加速物理学研究：高性能全球网络的助力

高带宽的路由器和交换机帮助加州理工学院（Caltech）及其全球研究伙伴处理来自巨大物理学实验的数据，这些实验处于科学的前沿。

**Business Challenge**

2007年，世界上最大且最强大的粒子加速器将在日内瓦的CERN物理中心启动，即大型强子对撞机（LHC）。LHC能够产生每秒数亿次的碰撞，模拟出宇宙在大爆炸之后的几百万万分之一秒的条件。LHC的巨大的能量集中和前所未有的粒子碰撞速率将使研究人员能够研究可能带来新发现的理论，如粒子质量的起源以及宇宙中神秘的暗物质。

加州理工学院（Caltech）及其研究伙伴开发了紧凑型磁通量（CMS），这是一个重量达12000吨的先进的粒子探测器的组合，这些探测器被安置在一个有史以来最宏伟的超导磁体中。CMS磁体将记录下粒子对撞事件中的能量、电荷和轨迹。

CMS实验是LHC相关的两个实验中最大的一个，它是由来自38个国家的182所机构的2000多名物理学家和工程师组成的协作项目。

Caltech物理教授Harvey Newman是U.S. CMS协作的董事会主席，他也是Caltech的UltraLight项目负责人。UltraLight项目开发了基于Cisco高性能网络的全球研究网格，使用了由Cisco提供的国家网络设施。该网络将CMS机构和个人研究团队连接起来，使得数据可以共享，达到前所未有的速度。

**EXECUTIVE SUMMARY**

<table>
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<tr>
<th>CALIFORNIA INSTITUTE OF TECHNOLOGY (CALTECH)</th>
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<td>• Education and research</td>
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<td>• Pasadena, California</td>
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<td>• Over 2600</td>
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**BUSINESS CHALLENGE**

• Prepare for startup of major physics experiments, CMS and ATLAS, at the Large Hadron Collider at CERN (Geneva) in 2007
• Overcome limitations of long-range networks and storage to share massive amounts of data among global research collaborations
• Add capacity and features while protecting existing investments in equipment

**SOLUTION**

• High-speed intelligent switched IP network with 10 Gigabit Ethernet line cards
• MPLS, VLANs, and policy-based routing features help segment, prioritize, and direct traffic flows across the global computing grid

**BUSINESS RESULTS**

• Upgraded to higher density switches without changing switching chassis
• Achieved high performance in a production network to share, process, and analyze many terabytes of physics data.
• Maintained flexibility to mix and match small- and medium-sized servers while fully utilizing high-speed bandwidth

最大的五个LHC相关的实验，是由超过2000名物理学家和工程师组成的，他们来自38个国家的182所机构。

关键在于，科学家们是否能够反复访问到巨大的数据集，并在LHC中寻找新的物理学信号，从而在已理解的粒子相互作用的洪流中发现新的线索。

加州理工学院（Caltech）及其研究伙伴已经开发了紧凑型磁通量（CMS），这是一个12000吨的粒子探测器的组合。CMS实验是LHC相关的两个实验中最大的一个，它是由来自38个国家的182所机构的2000多名物理学家和工程师组成的协作项目。

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According to Newman, “Over the last few years, our team and our collaborators have addressed, and largely overcome, many of the challenges of disk-to-disk transfer, including TCP protocol, disk buffering, network interface, and Linux kernel. Solving the challenge of disk-to-disk transfer, which is now only constrained by the read-write speed of disks, is crucial for distributing as much data as possible, as quickly as possible, across the globally distributed grid system.”

Network Solution

The existing network designed by the Ultralight project team is based on Cisco Catalyst® 6500 Series Switches and Cisco 7600 Series Routers. In 2005 this Caltech-led team won the Supercomputing Bandwidth Challenge for the third straight year, transferring physics data at a rate of over 150 Gbps over the Cisco network, equivalent to downloading more than 130 DVD movies in one minute. The team also developed a “hyper-challenge” for Supercomputing 2006 in cooperation with Cisco, once again using fully populated Catalyst 6509-E switches to support storage-to-storage transfers at full speed to and from large sets of disks located at CERN, in Brazil, and in South Korea.

