CASE STUDY

High Performance Computing
Intel® Omni-Path Architecture

Expanding Parallelism at Kyoto University

Cray installs new HPC supercomputer based on Intel® Xeon® Processor E5 and E7 family with large Intel® Xeon Phi™ processor cluster

Kyoto University Supercomputing Capabilities

- Designed with expanded parallelism in mind with Intel® Xeon Phi™ processors using Intel® AVX512
- Large node count with Intel® Xeon® processor E5 and E7 family interconnected by Intel® Omni-Path Architecture
- Serves a large community of researchers around the world in a wide variety of disciplines

Kyoto University (Kyoto U) is a world-class research and education institution with campuses in Japan and extended schools around the world. The university has a broad research community that relies on supercomputing to contribute to worldwide knowledge across many disciplines—economics, weather and climate, and genetics, among others. "We support a wide variety of research fields," said Hiroshi Nakashima, Professor of Academic Center for Computing and Media Studies (ACCMS) at Kyoto University. "Our supercomputers are open to any HPC researcher in Japan, so they are very general-purpose."

Challenge

Nakashima leads ACCMS' Supercomputing Operation Committee. His department is responsible for the acquisition and operation of Kyoto U's supercomputers. "As a professor, I'm also pursuing various research work on supercomputing, mainly in high-performance programming. Some of my research topics, such as a framework for manycore-aware particle simulations with automatic load balancing, are being pursued in collaboration with our supercomputer users."

In 2015, Kyoto U's aging supercomputing complex was in need of refresh. Their systems were based on Intel and other processors, and some were several generations old. Their specifications for a new system required a mix of dual-socket and four-socket x86 processors "with Intel® Xeon® processor (formerly known as Haswell- or Broadwell) class performance," stated Nakashima. They were looking in particular at the value of increased parallelism by exploiting the advancements in SIMD operations. University users had already been taking advantage of MPI and OpenMP programming models to increase parallelism in their codes. "We were well aware of 256- and 512-bit SIMD-vectorized computations," explained Nakashima. "Our belief is that the improvement of an application to exploit the wide SIMD mechanism will be consistent with the past improvements with MPI and OpenMP, because the SIMD mechanism allows us to make gradual improvements without discontinuous programming changes, such as with CUDA or OpenACC," he added. So, for their new system, they also specified nodes with Intel® Xeon Phi™ processor-class performance.

Their acquisition process took over a year to complete, with Cray being awarded the build of the new supercomputer. It was installed in late 2016 and entered partial production on October 3, 2016, with a full system production launch in late December of that year.

Solution

The new Kyoto U AACMS was built for a wide range of workloads, from general computing to highly parallel vectorized codes and memory-demanding operations. The new supercomputer comprises three systems based on Intel® Xeon Phi™ processor 7250, Intel® Xeon processor E5-2695 v4, and Intel® Xeon® Processor E7-8880 v3.

The new supercomputer includes a Lustre storage cluster from Data Direct Networks with 16 PB of storage and a 230TB burst buffer. According to Nakashima, the university is proposing an expansion plan of Intel Xeon Phi processors to deliver up to two to three petaflops, and they will add another 8 PB to their Lustre storage cluster in 2018.

ACCMS is using Intel OPA in Laurel 2 and Cinnamon 2 to optimize bandwidth and latency. "We know that OPA is a good solution with respect to price and performance, and we were happy with the performance numbers of our benchmarks for the new system" commented Nakashima.

In fact, Kyoto U's RFP didn't specify Intel OPA at all, but rather "it must be InfiniBand EDR, or whatever equally efficient technology," explained Nakashima. "We said Intel OPA is acceptable if it shows good performance in IMB, HPCC (HPL and FFT), and our own five multi-node application benchmarks. For the most part, the performance numbers for the Intel fabric in Cray's proposal significantly surpassed our expectations."

Result

Researchers are looking forward to the inclusion of advanced vector processing with Intel Xeon® Phi™ processor-based nodes, in addition to higher performance general computing capabilities with the new supercomputer. Compared to the university's previous top system, the new system provides a roughly two-fold increase in application performance, providing a powerful platform for ambitious research projects.

Many research groups at Kyoto University will be using both new supercomputers with its Intel OPA fabric. "By far the largest group using the 850 nodes of Laurel 2 will be genomics," commented Nakashima, "followed by researchers in material science. Others will include molecular biology, quantum chemistry, meteorology, and several others." Cinnamon 2, the smaller cluster with 16 nodes of Intel Xeon processor (formerly codenamed Haswell) interconnected by Intel OPA will also host research from genomics and plasma physics and engineering, according to Nakashima.

Solution summary

Kyoto U's new supercomputer was built for research that involves both general processing of codes and high-performance vectorized workloads, such as weather prediction and economic fractal pattern analyses. The system comprises several subsystems, including a large number of nodes with Intel Xeon Phi processors. The system was built and installed by Cray in 2016.

Where to Get More Information

Learn more about Kyoto U's new supercomputer at http://www.iimc.kyoto-u.ac.jp/en/services/comp/supercomputer.

Learn more about Intel Omni-Path Architecture at www.intel.com/omnipath

Learn more about Intel Xeon Phi processor at http://www.intel.com/content/www/us/en/products/processors/xeon-phi.html.

Solution Ingredients

- Laurel 2—Cray CS400: 850 nodes of dual-socket Intel® Xeon® processor E5-2695 v4 with 128GB DDR4-2400 and the Intel® Omni-Path Architecture (Intel® OPA) fabric.
- Cinnamon 2—Cray CS400: 16 nodes of four-socket Intel Xeon processor E7-8880 v3 with 3TB DDR4-1800 and Intel OPA fabric.
- Camphor 2—Cray XC40: 1800 nodes of Intel® Xeon Phi™ 7250 with 96GB DDR4-2400, a Cray Aries Dragonfly network, and 230TB of burst-buffer.
- Luster Storage: DDN ExaScaler 16PB (expanding to 24PB in 2018) with 230TB burst-buffer (DDN IME)