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High-performance compute cluster at center of wind power research

AMD PROCESSORS HELP UNIVERSITY RESEARCHERS TARGET WEAKNESS IN WIND FARM EFFICIENCY **BY TAM HARBERT**

Wind energy holds great potential for meeting President Barack Obama's goal of deriving 10 percent of the nation's electricity from renewable sources by 2012. In fact, the U.S. Department of Energy has set a goal for the country to generate as much as 20 percent of its electricity specifically from wind by 2030.

Although the United States is a world leader in installed capacity of wind power, today wind power accounts for only a small fraction of the electricity generated in the country.

One key to increasing the amount of electricity generated by wind is to limit the power losses experienced by wind turbines due to problems such as wake turbulence. Wake turbulence occurs when the turbine's blades create large wakes that disrupt the flow of air to other turbines, thereby limiting the efficiency of the other turbines. On even a modest-size wind farm, wake turbulence can reduce potential profits by hundreds of thousands of dollars, so understanding wake turbulence and how it affects performance is critical.

Researchers at the University of Minnesota are working on the challenge. Nationally recognized for their study of fluid dynamics, from the flow of water in rivers to the flow of blood through heart valves, researchers at the university have expanded their techniques to the study of wind dynamics. This involves taking precise real-world measurements from wind farms, including the amount of stress on the blades, the force of the wind and the amount of power generated. These measurements are then used in a custom-built high-performance compute cluster to simulate and model wind patterns and atmospheric turbulence on wind farms. Using extremely complex atmospheric data and topographic information, the compute cluster runs different scenarios involving wind turbines and farms of various sizes and layouts to determine which patterns and blade designs would result in the least interference.

"We are trying to find novel ways to solve some of the most pressing problems in wind power generation, and we're using the computational models to help validate possible solutions," says a university spokesman.

The high-performance compute cluster was built by Nor-Tech of Burnsville, Minn., the second-largest builder of custom computer systems in the country and an AMD Platinum Solutions Provider. In 2006 Nor-Tech provided the University of Minnesota with a high-performance cluster using Dual-Core AMD Opteron™ processors, a system that is still being used by researchers today. So to meet the increased computing requirements of the wind research, Nor-Tech was asked to develop a high-performance cluster with 512 compute cores, along with an eight-core head node, that would be specifically tailored to computational fluid dynamics.

After running its custom code on two different brands of processors, the university decided to use Quad-Core AMD Opteron processors in the cluster. Although other processors offered comparable computing power, the AMD processors provided the best value in terms of processing power and memory configuration. First, the AMD processors cost less than the competition, which meant that the university could get more compute nodes, an important factor in this type of computing. Each compute node holds the measurements for a particular part of a wind turbine installation. On a large scale, the node can represent an entire wind turbine in a large wind farm. On a smaller scale, that node could be one cubic inch on one blade of one wind turbine, explains Dominic Daninger, vice president of engineering at Nor-Tech. So the more nodes in the cluster, the more granularly it can represent the forces on a wind turbine or, alternatively, the more wind turbines it can represent in a wind farm.

The university's goal was to get 512 nodes in this cluster, and the Quad-Core AMD Opteron processors enabled that. "In clustering, you decompose the problem into pieces, and those pieces have to fit neatly into mathematical matrixes," says Daninger.

Second, the Quad-Core AMD Opteron processors fit the researchers' memory requirements at a cost they could afford. "We needed at least 2 gigabytes of RAM per core," says the university spokesman. The competition's processor had 3 gigabytes per core, which would have forced the university to buy more memory per core than it needed. In addition, the Quad-Core AMD Opteron processors used DDR2 memory rather than the more expensive DDR3.

Even though each core of the Quad-Core AMD Opteron processors used less memory than the competition, this was offset by the lower cost of the processors. By being able to afford more processors, the university was able to get more memory for the overall cluster than it would have if it had chosen to use the competition's processor. "For the same amount of money, the AMD chips gave us about 50 percent more processing cores as well as more memory overall," says the university spokesman.

Also, communication among the nodes in the high-performance cluster was critical. The cluster uses InfiniBand high-speed interconnect, which processes data at 20 billion to 40 billion bits per second, says Daninger. Each node in the cluster is doing the calculations on the pressure and other physical forces it's subjected to, and those calculations, in turn, affect each adjacent node.

Delivered to the university in September 2009, the high-performance compute cluster is being used in a wide range of research, involving both wind and water. And having such strong computational capability is helping the university win more grants. Most recently, in October 2009, a consortium of wind energy researchers led by the University of Minnesota was awarded $7.9 million in stimulus funds from the Department of Energy. The consortium, which includes Syracuse University, Dakota County Technical College and industrial partners, will help foster wind energy research and development in the U.S. It was one of only three groups across the country receiving funding for this purpose. "Part of our commitment in the grant proposal was to contribute resources—in particular time on this cluster—for modeling some of these projects," says the university spokesman. "The high-performance compute cluster definitely assists us in being competitive for future grants."

The new compute cluster will also be used in an ongoing water power project in New York City, where the university is collaborating with industry and other national labs to generate energy from the East River's currents. The university is developing computational models to analyze the design and enhance the environmental compatibility of the rotors, turbines and turbine arrays in the river.

Looking to the future, the university is already evaluating Six-Core AMD Opteron processors as an upgrade to the quad-core-based cluster. Upgrading from a quad-core- to a six-core-based cluster is made relatively easy by the "drop-in" replacement ability of many of the Opteron processors and would give researchers a way to foster faster computations, represent more turbines or turbine parts or represent smaller sectors.

Such increased compute power could be crucial. The American Wind Energy Association estimates that the number of installed wind turbines in the U.S. has doubled in the last five years. In the last two years alone, the industry has added more than 15,000 megawatts of capacity, and with President Obama's energy goals, that growth is likely to accelerate. Fine-tuning these turbines' efficiency could determine how big a contributor wind power will be to the emerging renewable energy industry in the U.S.