Customer Profile

New York University—
3D Resilience

New York University (NYU) deploys a network core based upon a radical “tetrahedron” design with seven levels of resilience. The core is built with Cisco Catalyst® 6500 Series switches, which meet all design requirements.

Background

Founded in 1831, NYU is the largest private nonprofit university in the United States and occupies six major centers in Manhattan. The university’s founding fathers planned NYU as a center of higher learning that would be open to all, regardless of national origin, religious beliefs, or social background. Current enrollment exceeds 51,000 students attending 14 schools and colleges in 135 buildings at 6 locations in Manhattan and in more than 20 countries. The curriculum encompasses every major discipline, and NYU provides leadership education and research in medicine, dentistry, business, science, fine arts, law, social work, and education, among others. The faculty, which in 1831 consisted of 14 professors (among them artist and inventor Samuel F. B. Morse), now totals over 2600 full-time members. Among them are recipients of numerous fellowships and awards such as the coveted Nobel and Pulitzer prizes.

An innovative institution such as NYU needs the latest technologies to support its pursuits. NYU owns the largest private fiber infrastructure in New York City. It was one of the first members of the ARPANET, the precursor to today’s Internet. It was also a pilot member of the 6BONE and is currently a member of Internet 2. It has a network built end-to-end with Cisco products and technologies, developed over time beginning with Cisco AGS routers in the early 1990s. The 120 networked buildings of NYU house approximately 1100 network devices, an assortment of Cisco Catalyst switches and Cisco routers. Upgrades are scheduled to accommodate growth, support new features, or increase performance. The NYU network supports about 27,000 active network nodes running IP, IPX, and AppleTalk on a variety of server and desktop platforms.

The core network installed in 1995 consisted of Cisco routers with 100-Mbps Fiber Distributed Data Interface (FDDI) links. Since its installation, this network has never failed, which can be attributed to the resilient features of FDDI technology and the reliability of the Cisco 7000 and 7500 series routers.

Challenges

By 2001, NYU needed to increase its core network capacity to accommodate the growing number of network nodes, the greater bandwidth requirements of its applications and file transfers, and the emergence of integrated data, voice, and video networking. Network resilience is a primary concern because NYU is located in a busy metropolitan area, where road construction and other activities frequently lead to fiber cuts and other mishaps.

The network design team, led by Jimmy Kyriannis, Network Architect and Manager at NYU, wants its new core to exceed the high standard set by the existing FDDI ring, and “the bar has been set extremely high,” he says. “You want to be sure that you can at least equal if not exceed what you’ve already created. If folks are happy, then how do you take what you’ve learned and done so far, and build on it?”

NYU had to move away from FDDI because “the standards bodies had no plans to take it to gigabit speeds. Though it has run very reliably for many years, FDDI has really become a legacy technology,” says Kyriannis. After weighing many core technology options, Kyriannis and his team decided to build a new core network based on Gigabit Ethernet, the predominant enterprise core technology. Says Kyriannis, “We really want to stick with Ethernet technology. It’s proven. It’s a very easy support model. If you know how to support a 10-megabit Ethernet network, you can support 100 and Gigabit Ethernet—it’s all pretty much the same. The cost of equipment is much lower than if you were to build out other networks such as SONET [Synchronous Optical Network].”

