CASE STUDY
Intel® Xeon® Processor E5 Family
Education
High-Performance Computing
Energy, Environment, and Performance

Driving Cutting-Edge Research in the Heart of Oklahoma

A new University of Oklahoma HPC cluster built on Intel® Xeon® processors boosts performance for research while reducing power consumption

The UNIVERSITY of OKLAHOMA

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– Henry Neeman, Director, OU Supercomputing Center for Education & Research (OSCER), University of Oklahoma

The OU Supercomputing Center for Education & Research (OSCER) at the University of Oklahoma (OU) needed to refresh its primary high-performance computing (HPC) cluster to support a growing number of researchers across a broad range of disciplines. The OSCER team selected Dell PowerEdge* servers equipped with the Intel® Xeon® processor E5 family and QLogic InfiniBand* adapters for the new 6,992-core cluster, named Boomer. The new cluster typically delivers 3.5 times the sustained performance per server of the previous cluster and significantly expands the HPC resources available to the research community while reducing the total cluster energy consumption by approximately 30 percent.

CHALLENGES

- **Increase capacity.** Accommodate a growing number of HPC users and help them answer increasingly complex questions in fields ranging from aerospace and high-energy physics to weather forecasting to zoology.
- **Boost performance.** Enable researchers to increase the speed, detail, and accuracy of their work.
- **Improve energy efficiency.** Expand capacity while controlling power consumption and other operating costs.

SOLUTION

- **Dell PowerEdge servers with the Intel Xeon processor E5 family.** The OSCER team implemented a 6,992-core cluster, based on Dell PowerEdge servers equipped with the Intel Xeon processor E5 family and QLogic InfiniBand adapters.

TECHNOLOGY RESULTS

- **Better performance.** By doubling the number of cores per server and selecting the new Intel® processing architecture, the OSCER team has achieved approximately 3.5 times the sustained performance per server of the previous cluster, which was based on the Intel Xeon processor 5400 series.
- **Less energy.** With an energy-efficient processing architecture and server design, the new cluster consumes approximately 30 percent less energy than the previous cluster while providing 62 percent more cores and approximately 3.25 times the total sustained performance for the cluster as a whole.

BUSINESS VALUE

- **Cutting-edge research.** The new cluster helps more users at OU, across Oklahoma, and beyond to capitalize on the power of HPC to advance their research.

The OU Supercomputing Center for Education & Research (OSCER) at the University of Oklahoma (OU) is dedicated to offering HPC resources, expertise, and education to a wide range of user groups within the university and beyond. Weather researchers, for example, use these HPC resources extensively to run daily real-time forecasts as well as seasonal workloads that attempt to better predict tornadoes and severe storms.

Over the last decade, the OSCER team has refreshed its primary cluster several times to deliver the performance and capacity needed to support a growing number of researchers addressing increasingly complex questions. "We add between 100 and 150 new users every year," says Henry Neeman, OSCER's director. "At the same time, demand for resources doubles every one-and-a-half to two years as users strive to do more with HPC—their ambitions and their needs grow on pace with Moore's Law. To keep up with demand, we are almost continuously planning for the next-generation cluster."

Intel® Xeon® processors combine exceptional compute performance with large-scale memory bandwidth

Each of the three previous clusters used Intel® processors, but with every new cluster, the team considers a full range of hardware options. "We undertake a rigorous, multistage process that involves selecting a system vendor and evaluating numerous subsystem components," says Neeman. "With each component, we examine performance, price, energy efficiency, and other factors. Then we work to find the right combination of components that will provide the best resources to researchers and the best overall value to the university."

Building Boomer with the Intel Xeon Processor E5 Family

After an extensive evaluation process, the OSCER team selected the Intel Xeon processor E5 family for the new cluster, in part because of the exceptional memory bandwidth this processing architecture can provide. "Several applications—especially weather applications, which are a substantial part of our workload—are very sensitive to memory performance," says Neeman. "In our testing, we found that the Intel Xeon processor E5 family could deliver significant improvements in memory performance compared with previous-generation processors."

Meanwhile, Intel® Advanced Vector Extensions (Intel® AVX) instruction sets help improve performance of compute-bound applications. "The Intel Xeon processor E5 family supports vector lengths that are twice as long as the previous-generation architecture. As a result, since we've kept the same clock speed, compute-bound applications running on this cluster can achieve twice the floating-point performance per core as before," says Neeman. "That's a huge win for our compute-bound application users."

The new 6,992-core cluster—named Boomer, after one of the university's mascots—uses Dell PowerEdge R620 servers equipped with the Intel Xeon processor E5 family for most of its compute nodes. Additional Dell PowerEdge R720 servers and a Dell PowerEdge R910 server are used for other cluster functions. The cluster also uses high-performance QLogic InfiniBand adapters.

Based on previous cluster generations, OU expects Boomer to run more than 100 different science and engineering applications, ranging from the WRF* (Weather Research and Forecasting) application to the LAMMPS molecular dynamics simulation application. All applications run on the Red Hat Enterprise Linux* operating system.

Boosting Server Performance by Approximately 3.5 Times

With a theoretical peak of 111.6 TFLOPs, Boomer earned a spot on the TOP500 list of the world's top supercomputers. Among U.S. universities without a federally funded national supercomputing center, it debuted in the top 10.

On a per-server basis, Boomer is delivering significantly greater performance than the previous cluster. "By doubling the number of cores in each server and doubling the vector length per core, our new cluster can deliver up to four times the performance per server. In addition, we're typically seeing sustained performance per server approximately 3.5 times as high as on our previous cluster," says Neeman. "We can accommodate more users and more complex workloads than before while controlling the physical growth and costs of the infrastructure."

With greater compute and memory capacity, the new cluster is helping researchers enhance the detail and precision of their work. "Weather forecasting researchers can generate higher-resolution forecasts for a particular geographic area and also expand the geographic area that they cover," says Neeman. "In addition, they are also able to generate more simultaneous forecasts for the same region to improve the accuracy of predictions."

LESSONS LEARNED

In evaluating multiple cluster components based on multiple criteria, the OSCER team found that it was essential to stay organized. "It's never too early to create the large, detailed spreadsheet that you'll need to help make decisions," says Neeman. "By assembling all the information we needed, in a format that allowed modification as we received new information, we were able to clearly, efficiently, and quickly consider all the alternatives and to design a cluster that meets not only our current needs but also our evolving needs during its useful life."

Reducing Energy Consumption by 30 Percent

By selecting processors and a server design that help maximize performance per watt, the OSCER team has substantially reduced energy consumption for this cluster compared with the previous one. "Boomer has 62 percent more cores than the previous cluster, but we are consuming approximately 30 percent less energy," says Neeman. "Improving energy efficiency enables us to reduce operating costs and maximize the value of our infrastructure investment."

Attracting New Researchers to Oklahoma

The new cluster is not only expanding the capacity of HPC resources for the existing user community, it is also helping attract new faculty and students to the university. "Not all prospective faculty and graduate students initially recognize the potential for using HPC in their research, but they can quickly identify universities that are producing cutting-edge work," says Neeman. "The new cluster is contributing to an exciting environment that is helping to bring new, interesting research to our campus."

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