

ROCK-SOLID IT

Dell servers and storage are expected to help deliver up to 18 times better model resolution for the study of rock physics problems at the University of Toronto



At the Rock Fracture Dynamics Lab (RFDL) at the University of Toronto, researchers are working to solve the mysteries locked within the Earth's unstable crust. Studying the chain of events that turn a small rock fissure into an earthquake or landslide can help contribute to geophysical studies and address practical engineering challenges. The lab depends on specialized equipment and advanced IT to record large amounts of data, create complex computer models, and deliver real-time results for research.

SOLUTION

- CLUSTERING



CUSTOMER PROFILE

COUNTRY: Canada

INDUSTRY: Education

FOUNDED: 1827

NUMBER OF EMPLOYEES: 11,807

WEB ADDRESS: www.lassondeinstitute.utoronto.ca/young

CHALLENGE

The Rock Fracture Dynamics Lab wanted to build a one-of-a-kind rock dynamics lab that could record large amounts of experimental data, create detailed and accurate computer models, and provide access to information for numerous students and researchers.

SOLUTION

Dell Global Infrastructure Consulting Services (ICS) helped the lab design and build a 128-processor, 256-core high-performance computing (HPC) cluster using Dell™ PowerEdge™ servers. Dell ICS also helped design a direct attach storage system using Dell PowerVault™ disk arrays for streaming the lab's large amounts of experimental data.

BENEFITS

Get IT Faster

- Reduced complex model construction time by more than 50 percent

Run IT Better

- Expected to help improve model resolution by up to 18 times
- Enabled researchers to record detailed data streams for approximately 100 times longer duration
- Helped produce exceptionally accurate computer representations of natural phenomena





HOW IT WORKS

HARDWARE

- Dell™ PowerEdge™ 2950 and PowerEdge 1950 servers with dual-core Intel® Xeon® processors
- Dell PowerVault™ MD1000 disk arrays
- Dell PowerVault 124T tape library
- NEC 46-inch LCD monitors
- Broadcom Gigabit Ethernet network cards
- Nortel 5510 Ethernet routing switches

SOFTWARE

- CommVault Data Protection backup software
- Linux® OS
- Microsoft® Active Directory® directory service
- Microsoft Windows® Compute Cluster Server 2003 OS

SERVICES

- Dell Global Infrastructure Consulting Services

“DELL SERVICES WAS A WILLING AND EAGER PARTNER IN OUR ENDEAVOR. THAT INTEREST AND THE ABILITY TO OFFER WORLD-CLASS TECHNOLOGY CLEARLY SET DELL APART FROM THE COMPETITION.”

Paul Young, director of the Lassonde Institute for Engineering Geoscience, University of Toronto

Because the stresses on large rock formations are difficult to study in the field, researchers at the RFDL study rock dynamics on much smaller structures. “By shrinking the problem to a manageable scale, we can investigate what is happening when a rock fails in more detail,” says Paul Young, professor of Civil Engineering at the University of Toronto and director of the Lassonde Institute for Engineering Geoscience, the interdisciplinary research institute that oversees the RFDL. “Once we understand these details we can create computer models that can more accurately predict earthquake probability or the collapse of a mine.”

Before the RFDL could begin creating accurate models, it needed to develop more advanced methods of testing rock failures and recording experimental data. “There are two key components

to our research project,” says Young. “First, we use a custom testing machine to apply physical and thermal stresses to a rock sample. We record changes within the sample with high-frequency acoustic sensors. Then we can use that experimental data to create high-resolution computer models.”

In his previous lab in Liverpool, England, Young had employed a RAM recorder to capture data, but this recorder could record only a limited amount of information. “The RAM recorder had 40 GB of space, and we would easily use all of that space in a few minutes,” says Young. “The experiments were producing all this data to help us understand how the rock would fail, but we could only record a two-minute snapshot. We needed a way to capture all of the data.”

