPLICATION

Leading astrophysicists create leading-edge applications

Swinburne University's Centre for Astrophysics and Supercomputing, in Melbourne, Australia, is involved with the Square Kilometer Array (SKA) project – an international project aimed at developing the next generation of radio telescope. The new telescope collects data over an area of one square kilometer, which is about 100 times greater than the largest present-day instruments. The Centre's ultimate goal is to collect enough data to perform modeling and simulations of our entire galaxy and to make realistic, 3D, virtual-reality animations available to the general public, particularly to school children.

The Centre's research workhorse is the Swinburne Supercluster. It consists of two subclusters of 30 Dell 2650 rack-mounted servers and one subcluster of 30 Dell 2550 workstations, each with dual 2.2 GHz Pentium 4 and Intel Xeon processors and a minimum of 1 GB of RAM. A fourth subcluster consists of 16 Dell 2450 rack-mounted servers with dual Pentium III processors with 933 MHz and 1 GB of RAM. All systems run on Linux.

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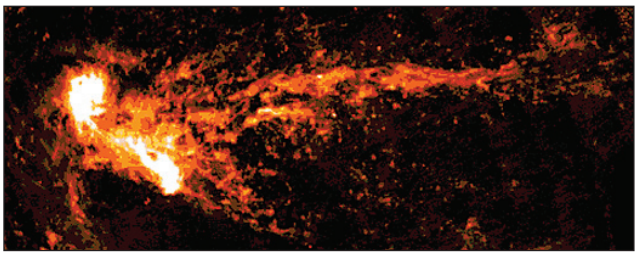

Radio map of the southern sky showing the debris of a satellite near our Milky Way that is in the midst of being cannibalized.
Courtesy M. Putman, L. Staveley-Smith, B. Gibson

THE CHALLENGE

Managing complex calculations

The Centre needed a Linux-capable Fortran compiler that could optimize their applications to boost performance beyond the capabilities of their HPC hardware alone. Furthermore, The Centre needed a Linux-capable Fortran compiler optimized for the features of the latest Intel Xeon, Pentium, and Itanium 2 processors, as well as for the multiprocessing capabilities required for computer clustering. Though the Swinburne Supercluster provides vast quantities of high performance computing power, their performance needs are great because calculations can take weeks or even months to complete, and some applications must deal with sub-microsecond timescales.

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THE ANSWER

Optimizing for speed

The scientists at The Centre compared the performance of the Intel Fortran Compiler running on their "Tera" subcluster and their "Jocelyn" test system with that of the GNU Fortran G77 Compiler. They tested both configurations using one CPU-based and four CPU-based systems.

The performance gains provided by using the Intel Fortran for Linux compiler were dramatic, ranging from 24.5 to 31.5 percent. "I am not a programming specialist, and the Intel diagnostics are most helpful," stated Dr. Kawata. "The application optimization delivered by the Intel compiler not only sped up my code, but also helped me find areas in my program that would benefit from rewriting and optimization."

Configuration[1]	GNU Fortran G77	Intel® Fortran Compiler	Percent Improvement
"Tera" subcluster	1 CPU: 244.9 sec	1 CPU: 168.6 sec	31.2%
	4 CPUs: 85.5 sec	4 CPUs: 66.6 sec	22.1%
"Jocelyn" test system	1 CPU: 216.5 sec	1 CPU: 148.3 sec	31.5%
	4 CPUs: 84.9 sec	4 CPUs: 64.1 sec	24.5%

THE ADVANTAGE

Achieving higher productivity

The Intel Fortran compiler optimizes applications running on the latest Intel architectures and takes advantage of the multiprocessing capabilities needed for computer clustering. Boosting the performance of the applications gave The Centre's scientists faster-executing applications, thus more time to focus on the important business of astrophysical scientific discovery.

As Dr. James Murray, Swinburne Supercluster Administrator and astronomer, noted, "The 24.5 to 31.5 percent speedups resulting from Intel Fortran Compiler for Linux performance improvements make huge differences in our applications. In one case, a calculation that used to take two months was completed in only six weeks with code compiled by the Intel Fortran Compiler."

[1] Benchmark rates, measured in seconds, were provided by Swinburne University's Centre for Astrophysics and Supercomputing. Buyers should consult other sources of information to evaluate the performance of systems or components they are considering purchasing. The benchmark program tested was written in Fortran, and uses a numerical technique called Smoothed Particle Hydrodynamics (SPH) to model the gravitational and hydrodynamic interactions that occur in astrophysical gases. The message passing interface protocol used includes a set of routines that allow several processors to be used simultaneously in one calculation, turning a cluster of PCs into a more powerful machine. Results were compiled using the Intel Fortran Compiler's -03 optimization flag. "Tera" consists of a subcluster of 30 Dell 2550 workstations with dual 2.0 GHz Pentium® 4 and Intel® Xeon™ processor workstations, each with 1 GB of RAM, and connected to one another using Giganet switching technology. "Jocelyn" is a test system consisting of four 1.0 GHz Itanium® 2 processors and 16 GB of RAM. Further testing of benchmark program compiled on the 4 CPU Jocelyn system using -03 and -tpp2 optimization flags provided a 25.18% performance improvement. Using -03, -ttp2 and -ipo optimizations on the same configuration yielded a 25.23% performance improvement.

Intel provides both the tools and support to enhance the performance, functionality, and efficiency of software applications. Compatible with leading Windows* and Linux* development environments, Intel® Software Development Products are the fastest and easiest way to maximize the latest features of Intel processors. Intel Software Development Products are designed for use in the full development cycle, and include Intel Performance Libraries, Intel Compilers (C++ and Fortran for Windows and Linux), Intel® VTune™ analyzers and Intel® Thread Checker. Performance depends upon the specific computer systems, components and/or measurement methods used; your results will vary.

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