CASE STUDY

intel Software

High-Performance Computing Education and Research

Intel® Parallel Studio Cluster Edition, Intel® Software Development Suite Student Edition

High-Performance Computing

Ural Federal University

named after the first President of Russia B.N.Yeltsin

Intel® Developer Tools and Online Courseware Enrich the High-Performance Computing Curriculum at Ural Federal University

In 2012, the world saw the first systems built on Intel's first many-cores commercial product, the Intel® Xeon Phi™ coprocessor. Today, Intel® Xeon® processors and these first-generation Intel Xeon Phi coprocessors contribute more floating point operations per second (FLOPS) to the Top500* than any other form of computation.

Tianhe-2*, the world's fastest supercomputer on the Top500 list, uses Intel Xeon processors and Intel Xeon Phi coprocessors.

First-generation Intel Xeon Phi coprocessors deliver one TeraFLOPS for single-thread performance. Second-generation Intel Xeon Phi coprocessors deliver a huge leap in performance—three TeraFLOPS double-precision peak theoretical performance per single socket node.

Imagine driving high-performance computing education and big data research and development at one of your country's most prestigious technical universities. You need the power of parallel computing at this scale. You'll want your professors and students to have access to the most advanced computational potential available—plus the expertise to use those technologies most effectively.

The Challenge

That is Dr. Andrey Sozykin's mission. Sozykin is head of the High Performance Computing Chair of the Institute of Mathematics and Computer Sciences (IMCS) at Ural Federal Technologies University (UrFU) in Yekaterinburg, Russia. He's also head of the Computer Science Department of the Institute of Mathematics and Mechanics at the Ural Branch of the Russian Academy of Sciences.

Professor Elena Akimova, Sozukin's colleague, is a doctor of physical and mathematical sciences, a leading researcher at the Institute of Mathematics and Mechanics of Ural Branch of RAS, and professor of the Numerical Methods and Equations of Mathematical Physics Chair of the Institute of Radioelectronics and Information Technologies at UrFU.

Their main scientific interests are inverse geophysical problems, numerical methods, parallel algorithms, and multiprocessor computing systems. Their main research project is finding the theory and algorithms for solving nonlinear, inverse gravity and magnetic problems in a multilayer medium using parallel computing systems.

Training Highly Skilled Specialists

"Through the Intel relationship, the university prepares specialists not only with broad theoretical knowledge, but also with practical software development skills. Students are able to use effective modern software development tools to solve real scientific problems."

– Andrey Sozykin, Head of the High-Performance Computing Department Chair, Institute of Mathematics and Computer Sciences, Ural Federal University

UrFU is one of the top-ranked scientific centers in Russia, carrying out research in natural, technical, and social sciences; humanities; and economics. Since 2008, the university has borne the name of Boris Yeltsin, the first President of Russia, a 1955 graduate.

UrFU is ranked 551 on the QS World University Rankings for 2014/2015 and 80th in the BRICS ranking of universities in five major emerging national economies (Brazil, Russia, India, China, and South Africa).

University administrators have their sights set much higher. In 2013, UrFU became one of 15 Russian universities chosen to receive a special subsidy to enhance its global competitiveness and raise its positions on international rankings. In October 2013, a roadmap was approved that is designed to push UrFU into the top 100 of world universities by 2020.

Fueling the Educational and Research Mission from a Distance

Elevating UrFU's status means training highly skilled specialists. And that means the University must provide not only general theoretical courses, but also special training in modern computational technologies.

Sozykin's High Performance Computing Chair offers graduate-level programs in computer science with specializations in parallel computing and system software development. The curricula of both tracks includes courses in high-performance computing, supercomputing technologies, big data, numerical methods, data analysis, and more.

Students perform practical exercises on the University's computational cluster using a number of development tools from Intel, plus OpenMP*, OpenACC*, CUDA*, Apache Hadoop MapReduce* and other technologies. Students can also participate in scientific projects carried out by the department in cooperation with several institutes of the Ural Branch of the Russian Academy of Science.

"Our students need to know how to effectively use software development tools for modern computational architectures, including multi-core and many-core processors," said Sozykin. The university's computing cluster contains Intel Xeon E5-2620 and Intel Xeon Phi 5110P processors.

How can faculty members and researchers keep their knowledge current in a fast-changing parallel computing and big data environment? How can they get the consultative support they need when they're a 24-hour drive from Moscow and a 20-hour flight from Intel headquarters in California?

