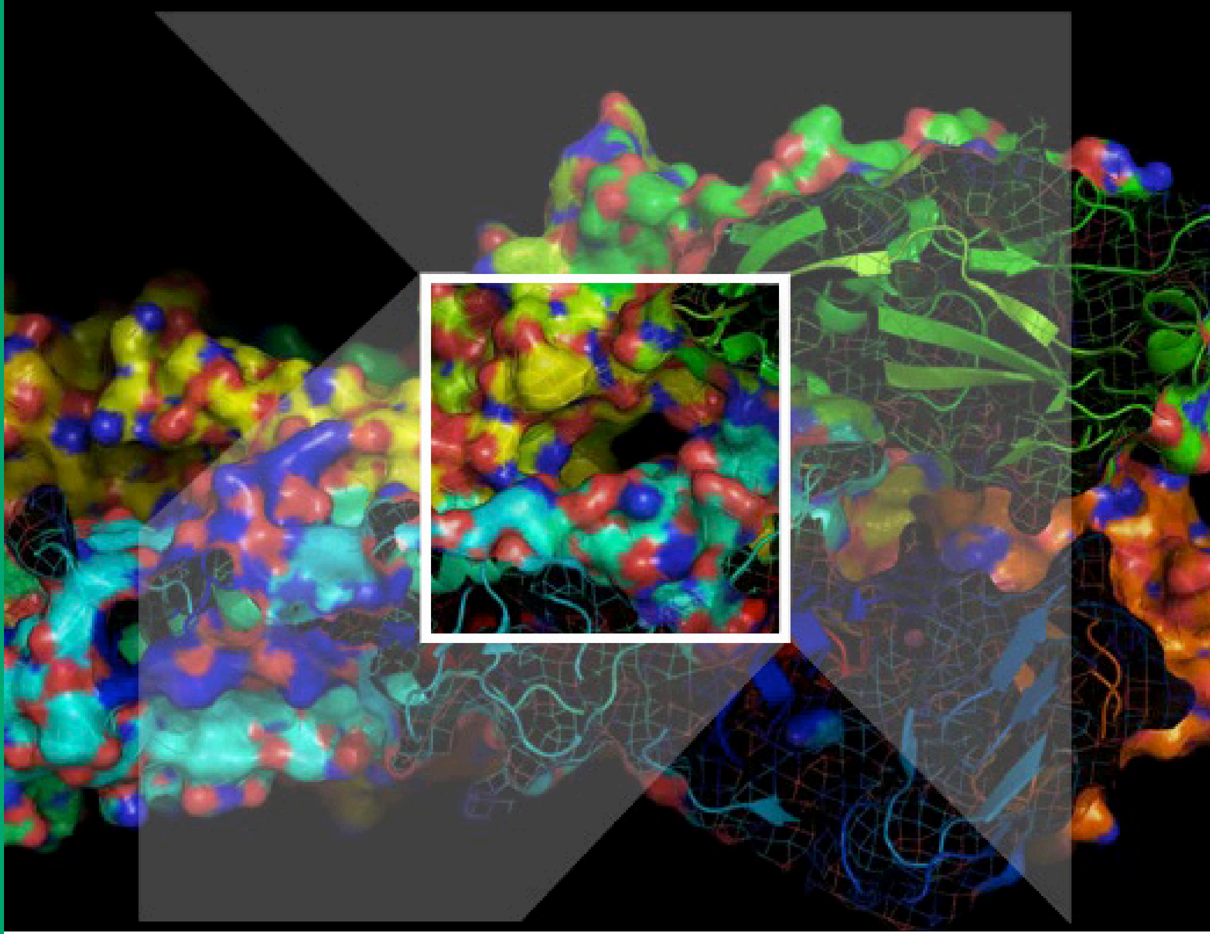

CUSTOMER:
Texas Advanced Computing Center
http://www.tacc.utexas.edu/

IN PARTNERSHIP WITH:
Dr. Aleksei Aksimentiev
http://physics.illinois.edu/people/profile.asp?aksiment

INDUSTRY
High Performance Computing/
Medical Research
Genetic sequencing technology

CHALLENGES
- Develop a faster process for DNA analysis
- Reduce the cost of genetic sequencing
- Increase availability of technology for a new era of personalized medicine

SOLUTION
- The 60,000 core Ranger supercomputer at the Texas Advanced Computing Center (TACC), powered by AMD Opteron™ processors.

RESULTS
- Analyzed researchers' experimental "nanopore" data
- Enabled robust, sub-microscopic DNA sequencing simulations
- Advanced the science behind personalized medicine

AMD TECHNOLOGY AT A GLANCE
Multi-core AMD Opteron™ processors

AMD Technology-powered Supercomputer Explores Next-Gen DNA Analysis and Delivers Personalized Medicine

Accelerating a medical revolution

Dr. Aleksei Aksimentiev is an Assistant Professor of Physics in the Beckman Institute for Advanced Science and Technology at the University of Illinois at Urbana-Champaign. As part of a collaborative research and experimentation team at the University of Illinois, Dr. Aksimentiev is working to develop a more affordable and accessible DNA sequencing process.

An expensive map leads to new ideas

A decade ago, the cost of mapping an individual human DNA sequence cost about $1 billion. Five years later, advances in technology brought the total down to about $10 million. Today, DNA sequencing runs about $50,000.

