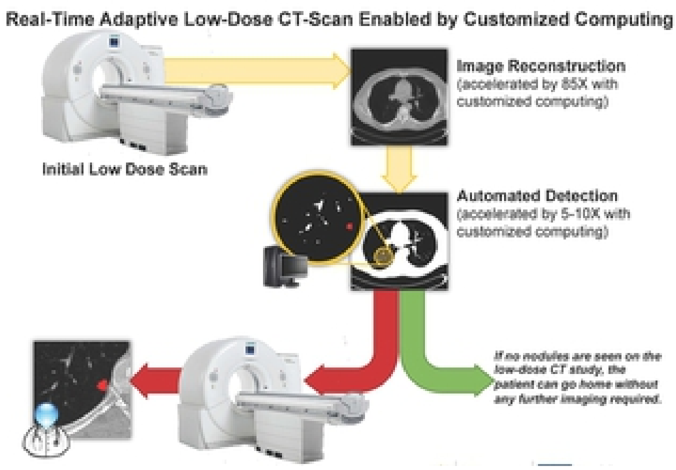
Taking great ideas from the lab to the fab

July 31 2014



This diagram depicts real-time adaptive low-dose CT-scan enabled by customized computing. Credit: Center Domain-Specific Computing

A "valley of death" is well-known to entrepreneurs—the lull between government funding for research and industry support for prototypes and products. To confront this problem, in 2013 the National Science Foundation (NSF) created a new program called InTrans to extend the life of the most high-impact NSF-funded research and help great ideas transition from lab to practice.

Today, in partnership with Intel Corporation, NSF announced the first InTrans award of $3 million to a team of researchers who are designing customizable, domain-specific computing technologies for use in healthcare.

The work could lead to less exposure to dangerous radiation during x-rays by speeding up the computing side of medicine. It also could result in patient-specific cancer treatments.

Led by the University of California, Los Angeles, the research team includes experts in computer science and engineering, electrical engineering and medicine from Rice University and Oregon Health and Science University. The team comes mainly from the Center of Domain-Specific Computing (CDSC), which was supported by an NSF Expeditions in Computing Award in 2009.

Expeditions, consisting of 5-year, $10 million awards, represent some of the largest investments currently made by NSF's Computer, Information Science and Engineering (CISE) directorate.

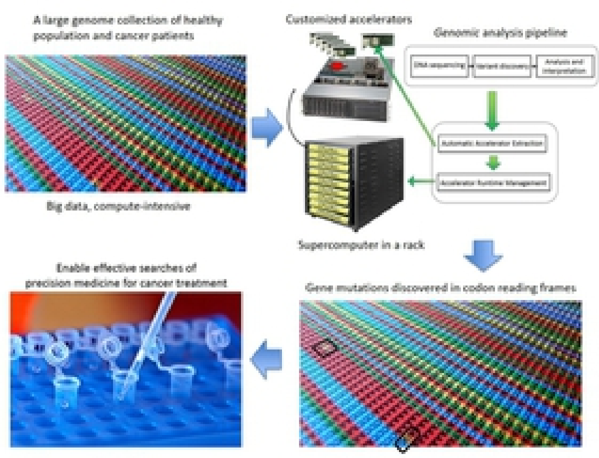
Today's InTrans grant extends research efforts funded by the Expedition program with the aim of bringing the new technology to the point where it can be produced at a microchip fabrication plant (or fab) for a mass market.

"We see the InTrans program as an innovative approach to public-private partnership and a way of enhancing research sustainability," said Farnam Jahanian, head of NSF's CISE Directorate. "We're thrilled that Intel and NSF can partner to continue to support the development of domain-specific hardware and to transition this excellent fundamental research into real applications."

In the project, the researchers looked beyond parallelization (the process of working on a problem with more than one processor at the same time) and instead focused on domain-specific customization, a disruptive technology with the potential to bring orders-of-magnitude improvements to important applications. Domain-specific computing systems work efficiently on specific problems—in this case, medical imaging and DNA sequencing of tumors—or a set of problems with similar features, reducing the time to solution and bringing down costs.

"We tried to create energy-efficient computers that are more like brains," explained Jason Cong, the director of CDSC, a Chancellor's Professor of computer science and electrical engineering at UCLA, and the lead on the project.

"We don't really have a centralized central processing unit in there. If you look at the brain you have one region responsible for speech, another region for motor control, another region for vision. Those are specialized 'accelerators.' We want to develop a system architecture of that kind, where each accelerator can deliver a hundred to a thousand times better efficiency than the standard processors."