The Solution

To achieve academic and research excellence, the High Performance Computing Chair takes advantage of two very different types of resources from Intel: advanced software developer tools and technical and instructional support.

Advanced Software Developer Tools

UrFU uses Intel® Parallel Studio XE Cluster Edition (formerly called Intel® Cluster Studio XE) for modeling living systems solutions and geophysical problems, handling large graphs, and for other applications. The developers' toolkit includes:

- C++ and Fortran compilers
- Performance libraries and parallel models optimized for fast parallel code
- Performance profiler, threading design/prototyping tools, and memory and thread debugger
- MPI (Message Passing Interface) cluster communications library with error checking and tuning

These capabilities make it easier for professors and students to design, develop, debug, and tune code that uses parallel processing. The result is a boost in application performance with less effort on compatible Intel® processors and co-processors.

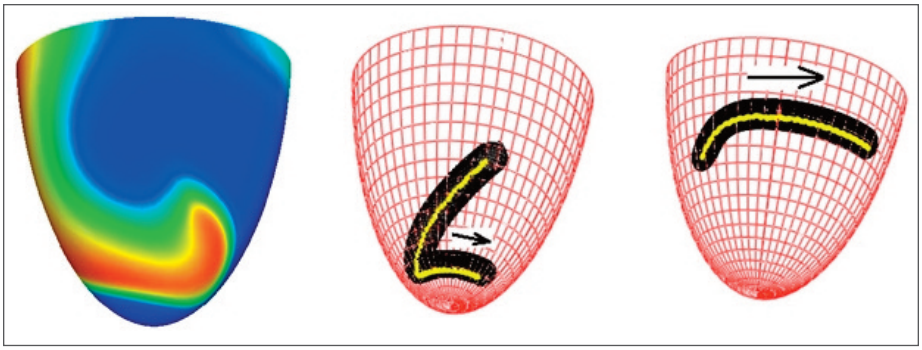

Figure 1. Modeling the drift of scroll waves in an anisotropic model of the cardiac left ventricle

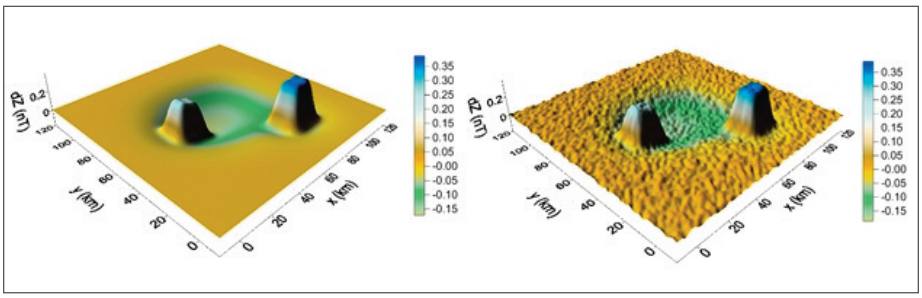

Figure 2. Solving the inverse problem of magnetometry

"Intel® software helps to significantly reduce the computational time of programs on our computing cluster, sometimes by several times," said Akimova.

Technical and Instructional Support

"The teachers must have practical experience and deep understanding of technical details of such tools, which is almost impossible for university professors; they cannot provide such training by themselves," said Sozykin. "We rely on help from leading commercial companies and industry specialists."

Intel has been instrumental in several ways:

- Intel Russia delivered special training sessions to accelerate professors' expertise with Intel software and hardware.
- Intel and UrFU collaborated to open a joint UrFU-Intel High-Performance Computing Competence Center. Intel engineers provide permanent technical support to this center.

In cooperation with the Intuit.ru portal, Intel provides the Intel Academy, a track of free, online courses about Intel's software development tools for mobile applications and parallel computing, to augment the university curriculum:

- Intel® Parallel Programming Professional
- Introduction to Application Performance Optimization Using Intel® Compilers
- Application Performance Optimization Using Intel® Compilers
- Application Performance Optimization Using Intel® Math Kernel Library
- Introduction to Silk Plus* Programming

In addition, materials from Intel Academy courses are used in UrFU courses:

- Parallel Computing
- Application Performance Optimization
- Architecture of High Performance Computing Systems

Students watch Intel-provided video lectures online from anywhere, and then run the practical exercises on the UrFU computing cluster and discuss what they've learned from the results and online seminars.

The combination of online, practical, and classroom learning provides a richer and more comprehensive educational experience.