But a revolutionary new process currently in development could bring the cost of DNA sequencing below $1000—and simultaneously usher in a new era of personalized medicine designed for a patient's unique genetic makeup.

"We are using supercomputers to discover new ways to sequence DNA to make this procedure faster and less expensive so it can be used as a routine medical procedure," says Aksimentiev. "It's really the ultimate diagnostic tool to determine all kinds of genetic disorders."

The medical revolution will be personalized

"The main idea is that when a patient comes to the hospital, he or she would give blood and in real-time, maybe in less than an hour, the physician could get access to the patient's sequence. Then the physician could see which diseases could be associated with the genetic makeup of the individual and prescribe drugs that would be most effective."

Today's "one size fits all approach" is less effective in treating disease and, in some cases, it can be dangerous if key information about a patient's genetic predispositions are not taken into account. New gene sequencing methods are needed to provide physicians with a cost-effective means to base their evaluation and treatment on the unique characteristics of their patients.

"Supercomputers are making it possible for us to understand the intricate machinery of a biological cell."

Dr. Aleksei Aksimentiev
Assistant Professor of Physics, Beckman Institute for Advanced Science and Technology, University of Illinois at Urbana-Champaign

AMD

The future of DNA sequencing

Though still in the development phase, Aksimentiev's experimental sequencer design uses an electric field to physically drive a DNA strand through an ultra-thin silicon membrane via a hole one-ten-thousandth the width of a human hair (known as a "nanopore"). As the DNA passes through the nanopore, scientists can record electric signals that result from DNA interactions with the membrane. From this data, an accurate genetic sequence can be calculated.

"Researchers have been able to sequence, so far, only very short fragments of DNA. But, it's conceivable that within a two-year timeframe we might see an experimental demonstration of DNA sequencing using nanopores," says Aksimentiev. "And after that, it would probably be another two years before the first commercial device is available on the market."

But since one can't actually see inside a sub-microscopic nanopore to analyze the intricacies of the sequencing process as it happens, Aksimentiev uses the AMD Opteron™ processor-powered Ranger supercomputer at the Texas Advanced Computing Center (TACC) to create detailed sequencing simulations to help visualize, verify, alter, and improve their physical DNA experiments.

"Using computers, we can test different strategies and determine what is optimal and then go back to the experiments to see if it works in practice," says Aksimentiev.

A supercomputer with serious density

Launched in June of 2008, the National Science Foundation-sponsored Ranger supercomputer at TACC has held a position as one of the world's largest, most powerful supercomputers and has been a mainstay of the academic computational research community.

Designed around multi-core AMD Opteron™ processors, Ranger features a density of more than 60,000 processing cores. It offers peak performance capability of 579 trillion calculations (or teraflops) per second, 123 terabytes of total memory, and 1.7 petabytes of raw global disk space—pushing the limits of what's possible with advanced computing capabilities.

Ranger is a blade-based system with each node comprised of a Sun Microsystems SunBlade x6420 blade running a 2.6.18.8 Linux kernel. Each node contains four AMD Opteron™ Quad-Core 64-bit processors (16 cores in all) on a single board, as an SMP unit. The core frequency is 2.3 GHz and supports 4 floating-point operations per clock period with a peak performance of 9.2 GFLOPS/core.

The AMD Opteron™ processor's quad-core architecture enabled Sun Microsystems to build an HPC system with peak performance beyond 500 teraflops and achieve their goal for Ranger to be the world's largest and fastest academic supercomputer at the time of its introduction.

Among its achievements, Ranger has helped scientists address massive scientific problems with incredible speed—including improving hurricane forecasts, limiting the spread of the H1N1 virus, and understanding solar energy capture.

"I think supercomputers and the way they have been developing over the past ten years are offering a completely new perspective," says Aksimentiev. "Computer development has really exceeded my expectations and everybody's expectations."

"Supercomputers enable us to develop new technologies to improve human health, one of which is personalized medicine," says Aksimentiev. "Personalized medicine is coming. High-throughput genome sequencing may be available soon, and we need to plan for it."

For more information about AMD's innovative technologies and our work in High Performance Computing, go to: http://www.amd.com/hpc

"We really need a better look at what is going on inside a nanopore.That's why we build these computational models. We can simulate in atomic detail the process of DNA transfers through these pores and directly compare the results, which gives us confidence that our computational model is correct."

Dr. Aleksei Aksimentiev
Assistant Professor of Physics, Beckman Institute for Advanced Science and Technology, University of Illinois at Urbana-Champaign

Image page one: The 2009 H1N1 Swine Flu virus was responsible for an estimated 18,000 deaths worldwide. The Hemagglutinin receptor section of the 2009 H1N1 Swine Flu virus is ray- traced using the PyMol molecular visualization system. Ray-tracing was performed using the Bronco visualization system in the Texas Advanced Computing Center's (TACC) ACES Visualization Laboratory at The University of Texas at Austin. This dataset is publicly available from the Protein Data Bank http://www.rcsb.org/pdb/home/home.do Credit: Brandt Westing, TACC

Image page two: At 579.4 teraflops, the Ranger supercomputer provides unprecedented computational abilities to the national research community and enables groundbreaking research in computational science and technology research. Photo Credit: AMD

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