DELL SERVICES OFFERS PARTNERSHIP AND GUIDANCE

As part of a public university, the RFDL needed to conduct a thorough comparison of its hardware options before selecting a vendor. “What we really needed was a technology partner that would take an interest in our research,” states Young. “Dell Services was a willing and eager partner in our endeavor. That interest and the ability to offer world-class technology clearly set Dell apart from the competition.”

Dell Global ICS met with researchers to understand the unique requirements of the lab’s IT infrastructure. “We had a number of discussions with Dell engineers,” notes Young. “The Dell ICS team made sure they understood everything we wanted to do before designing the high-performance cluster and the storage environment to support our work.”

“DELL SERVICES HELPED US IMPLEMENT A BACKUP ENVIRONMENT TO QUICKLY FREE UP STORAGE SPACE SO WE CAN CONTINUE TO CONDUCT EXPERIMENTS.”

Paul Ruppert, director of strategic research systems, Department of Civil Engineering, University of Toronto

DELL-DESIGNED CLUSTER IS EXPECTED TO DELIVER UP TO 18 TIMES THE MODEL RESOLUTION OF PREVIOUS CLUSTER

To provide the processing power that the RFDL cluster needed, Dell ICS installed 64 Dell PowerEdge 1950 servers equipped with dual-core Intel® Xeon® processors. With two dual-core processors per server, the lab's high-performance cluster is capable of 256 processing threads. “The cluster can be used in different configurations,” says Paul Ruppert, director of strategic research systems for the University of Toronto Department of Civil Engineering. “We can split the processor threads to handle multiple problems at once or combine them to solve problems faster. The cluster is flexible and powerful.”

The new cluster has helped the RFDL improve the resolution of computer models and reduce the time it takes to create complex 3D representations of rock fractures. “Now we plan to create models that include 40 million particles—18 times more than the HPC cluster in our old lab,” says Dave Collins, research associate at the RFDL. “We can also reduce the time it takes to create those higher-resolution models from about a week to less than three days.”

HIGH-PERFORMANCE STORAGE IS DESIGNED TO CAPTURE EVERY BIT OF DATA

The cluster helped solve the complex computer modeling challenges faced by the RFDL, but the lab also needed a way to capture all of the data produced by the rock deformation experiments. “We use as many as 20 acoustic sensors to measure the reactions of the rock sample,” explains Young. “We are generating a continuous 10 MHz stream of seismic data over a period of hours. That amounts to 400 MB of data produced per second.”

To fully understand the changes within a rock sample, the RFDL needed to record more of the streaming data produced by the experiment. “Engineers in the film industry face similar technical challenges,” says Ruppert. “Just as they need to capture a constant stream of information over a long duration, we need to record data at full speed, continuously, for up to hours at a time.”

To help the RFDL better record the data being produced by its rock deformation equipment, Dell ICS added six Dell PowerEdge 2950 servers to act as storage nodes within the cluster. These storage nodes are equipped with three Broadcom Gigabit Ethernet network cards and are connected to three Dell PowerVault MD1000 disk arrays, which provide a total of 4.8 TB of RAID-5 storage space. “With the fast I/O of the PowerEdge storage nodes and 15,000 rpm Serial Attached SCSI disks in the PowerVault disk arrays, we can capture virtually all of the experimental data continuously over a number of hours,” says Ruppert. “As a result, we can reconstruct a high-resolution model of what is happening within a stressed rock sample from the moment stresses are applied all the way up until failure.”

Dell PowerEdge servers have proven to be an ideal platform for the lab's needs. “These servers are workhorses,” says Ruppert. “Typically these systems are pushed to the limit by graduate students. The servers are so resilient and the system is so flexible that we can let them do whatever is required for research, and if something gets corrupted we just wipe the OS from the cluster nodes and reload the system.”