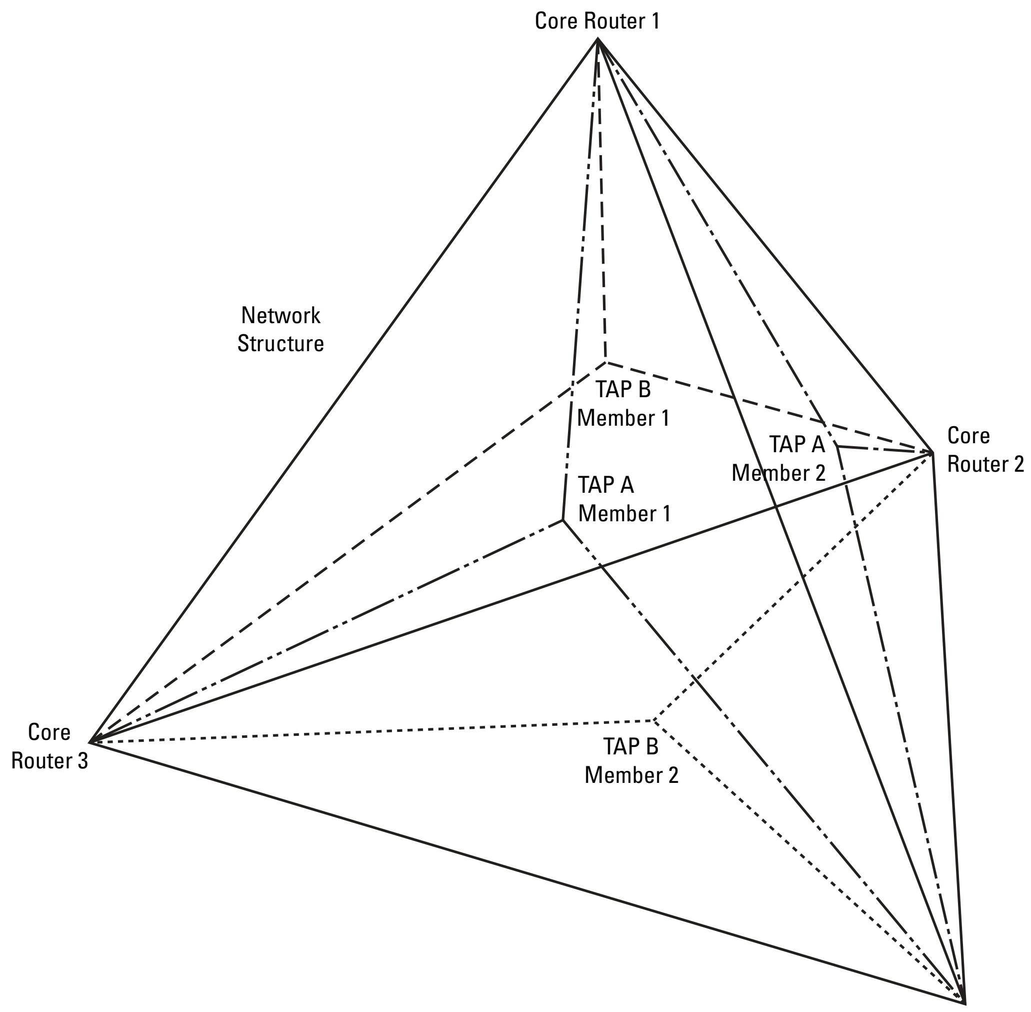
Cisco intelligent network services, supported in a wide range of Cisco routers and switches, also offer innovation that meets NYU’s need for resilience, load balancing, and growth over time. “Inherent technologies within the Cisco product line—such as Gigabit EtherChannel® technology—allow us to take Gigabit Ethernet one step further, adding redundancy and resilience with eight EtherChannel links instead of one,” says Kyriannis. “If one Gigabit Ethernet fiber optic cable were to break or become damaged, you have seven others available.”

Solution

To meet the need for nonstop application delivery in the NYU network, Kyriannis applied concepts learned as a computer scientist to network design. “I started thinking along the lines of taking a standard Gigabit Ethernet network, applying a three-dimensional model, and using that to add greater redundancy. The idea of multiple dimensions is a unique way of doing things. It works well and there has been a great deal of research, particularly in parallel-processor networks.” Kyriannis validated this concept after discussions with Cisco, which has applied some of that research to data networking.

The result of his cogitation is a design he calls “The Tetrahedron Core,” a partially meshed topology of four routers with four virtual LANs (VLANs) between them acting as Tetrahedron Attachment Points (TAPs). This revolutionary design requires absolute symmetry in both hardware and software on all devices; so that viewed from any angle things appear exactly the same (Figure 1). Cisco Catalyst 6500 Series switches precisely meet the design specifications of the Tetrahedron.

