What's Next for HPC? HPD, Says SDSC Head

Fusing High-Performance Data with High-Performance Computing Will Speed Research

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As researchers in all major science domains struggle to keep up with the exponentially growing amount of digitally based data, the HPC (high-performance computing) community will evolve to include HPD, or high-performance data, to benefit researchers who need to access, analyze, and store extremely large data sets in significantly shorter amounts of time.

"We are figuring out ways to fuse HPC together with what I now call HPD, and put the best of both worlds into one computer system," said Michael Norman, interim director of the San Diego Supercomputer Center (SDSC) at UC San Diego, during a presentation this week as part of the University's activities complementing the American Association for the Advancement of Science (AAAS) annual meeting in San Diego.

Distinctions between HPC and HPD can be made on several measures, said Norman, but fusing them together has the potential to create both robust systems that will be at least one order of magnitude faster than anything in the HPC community today for certain applications. Last November, SDSC announced plans to build a new system called *Gordon*. Funded by the National Science Foundation and slated to be operational in mid-2011, *Gordon* will be the first data-intensive supercomputer of the modern era because of its novel technology.

In fact, when complete, *Gordon* should rate among the top 30 or so supercomputers in the world. That's because with the aid of flash memory SSDs (solid state drives), this system will have the ability to do latency-bound file reads 10 times faster and more efficiently than any HPC system today. "It's not just about FLOPS (floating point operations per second) anymore as a key hardware metric," said Norman, who is a distinguished professor of physics at UC San Diego and a noted astrophysicist in addition to leading SDSC. "It's also about IOPS, or I/O operations per second. We expect *Gordon* to have a rating of about 35 million IOPS, which would be a record. That makes it ideal for tackling data-intensive problems that don't scale well on today's massively parallel supercomputers, such as the analysis of individual genomes to tailor drugs to specific patients, developing more accurate models to predict the impact of earthquakes or other natural disasters on buildings and other structures, and coupled ocean/atmospheric simulations that offer greater insights into what's happening to the planet's climate."

Other key distinctions between HPC and HPD systems is that an HPD system such as *Gordon* has fewer, large memory SMP nodes, while HPCs have many small-memory multi-core nodes. Moreover, HPD systems typically have smaller, random disk I/O patterns, while HPCs use larger blocks that are sequential.

World's largest thumb drive One of the key technologies of *Gordon's* lightning-fast architecture is the use of a large amount of flash memory, or SSDs. When fully configured and deployed, *Gordon* will feature 245 teraflops of total compute power (one teraflop or TF equals a trillion calculations per second), 64 terabytes (TB) of DRAM (digital random access memory), and 256 TB of flash memory, or about one-quarter of a petabyte.

"This is the kind of memory that's in your thumb drive or memory stick, and this kind of memory is now at a price point where you can afford to put a large amount of it on a supercomputer," said Norman. "So we consider *Gordon* to be the largest thumb drive in the world for academic research."

Moreover, *Gordon* will help fuse HPC and HPD together because it is designed for data-intensive predictive science, such as earthquake applications; along with data mining applications, where researchers try to extract patterns from massive amounts of data.

"This is quite a new area for the NSF, and what's interesting is that those data-intensive predictive science applications often turn into data mining applications once the results have been computed, so there is a great synergy between these two kinds of inquiries," said Norman.

Drowning in data This 'best of both worlds approach' is because researchers are simply drowning in data as the world goes digital. The amount of valuable, digitally-based information - consisting of text, video, images, etc. generated throughout all areas of our society - is growing faster than originally thought, according to a recent study by the International Data Corporation (IDC). Despite the weak economy, a total of 3,892,179,868,480,350,000,000 (that's 3 sextillion, 892 quintillion, 179 quadrillion, 868 trillion, 480 billion, 350 million) new digital information bits were created in 2008 alone, three percent more than predicted.

Looking forward, this 'digital universe' is expected to double in size every 18 months. And by 2012, five times as much digital information will be created versus just four years earlier, according to the IDC report.

Gordon is just one of several new systems that are either already in place or scheduled to go online next year at the supercomputer center, one of the first such centers founded by the National Science Foundation (NSF) 25 years ago.

Already in place is the *Triton Resource*, a new data-intensive system which features some of the most extensive data analysis power available commercially or at any research institution in the country because of its unique large-memory nodes. Intended for use primarily by UC and UC San Diego researchers, the system includes a Petascale Data Analysis Facility (PDAF) designed for the analysis of very large data sets, and the Triton Computer Cluster (TCC), a scalable cluster designed as a centralized resource and a highly affordable alternative to less energy-efficient 'closet computers.'

The third "prong" of the *Triton Resource* is a large-scale storage facility known as the Data Oasis. When fully configured, Data Oasis will provide up to four petabytes (PB) of extensible storage - the largest capacity of any academic data center. "We view Data Oasis as the heart of UC San Diego's emerging research cyberinfrastructure," said Norman, adding that *Gordon* will tap into Data Oasis' vast storage capability

"All of these systems are excellent examples of integrating HPC and HPD," Norman told the AAAS attendees. "We have developed a very broad expertise here at SDSC in all things having to do with data management, and we have been looking for new ways and new support mechanisms to make that expertise available to our customers."

Within the *Triton Resource* is a small but extremely fast "system within a system" that marks the first use of flash memory in an HPC system. Called *Dash*, it was designed to be a prototype for the much larger *Gordon. Dash* began trial runs late last year, and already won the Storage Challenge Award at SC09 last November.

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