About Ural Federal University

Ural Federal University is a public, government-owned institution that offers 350 degree programs through 17 institutes to more than 50,000 students. The 2011 merger of Ural Federal University and Ural State University—the region's two oldest universities—significantly raised the university's international reputation and its position in global rankings.

Ural Federal University is the core of a research cluster comprising scientific institutes of the Ural Branch of the Russian Academy of Sciences, specializing laboratories, and high-tech enterprises.

The university is engaged in many international projects funded by governmental and non-governmental organizations from Russia, the European Union, and the U.S.

Ural Federal University is a member of the Shanghai Cooperation Organization (SCO) Network University, the Community of Independent States (CIS) Network University, and the Network University of the Arctic.

UrFU also uses certification tests on application performance optimization provided by Intel Academy. Students can gain credentials that will springboard their careers.

Results

Faster Computing

Intel® software helps to significantly reduce the computational time to run programs on UrFU's computing cluster. Students and researchers can achieve more with less, or run more iterations, ask more what-if questions and, in turn, produce better results.

Academic Quality

"With the help of Intel, we can provide quality, university-level instruction in the most effective use of Intel® tools to develop scientific applications and optimize application performance on modern multi-core and many-core processors," said Sozykin. "Students can have more practical classes in the university, because they have already gained the necessary theoretical knowledge from the online lectures."

Blending online and classroom learning to take advantage of expertise half a world away. It's like implementing the parallel processing, cloud computing model for high-performance learning. And it is an important key leading to a more prominent role on the world stage for UrFU.

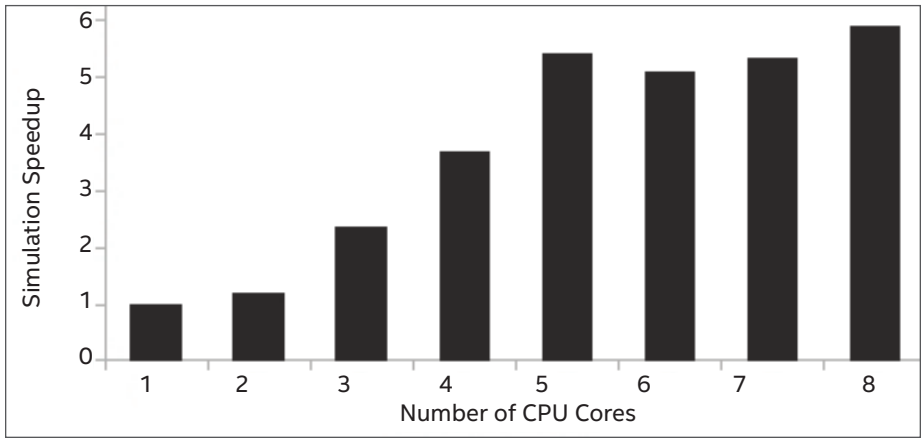

Figure 3. Average cardiac ventricle simulation time comparison: serial versus parallel

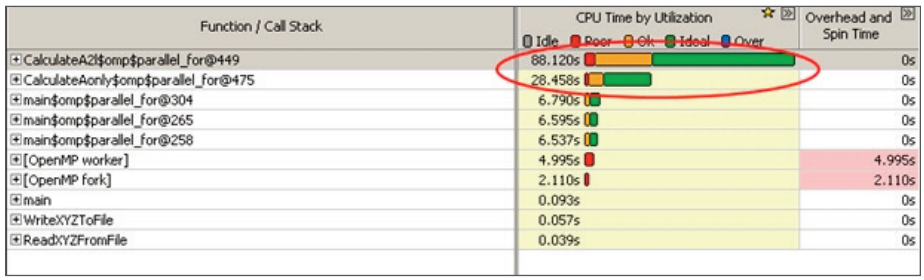

Figure 4. Using Intel® VTune Amplifier to find hotspots in geophysical simulation software

ASC 15 Student Supercomputer Challenge

A team of students and masters of the Numerical Methods and Equations of Mathematical Physics Chair, under the supervision of Dr. Elena Akimova, won the Silver Cup First Prize and was awarded with Diplomas-Letters of Honour on the international ASC15 Student Supercomputer Challenge. ASC15 was co-organized by Asia Supercomputer Community, Inspur Group, and Taiyuan University of Technology. The team was one of 16 finalists out of 152 participating teams from 135 universities and six continents.

Learn More

Ural Federal University:
http://urfu.ru/en/

Intel® Software Developer Tools:
https://software.intel.com/en-us/intel-sdp-home

Intel® Parallel Studio XE:
https://software.intel.com/en-us/intel-parallel-studio-xe

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