Dell ICS recommended that the lab use Nortel switches as the cluster interconnect. “We needed to optimize throughput without exceeding our budget,” says Ruppert. “The Nortel 5510 switches that Dell recommended work well with the Broadcom network cards to give us the throughput we need. We've been very impressed with their performance.”

As the data is recorded, the cluster can process and display it in near real time. The RFDL has a visualization facility equipped with six NEC 46-inch LCD monitors that enable students to watch the experiments as they occur. “Dell also came in and helped us set up the visualization facility,” notes Collins. “As a teaching tool, the visualization element of the lab is essential. Everything is happening within this big machine, but we can use the cluster, the 3D modeling software, and the LCD monitors to reproduce the experience in high definition for the students.”

LONG-TERM STORAGE HELPS ENSURE YEARS OF PRESERVED RESEARCH DATA

Capturing more data has increased the importance of long-term storage. “We need to keep a time-series data set of each experiment so that we can combine it with other experiments for analysis,” says Ruppert. “Dell Services helped us implement a backup environment to quickly free up storage space so we can continue to conduct experiments.”

The RFDL moves data from one Dell PowerVault disk array to an array with fifteen 500 GB disks. A Dell PowerVault 124T tape library is connected to this array. “We move data off of the faster disks to backup disks using CommVault Data Protection backup software,” says Ruppert. “Then we can move that data to tape for long-term storage. This way we can go back to old data sets if we develop some new analysis techniques.”

DELL AND MICROSOFT OFFER A FLEXIBLE AND EASY-TO-MANAGE INTERFACE

The lab needed to create a dual-boot Linux® and Microsoft® Windows® environment to run the cluster. "Many applications are built for the Linux OS, but an increasing number of graduate students and professors have extensive knowledge of Windows," says Ruppert. "We wanted to offer both operating systems within the cluster and be able to switch between the operating systems depending on the project and the researcher."

The Dell team helped facilitate a smooth implementation of the Microsoft Windows Compute Cluster Server 2003 OS. "Dell acted as an intermediary with Microsoft," says Young. "The Dell team helped us coordinate everything and get Microsoft engineers on-site to help with the implementation."

Dell helped install two Dell PowerEdge 2950 servers to control a movable partition running on the cluster that can determine how many nodes of the cluster are running Linux and how many are running Windows. "One server runs an open source clustering program on Linux," notes Ruppert. "The other server houses Windows Compute Cluster Server 2003. We are working very closely with Dell and Microsoft to develop a repeatable boot sequence that will allow us to pick what image we are deploying to the cluster."

In addition to offering users a familiar, easy-to-use Windows-based interface, choosing to implement Windows Compute Cluster Server enabled the RFDL to standardize on the Microsoft Active Directory® directory service as an access and authentication platform. "Windows Compute Cluster Server management integrates with Active Directory to give us a very simple way to interface with the master nodes," explains Ruppert. "Through Active Directory we can assign rights to users and give them the ability to log in at their desktop to access the cluster. And anyone with basic Windows knowledge can help administer the cluster, which is great since we only have a three-person team here dedicated to IT."



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The servers, storage, and testing equipment that make up the new lab have radically changed the way researchers study rock fractures. "It is amazing to go from only being able to record what happens to a rock at the point of failure to being able to record every change it undergoes over a longer period of time," says Young.

Researchers at the RFDL expect the new lab to greatly advance the understanding of major rock deformation events in nature. "In terms of the big picture, our new equipment will enable us to replicate complex processes better, with higher resolution," says Young. "The more data we can absorb from experiments, the more particles we can use to create more accurate models. We are focused on rocks right now, but we can study the properties of other materials as well, like concrete."

The lab is expected to not only promote new research, but also improve education. "The power of the cluster and the visualization lab we've put together really helps students see the forces at work," says Young. "When you can create an accurate model and display an image of what is happening at the moment an earthquake is triggered, that is an incredible teaching tool. It's like a window into the Earth."

For more information on this case study or to read additional case studies, go to DELL.COM/CaseStudies.