The network supports a distributed computing environment in which data from the Tier-0 CERN laboratory is sent to Tier-1 national research centers around the world. These centers, which are capable of storing multiple petabytes of data, then distribute data samples to university-based Tier-2 centers where physicists perform most of the required data analysis and simulation.

A Tier-1 data center has 500 to 1000 nodes; each Tier-2 data center has approximately 100-200 nodes. All nodes have four disks, and by 2008 most nodes will have 1-terabyte (1000 GB) disks, or 4 TB of disk space in each node. “We needed to find a way to overcome the limitations of these slow electromechanical devices by increasing switching capacity. This would allow more servers to transfer data over the network at the same time,” says Newman. “We also hoped to add this capacity while preserving our investment in the existing network.”

The Cisco Catalyst 6509-E Switches were equipped with Cisco Catalyst 6704 4-port, 10-Gbps Ethernet line cards, providing a density of 32 10-Gbps ports per chassis. Newman and his team were among the first to install the new Cisco Catalyst 6708 8-port 10-Gbps Ethernet module, doubling the port capacity of the switch. “By increasing the throughput of the network using the higher density switch, we could transfer data from more disks at the same time to compensate for the read-write speed limitations,” says Newman. “The challenge is to refresh 200 terabytes of disk cache without stressing the network. We pushed the 6708 to the limit with all channels loaded, and we were able to achieve multiple ten gigabits per second between the Pasadena campus and a point of presence in Los Angeles. The Cisco equipment performed admirably.”
In addition, about half of the servers in the grid have 10-Gbps Ethernet interfaces and the rest have 1-Gbps Ethernet ports. “Our application does not require fielding very large disk servers,” says Newman. “It is more cost-effective for the global grid to use a mix of small and some medium-sized servers. The 6708 module, along with 6748 48-port 10-Gbps Ethernet modules, also gives us the room and flexibility to support a mix of 1-Gbps and 10-Gbps server interfaces in the same chassis. We could concentrate more of these cost-effective small and medium-sized servers to use our high-speed bandwidth fully.”

Several projects are being integrated through the UltraLight initiative. The team is using multiple intelligent service features on the switches and routers, including VLANs to segment project traffic, IP Multiprotocol Label Switching (MPLS) to facilitate interconnectivity with different locations, and policy-based routing, to build Layer 1, 2, and 3 paths dynamically. “We are enabling a lot of different features and we haven’t experienced any conflicts or performance degradation in the network,” says Newman. “With the Cisco equipment, we did not have to sacrifice functionality to get the performance we needed.”

**Business Results**

There are six Cisco Catalyst 6509 Switches located at the university-based centers represented by Caltech, the University of Michigan, and the University of Florida, as well as the Stanford Linear Accelerator Center and Fermilab. According to Newman, the switch provided a “natural evolution to higher throughput by allowing us to replace the 4-port 10-Gbps modules with the 8-port 10-Gbps modules. We are able to preserve our investment in the existing equipment, while adding substantial throughput to the network.”

That investment protection also extends to the servers. The Cisco switches provide the flexibility to mix and match interfaces, enabling the researchers in Tier-1 and Tier-2 centers to support and upgrade servers more easily to keep pace with data-intensive computing demands.

“The report card is extremely good. The Cisco switches just operate and we don’t have to worry about them,” says Newman. “We are on track to make use of our networks in support of our science, limited only by the read and write speeds of disks, not the networks.”

**PRODUCT LIST**

**Routing and Switching**
- Cisco Catalyst 6500 Series Switches
- Cisco 7600 Routers

**NEXT STEPS**

“The network will revolutionize data-intensive grid computing and other forms of scientific computing over the next decade,” says Newman. “It is an enabling force in the next round of scientific discoveries expected when the LHC begins operation.” Newman also expects that many of UltraLight’s developments in the areas of networking, monitoring, management, and collaborative research to be applicable to many fields of data intensive e-science.
FOR MORE INFORMATION

To find out more about Cisco routing solutions, visit: http://www.cisco.com/go/routing

To find out more about Cisco switching solutions, visit: http://www.cisco.com/go/switching

To find out more about Caltech, visit: http://www.caltech.edu

This customer story is based on information provided by Professor Harvey Newman at The California Institute of Technology and describes how his organization benefits from the deployment of Cisco products. Many factors may have contributed to the results and benefits described; Cisco does not guarantee comparable results elsewhere.