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NMSU engineering research may help solve some of the biggest computer problems

(Source: Las Cruces Sun- News)

LAS CRUCES — A long-time partnership between Jeanine Cook, New Mexico State University electrical and computer engineering associate professor, and Sandia National Laboratories has resulted in a project that will push the limits of computing power to help scientists more quickly and efficiently solve complex problems that are important to areas such as national security and medical research.

The four-year National Science Foundation project aims to develop an entirely new computer system focused on solving complex, graph-based problems that will reach into the next frontier of supercomputing: exascale processing that is 1,000 times that of the fastest computer currently operational, at one quadrillion operations per second.

"A simple example of a graph-based computer problem is Facebook," explains Cook, who directs the Advanced Computer Architecture Performance and Simulation Laboratory at NMSU. "When you make a profile and begin adding friends, Facebook goes out and identifies other friends that you might add to your network. It's all based on a giant graph of connections showing relationships among people."

Computers are increasingly being used to solve graph-based, data-intensive problems in application areas such as cybersecurity, medical informatics and social networks.

But computers aren't designed specifically to solve these types of problems.

"Our system will be created specifically for solving these types of very complex problems. Intuitively, I believe that it will be an improvement. These are the most difficult types of problems to solve, mainly because the amount of data they require is huge and is not organized in a way that current computers can use efficiently," Cook said.

Cook specializes in micro-architecture simulation, performance modeling and analysis, workload characterization and power optimization. "I create software models of computer processor components and their behavior and use these models to predict and analyze performance of future designs," Cook said.

It was her work while on sabbatical with Sandia's Algorithms and Architectures group in 2009 that led to the $2.7 million NSF collaborative project. Cook developed processor and simulation tools and statistical performance models that identified performance bottlenecks in Sandia applications. Her work with Sandia also led to her selection by President George W. Bush as one of the recipients of the prestigious Presidential Early Career Award for Scientists and Engineers.

While there, Cook worked with Richard Murphy, a leading expert in the area of computer systems architecture. Murphy was interested in developing a system that would solve graph-based problems faster while consuming less energy. Together they assembled a team of researchers from Sandia, NMSU, Indiana University and Louisiana State University. Cook, Murphy and two NMSU electrical engineering Ph.D. students, Patricia Grubel and Samer Haddad, will collaborate on hardware development. Colleagues Andrew Lumsdaine, at Indiana University, and Thomas Sterling, at Louisiana State University, will develop the software.

A main goal of the design is to incorporate programmable hardware, known as Field-programmable Gate Arrays, to provide customized circuitry for executing graph algorithm operations.

Another goal is to make it available for public license. The system will be described in VHDL, a hardware description language that is an international standard, and the description will be made freely available to a whole gamut of users who perform graph-based computing — government laboratories, commercial enterprises and academia.

"Anyone, anywhere could buy off-the-shelf reprogrammable hardware and download our architecture and software and replicate the system," Cook said.

The biggest goal, however, is improved performance and energy efficiency.

"This system will be faster because the processor will be custom designed to execute these specific applications, so performance will be optimized. The current systems used for running graph-based problems are relatively slow," explained Cook.

"They will also use less energy because FPGAs are very energy-efficient," she added. "This is a significant consideration because it reduces the cost of running these types of large applications. And everyone is having trouble paying their electric bills these days."

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