CASE STUDY
Intel® Xeon® processor 5500 and 7500 series
Intel® software development products
High-Performance Computing

Driven to discover with HPC

University of Minnesota fuels breakthrough research by building two new HPC clusters with Intel® processors

For more than 25 years, the University of Minnesota Supercomputing Institute for Advanced Computational Research (MSI) has provided high-performance computing (HPC) resources for researchers in a broad range of academic fields. When it was time to refresh its HPC resources, MSI selected systems based on Intel® Xeon® processors. The 8,688-core "Itasca" cluster uses the Intel Xeon processor 5500 series to deliver twice the performance of previous-generation Intel processors while controlling power and cooling. The Intel Xeon processor 7500 series provides the foundation for the 1,152-core shared-memory "Koronis" cluster, which will help solve complex problems in the life sciences.

University of Minnesota
Supercomputing Institute

"On average, applications run nearly two times faster on the Intel® Xeon® processor 5500 series than on previous-generation Intel processors. That speed will help researchers publish results sooner and give them the time for further exploration."

– Brian Ropers-Huilman
Director, Systems Administration and Technical Operations
Supercomputing Institute for Advanced Computational Research
University of Minnesota

CHALLENGES

- **Improve performance.** Enable researchers in a range of fields to solve more complex problems than before by providing access to larger-scale clusters with outstanding processing compute performance and memory bandwidth.
- **Maximize energy efficiency.** Select an energy-efficient hardware platform that will enable MSI to build large clusters without significantly increasing power or cooling.

SOLUTION

- **HPC clusters based on Intel Xeon processors.** The 8,688-core Itasca cluster uses the Intel Xeon processor 5500 series, while the 1,152 core, 3.1 TB shared-memory Koronis cluster uses the Intel Xeon processor 7500 series. Intel® software development products help researchers optimize code for the new clusters.

IMPACT

- **Rapid results.** The Intel Xeon processor 5500 series delivers twice the performance of the previous-generation Intel processors, enabling researchers to expand their scientific exploration and accelerate results.
- **Bigger questions.** With the Intel Xeon processor 7500 series, the shared-memory cluster enables researchers to address life sciences problems that can only run on a shared-memory system.
- **Improved energy-efficiency.** MSI was able to significantly expand HPC resources without exceeding data center power and cooling constraints.
- **Optimized code.** Intel software development products help developers optimize code for the latest Intel processors.

Intel® Xeon® processors help researchers answer complex questions

From astronomers studying magnetic fields in faraway galaxies to engineers evaluating the effects of turbulence on new airplane wing designs, University of Minnesota researchers and their collaborators around the world rely on high-performance computing (HPC) to solve complex problems. The Minnesota Supercomputing Institute (MSI) accommodates the needs of researchers in these and other fields with five HPC systems and a broad range of software packages.

MSI regularly refreshes its HPC resources to keep up with constant demand for greater computational performance. "Providing a selection of cutting-edge technology is vital for supporting our diverse research community," says Hakizumwami Birali Runesha, director of scientific computing and applications at MSI. "Until recently, our largest cluster included 2,048 cores from the Intel Xeon processor 5300 series. When it was time to invest in a new system, we wanted to build a larger cluster for applications with even greater scalability."

MSI also needed a distinct, shared-memory cluster to support research that could not be accomplished with existing clusters at Minnesota. "We wanted a system that would allow life science researchers to address very complex problems, with large memory data sets, that they would not have been able to solve otherwise," says Runesha.

For both machines, MSI needed energy-efficient systems. "We anticipated retiring older systems and upgrading our power and cooling to support the new clusters," says Brian Ropers-Huilman, director of systems administration and technical operations. "But we wanted to minimize the cost of those upgrades. We were looking for systems that would let us deliver the greatest performance without exceeding our power and cooling constraints."

MSI builds its large-scale cluster with Intel® processors

MSI focused on the large-scale cluster first. After evaluating multiple processing architectures and conducting benchmark testing, the MSI team selected dual-socket servers with the Intel Xeon processor 5500 series. "Through our extensive evaluation process, it was clear that systems based on the Intel Xeon processor 5500 series would meet our needs for performance and energy-efficiency," says Ropers-Huilman. "By processing more instructions per clock cycle and providing improved memory bandwidth, these Intel Xeon processors can deliver significantly greater application performance compared with previous-generation processors."