This image depicts customized computing in search of precision medicine for cancer treatment. Credit: Center for Domain-Specific Computing

The team plans to identify classes of applications that share similar computation kernels, thereby creating hardware that solves a range of common related problems with high efficiency and flexibility. This differs from specialized circuits that are designed to solve a single problem (such as those used in cell phones) or general-purpose processors designed to solve all problems.

"The group laid out a different way of presenting the problem of domain-specific computing, which is: How to determine the common features and support them efficiently?" said Sankar Basu, program officer at NSF. "They developed a framework for domain-specific hardware design that they believe can be applied in many other domains as well."

The group selected medical imaging and patient specific cancer treatments—two important problems in healthcare—as the test applications upon which to create their design because of healthcare's significant impact on the national economy and quality of life.

Medical imaging is now used diagnose a multitude of medical problems. However, diagnostic methods like x-ray CT (computed tomography) scanners can expose the body to cumulative radiation, which increases risk to the patient in the long term.

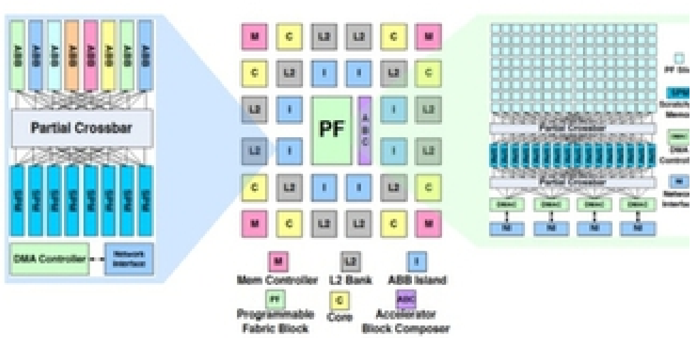
Scientists have developed new medical imaging algorithms that lead to less radiation exposure, but these have been constrained due to a lack of computing power.

Using their customizable heterogeneous platform, Cong and his team were able to make one of the leading CT image reconstruction algorithms a hundred times faster, thereby reducing a subject's exposure to radiation significantly. They presented their results in May 2014 at the IEEE International Symposium on Field-Programmable Custom Computing Machines.

"The low-dose CT scan allows you to get a similar resolution to the standard CT, but the patient can get several times lower radiation," said Alex Bui, a professor in the UCLA Radiological Sciences department and a co-lead of the project. "Anything we can do to lower that exposure will have a significant health impact."

In theory, the technology also exists to determine the specific strain of cancer a patient has through DNA sequencing and to use that information to design a patient-specific treatment. However, it currently takes so long to sequence the DNA that once one determines a tumor's strain, the cancer has already mutated. With domain-specific hardware, Cong believes rapid diagnoses and targeted treatments will be possible.

"Power- and cost-efficient high-performance computation in these domains will have a significant impact on healthcare in terms of preventive medicine, diagnostic procedures and therapeutic procedures," said Cong.



This image shows accelerator-rich architecture with composable and reconfigurable accelerators. Credit: Center Domain-Specific Computing

"Cancer genomics, in particular, has been hobbled by the lack of open, scalable and efficient approaches to rapidly and accurately align and interpret genome sequence data," said Paul Spellman, a professor at OHSU, who works on personalized cancer treatment and served as another co-lead on the project.

"The ability to use hardware approaches to dramatically improve these speeds will facilitate the rapid turnarounds in enormous datasets that will be necessary to deliver on precision medicine."

Down the road, the team will work with Spellman and other physicians at OHSU to test the application of the hardware in a real-world environment.

"Intel excels in creating customizable computing platforms optimized for data-intensive computation," said Michael C. Mayberry, corporate vice president of Intel's Technology and Manufacturing Group and chair of Corporate Research Council. "These researchers are some of the leading lights in the field of domain-specific computing.

"This new effort enables us to maximize the benefits of Intel architecture. For example, we can ensure that Intel Xeon processor features are optimized, in connection with various accelerators, for a specific application domain and across all architectural layers," Mayberry said. "Life science and healthcare research will undoubtedly benefit from the performance, flexibility, energy efficiency and affordability of this application."

The InTrans program not only advances important fundamental research and integrates it into industry, it also benefits society by improving medical imaging technologies and cancer treatments, helping to extend lives.

"Not every research project will get to the stage where they're ready to make a direct impact on industry and on society, but in our case, we're quite close," Cong said. "We're thankful for NSF's support and are excited about continuing our research under this unique private-public funding model."

Provided by National Science Foundation