Figure 1
Tetrahedron Design Concept



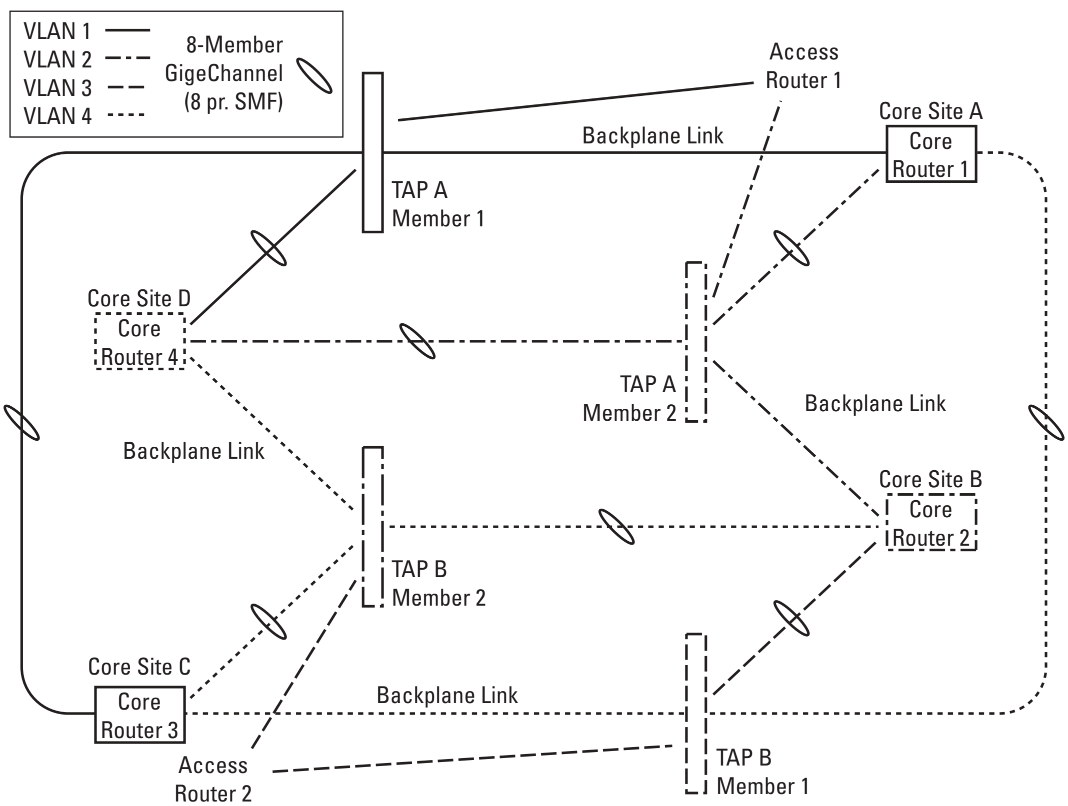
Load Balancing with OSPF

The Tetrahedron has eight Gigabit EtherChannel links, each composed of eight members. Each channel is configured on a separate fiber path and across four gigabit Ethernet cards within each Cisco Catalyst 6513 chassis. This ensures fault tolerance in case of a fiber cut, card failure, or other mishap. Traffic entering the Tetrahedron has six possible pathways through a pair of TAPs, which are VLANs with enough addressing capacity to accommodate 30 distribution-layer routers. These routers, in turn, provide connectivity to departments, server farms, external connections, and specialized LANs.

Each Gigabit EtherChannel link has exactly the same characteristics, allowing NYU to deploy Open Shortest Path First (OSPF) for optimal load balancing across all eight symmetrical links. "We've been using OSPF for close to a decade. It's been extremely stable for us and well documented in the standards papers," explains Kyriannis. "When OSPF calculates routes, it takes available bandwidth into consideration. If, for example, one fiber optic cable were to fail, OSPF would see this change in the available bandwidth on its EtherChannel link. It then adapts to favor the seven remaining EtherChannel links because they operate at higher data rates. It bypasses that particular EtherChannel link, yet it maintains the Tetrahedron structure. The EtherChannel link with the failed fiber-optic cable remains available as a fallback link. When you're dealing with failure, this is a great feature. But if you're not dealing with failure, you want the network to be totally balanced and have every possible path treated equally. So you have to ensure that every path is identical. Gigabit EtherChannel in the Tetrahedron is identically configured and provisioned in all possible links."

Figure 2

Logical Topology of Cisco Catalyst 6500 in the Tetrahedron



Failure is Not an Option

The Tetrahedron network design incorporates redundancy at seven levels (Table 1). "We made a strong commitment to redundancy and high availability," says Kyriannis.

