HELPING TO UNLOCK THE SECRETS OF THE UNIVERSE

U.S. Dept. of Energy's ESnet network brings the world's researchers together to pool their knowledge and advance science

What is the origin of matter? How are the world's climates changing and what can we do about it? What are the secrets to clean, renewable energy?

These are just some of the important scientific challenges being tackled today by thousands of U.S. Department of Energy (DOE) scientists, researchers and collaborators worldwide with the help of the Energy Sciences Network Fourth Generation (ESnet4)—a best-in-class research and education (R&E) network powered by Juniper solutions.

Engineers lower the second small wheel down the 100 m shaft into the ATLAS cavern at the Large Hadron Collider (LHC) at CERN in Switzerland. ©CERN.

Powerfully connecting the world's most brilliant minds

Juniper Networks MX Series 3D Universal Edge Routers and Juniper Networks EX4200 Ethernet Switches comprise the entire core of the multiple-10Gbps ESnet infrastructure. ESnet provides connectivity to more than 40 major DOE research sites plus fast interconnections to more than 100 other global R&E networks.

Engineers check the electronics of the cryogenic instrumentation under a dipole magnet. ©CERN.

ESnet allows the R&E community to share and analyze massive amounts of data being generated by large-scale scientific research projects around the world. These include the Large Hadron Collider (LHC) at CERN in Switzerland, the Earth System Grid II (ESG) for research in global climate change, and many other key research initiatives. ESnet is funded by the DOE Office of Science, and managed and operated by the ESnet staff at Lawrence Berkeley National Laboratory in Berkeley, CA.

"This is just the beginning of what we think is an exciting trend," said Steve Cotter, ESnet department head. "Large instruments such as the Large Hadron Collider are increasingly complex and expensive to build, so more and more nations are joining together

to leverage these facilities. Using networks like ESnet, we're creating international virtual communities—enabling research to happen remotely, but allowing scientists worldwide to participate in these experiments, benefit from one another's breakthroughs, maximize billion-dollar facilities and advance science."

Double network system

Over the last few years, ESnet engineers have carefully built out the next generation scientific network specifically to handle massive amounts of data anticipated from LHC and other "Big Science" experiments. ESnet comprises two logical networks—an IP network to carry day-to-day traffic of the labs (e-mail, video conferencing, etc.), and a second network to transmit large volumes of scientific data.

The last of 1,746 superconducting magnets is lowered into the LHC tunnel via a specially constructed pit. This 15-m long dipole magnet is one of 1,232 dipoles positioned around the 27-km circumference of the collider. Dipole magnets produce a magnetic field that bends the particle beams around the circular accelerator. ©CERN.

ESnet engineers developed a protocol they named OSCARS (On-demand SeCure Advanced Reservation System) so that DOE scientists can reserve bandwidth on the second network for large data transfers as they conduct their experiments, particularly where guaranteed bandwidth is a critical concern. "We run that protocol using MPLS to isolate these high-bandwidth flows between end points," explained Steve. "Our engineers are very familiar with the MX960 3D Universal Edge Routers and Junos® operating system, and we've been very pleased with the reliability of our Juniper equipment as a cost-effective way to carry massive amounts of data over 10-gig Ethernet circuits."

Using the MX960 with Advanced Routing features turned on, including MPLS network virtualization, low-latency multicast, and QoS, ESnet is approaching "Five 9's" availability-- having delivered 99.997 percent availability in 2008.

What is a "massive" data transfer?

Citing just one experiment to highlight near-term bandwidth requirements, Steve notes that the LHC is expected to deliver 100Gbps of data nonstop onto ESnet by 2010. In two major upcoming experiments, which will continue for up to 20 years, hundreds of billions of protons will be spun through the accelerator and, as they approach the speed of light, smashed together to create conditions similar to what scientists believe occurred immediately after the "Big Bang." Scientists are hopeful that these collisions will create debris that will give them valuable insights into the origins of matter and "dark energy" of the universe.

"As these experiments occur, they will be producing terabits of data—an unprecedented level of information," said Steve. To put that into perspective, a 10-gigabit link is the equivalent of transmitting 500 hours of digital music per second. A terabit is 100 times that amount—50,000 hours of music per second. "And we're talking multiple terabits of data just for the high-energy physics community alone," he added.

ESnet will distribute LHC data to more than two dozen sites in the U.S. including the Fermi National Accelerator Laboratory just outside Chicago, IL, and the Brookhaven National Laboratory on Long Island, NY. From there, LHC data will be distributed to scientists around the world.

Climate studies produce landslide of data

Experiments concerning global climate change are another area producing huge amounts of data that must be accessed globally not only by scientists, but by researchers, government organizations and private industry. As of last year, the DOE's climate scientists had approximately 340 terabits of data downloaded from their archives. "There are individual sites that have up to a petabyte of data in storage that needs to be available; worldwide there are about 6-10 petabytes of data," said Steve. One petabyte is equal to equal to one quadrillion bytes or 1,000 terabytes.

ESnet Wins Coveted "Excellence.gov" Award

ESnet recently won a highly coveted "Excellence.gov" award from the American Council for Technology and Industry Advisory Council (ACT/IAC). Excellence.gov awards are among the most prestigious given in the U.S. federal government arena.

ESnet4 was named the winner in the category of "Excellence in Leveraging Technology," one of five 2009 Excellence.gov categories. More than 60 federal programs submitted projects for consideration. A panel of judges made up of federal government and industry executives reviewed the nominations, selected 21 finalists, and announced the five winners at the annual ACT/IAC Excellence.gov Awards Luncheon on Tuesday, April 14, in Washington, D.C.

Just the beginning

Estimates show that by 2012 the Fermi and Brookhaven labs will generate 50Gbps of sustained traffic from their sites. "Using the MX960 3D Universal Edge Routers and our OSCARS protocol, we can minimize the number of large routers we have in the core by doing more intelligent traffic categorization at the edge," said Steve. "This allows us to keep our costs down significantly and more efficiently use the backbone infrastructure."

About Juniper Networks

Juniper Networks, Inc. is the leader in high-performance networking. Juniper offers a high-performance network infrastructure that creates a responsive and trusted environment for accelerating the deployment of services and applications over a single network. This fuels high-performance businesses. Additional information can be found at **www.juniper.net**.

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