Named "Itasca" after a Minnesota lake, the new cluster has 1,086 compute nodes and a total of 8,688 compute cores. Researchers run applications on a Novell SUSE Linux* Enterprise Server operating system. The cluster also provides a selection of message-passing interface (MPI) software, which includes the Intel® MPI Library, and standard open-source and commercial scientific libraries such as the Intel® Math Kernel Library (Intel® MKL).

New cluster doubles application performance

Running applications on the latest Intel® processing architecture provides a significant performance boost for researchers. "On average, applications run nearly two times faster on the Intel Xeon processor 5500 series than on previous-generation Intel processors," says Ropers-Huilman. "That speed will help researchers publish results sooner and give them the time for further exploration."

With more than four times as many cores, Itasca also enables researchers to ask and answer more compute-intensive questions. "Life sciences researchers are conducting studies that involve analysis of the entire genome. Astronomers are performing high-resolution magnetohydrodynamic (MHD) simulations of the generation of magnetic fields—an 8 billion–zone MHD simulation has already been performed on Itasca. Researchers also can run interactive workloads during which they simultaneously collect data and visualize results in real time," says Runesha. "This cluster is opening up a wide range of research possibilities."

Intel processors provide the foundation for the shared-memory cluster

For the shared-memory cluster, named "Koronis" after another lake, the MSI team chose a supercomputer based on the Intel Xeon processor 7500 series. "With up to four high-speed interconnect links per processor, the Intel Xeon processor 7500 series is the right choice for a large shared-memory cluster," says Ropers-Huilman. "By using the Intel Xeon

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"With these new Intel® processor–based clusters, we can attract new faculty and students to the university, and help researchers compete successfully for new grants....Today more University of Minnesota researchers can conduct their breakthrough research right here on campus."

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processors as the basis for Koronis, each core can access all 3.1 terabytes of memory directly."

Funded by a grant from the National Institutes of Health, the new cluster will drive research in multi-scale modeling, chemical dynamics, bioinformatics and computational biology, and biomedical imaging. "Genomics researchers might need half a terabyte of memory to run just one calculation on a very large data set," says Runesha. "Until now, researchers were limited by available system memory. They had to choose between working on only a small problem or going to another HPC center. With Koronis, we can provide the resources researchers need to address their complex problems."

Energy-efficient systems keep power and cooling under control

The energy-efficient Intel Xeon processors helped MSI build Itasca and Koronis without a drastic overhaul of the data center. "We were prepared to make some changes to accommodate these clusters," says Ropers-Huilman. "But by choosing dense, energy-efficient systems based on Intel Xeon processors, we were able to control the costs."

Intel software development products help optimize code

MSI offers several Intel software development products, including Intel® C++ and Fortran Compilers, to help researchers optimize code for the new clusters. "The Intel compilers play an essential role in enhancing HPC application performance," says Runesha. "We offer several Intel tools to give our researchers a full range of choices."

New clusters attract researchers and sponsor on-campus discovery

The new clusters will play a key role in sustaining the university's culture of intellectual and scientific discovery. "With these new Intel processor–based clusters, we can attract new faculty and students to the university, and help researchers compete successfully for new grants," says Runesha. "Instead of having to locate HPC resources around the country, today more University of Minnesota researchers can conduct their breakthrough research right here on campus."

Keeping a sharp eye on emerging technologies helps to ensure that MSI continues to support those breakthroughs in the future. "By working with the Intel team and participating in the HPC roundtable that Intel hosts, we gain a clear view of the Intel technology roadmap," says Ropers-Huilman. "We can make intelligent decisions about how to build systems for fostering the next generation of discovery at Minnesota."

Performance: Data-Intensive Computing. Support the most demanding business data processing, and computationally intense graphics.

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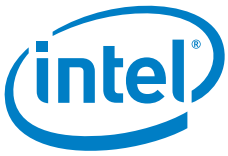
SPOTLIGHT ON THE UNIVERSITY OF MINNESOTA'S SUPERCOMPUTING INSTITUTE FOR ADVANCED COMPUTATIONAL RESEARCH

In 1981, the University of Minnesota was the first U.S. university to acquire a supercomputer. Today, the university's Supercomputing Institute for Advanced Computational Research provides access to five HPC clusters to students and faculty in a diverse range of fields. The Intel® processor–based Itasca and Koronis clusters are designed to enable researchers to capitalize on the power of information technology to address complex problems in their respective disciplines.



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