Table 1 Multilayer Redundancy within the Tetrahedron Core

Network Element	Nature of Redundancy	Problem Averted
Tetrahedron Core	3 redundant connections from each of 4 core routers	Core router failure
Core router connections	8 fiber-optic connections per link	Fiber-optic failure
Boards	The 8 fiber-optic connections insert into 4 different cards on the router chassis	Router card failure
CPUs	Dual Supervisor Engine II on Catalyst 6500 Series switches	CPU failure
Cisco Catalyst 6500 switches	Dual Switch Fabric Module 2 (SFM2) functions	Backplane card failure
Electrical	Dual power supplies	Electrical failure
Building	Each core router resides in a different building	Building catastrophe, such as fire

Cisco Catalyst 6500 Series Supervisor Engine 720

Kyriannis is exercising an early field trial version of the Cisco Catalyst 6500 Series Supervisor Engine 720 in a Cisco Catalyst 6509 switch at the distribution layer. The Supervisor Engine 720 increases the performance capacity of the Catalyst chassis over the Supervisor Engine II. Moreover, it consolidates the functions of the Catalyst 6500 Supervisor Engine II and the Catalyst 6500 Switch Fabric Module (SFM) while providing additional features and capabilities, such hardware accelerated IPv6 and enhanced operational control with ERSPAN. This means that in a redundant configuration, the same function requires only two slots with the new Supervisor Engine 720 instead of four slots—nearly half the modular capacity of the Catalyst 6509 chassis—with the Supervisor Engine II. "The investment protection you get makes quite a difference," says Kyriannis. "And the Supervisor Engine 720 has higher performance than the Supervisor Engine II. With the 16-port Gigabit Ethernet cards, all of a sudden you have 32 more Gigabit Ethernet ports available. And 10 Gigabit Ethernet is in the future. The limitations of the Supervisor Engine II holds us to only eight gigabits per second access per line card into the backplane."

Most performance-critical Cisco IOS® Software features are now embedded in the Supervisor Engine 720 hardware. Some of these features are IPv6, and Multiprotocol Label Switching (MPLS) Network Address Translation, NAT, and GRE. NYU expects that these features will add significant capabilities to the NYU network over time.

Emerging Technology—IPv6

NYU is particularly interested in the worldwide adoption of IPv6, which Kyriannis believes will begin in just a few years. In fact, NYU researchers are interested in using IPv6 on Internet 2 for various projects. The Cisco commitment to IPv6 as a hardware-based feature in its platforms, particularly the Supervisor Engine 720 for the Catalyst 6500 Series, is important to NYU. Says Kyriannis, "We need to be able to support the computing needs of the organization as they change over time. Any version of UNIX you find today supports IPv6. So do Macintosh OS X and Windows XP. The Catalyst 6500 has hardware support for IPv6 now and into the future. That is a big thing for us, since we plan a five- to seven-year lifetime for this technology."

MPLS and HIPAA Security

Another hardware-based feature of the Supervisor Engine 720 is MPLS. NYU is investigating the efficacy of MPLS to help protect medical images and private medical records traversing the NYU network. The Health Insurance Portability and Accountability Act of 1996 (HIPAA) dictates that medical data traversing public networks must be encrypted for privacy.

The distributed nature of the NYU campus would benefit greatly from campus-wide privacy protection. "We don't typically have specific buildings for different departments. There are staff in various university locations in downtown Manhattan," says Kyriannis. "It's rare that an entire department will exist solely in a single physical location, and as a result, network data belonging to a HIPAA-covered entity may appear at different points on the university network. We're investigating whether MPLS can help us classify types of network traffic, some of which may be security-sensitive, ranging from HIPAA-related data to 802.11 wireless client data. Cisco encryption technology applied to those packets can assist us in securing that traffic."

Results

The Tetrahedron Core of Cisco Catalyst 6500 Series switches provides NYU with the bandwidth it needs today and ample investment protection for growth over its planned five- to seven-year lifetime. Initial testing proves the strength of the architecture and the capabilities of the Catalyst chassis. With seven layers of nonstop application delivery and future possibilities from the Supervisor Engine 720, the NYU Tetrahedron Core exceeds the standard for resilience set by the previous FDDI core. Kyriannis expects that NYU will continue to benefit from failure-free service well into the future.

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