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APPLICATION NOTE

Rethinking Campus Networks

A New Network Architecture Approach for Today's Campus Realities

Mobile device utilization on campuses is exploding. Streaming media (Netflix, Facebook, YouTube, etc.) is straining campus bandwidth. The education experience is moving to the cloud. Scientific file transfers are consuming more and more campus bandwidth.

Campus networks are undergoing a rapid evolution of user- and application-driven network capacity and utilization demands, driving many campus network operators to evaluate capacity upgrades. Yet for many universities, due to rising costs and shrinking resources, network technology investments have not kept pace. But now, universities have a way to upgrade their campus networks for 30 to 50 percent less CAPEX investment than an IP/MPLS solution, providing equivalent services and extending the life of existing infrastructure while actually simplifying the architecture to enable lower operational costs.

Is Your R&E Network Ready?

Network capabilities are critical to the higher education mission. Many of today's campus networks were designed around a three-tiered routed network model that assumed learning took place in the classroom and data was primarily stored and utilized on campus. However, campus network operators today increasingly must answer a variety of demands with a network that supports the increasing use of mobile technologies, cloud-based applications and infrastructure, and large, unpredictable research file transfers. Customers have reported that up to 70 percent of campus network traffic is destined to leave the campus network. Figure 1 shows a typical customer traffic mix distribution example composed of 'user-to-conent' traffic, typically made up of streaming media from

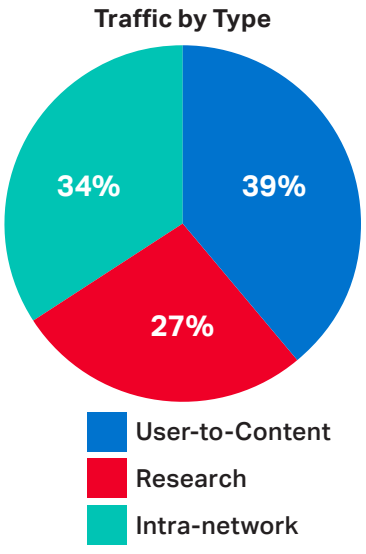

Figure 1. Typical campus traffic allocation

Benefits:

Evolve to a higher-performance network:

- Scales capacity cost-effectively
- Extends the life of existing routers
- Simplifies network operations
- Improves service delivery time
- Lowers network space and power cost
- Supports growing variety of applications

content providers and public cloud services, or large scientific data files being accessed from or transferred to remote data storage. Furthermore, the percentage of traffic bound for off-campus destinations is growing at higher rates than any other traffic. The majority of university traffic is becoming transitory in nature, requiring the consideration of new network realities.

Traffic Trends

Today's applications are driving bandwidth growth and creating a new traffic paradigm for campus networks based on a highly user-to-content connectivity model. Campus traffic today is dominated by deterministic pass-through traffic from end-users accessing content from the Internet or cloud data centers.

Application Performance

Education is moving to a cloud-based curriculum where students access lessons, resources, and collaborative learning tools online. Research data stored in data centers or high-performance computing centers must be easily accessible from anywhere, anytime. Institutions' increasing reliance on cloud services, the advent of cloud-based applications, and a need to be 'always on' has altered expectations of network connectivity.

Resource Constraints

Campus network resources are often stretched incredibly thin. This constraint is often compounded due to the complexity of today's campus networks. As a result, new features are slow to emerge and often do not interoperate in a multi-vendor environment, thereby requiring extensive and time-consuming testing cycles—along with very specialized technical personnel—before deployment in the 'active' network.

The 'dumb pipe' is officially dead. The conventional response addressing increasing bandwidth demand challenges has been to continually upgrade router capacity and add increasingly complex functionality into traditional Layer 3-based router platforms. This approach adds significant cost and complexity to an already costly platform. **It is time to consider that the traditional, all-routed approach to campus networks may no longer provide efficiency from a network cost or bandwidth utilization perspective, and often leads to over-designed and costly networks.**

As illustrated in Figure 2, most campus network architecture today involves a tiered approach that leverages routers as IP network access points for each building. The purpose of the access/aggregation network is to connect users to their desired content or application while making the most efficient use of the available fiber plant. Chances are, campus traffic is dominated by traffic destined for the Internet or a data center. This traffic is highly deterministic and, while IP provides tools for traffic engineering, it often adds unnecessary operational complexity and unneeded cost. This so-called user-to-content connectivity benefits little from full-scale routing and the complex and often proprietary functions that can overburden today's router hardware. All that is needed are simple connections that can be traffic engineered and protected, if necessary, and provide deterministic (well-bounded) behaviors such as latency, jitter, and packet loss protection.

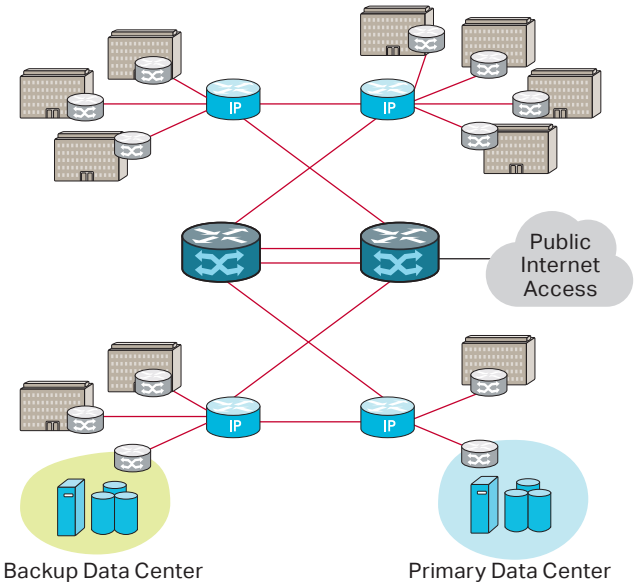

Figure 2. Traditional fully routed network

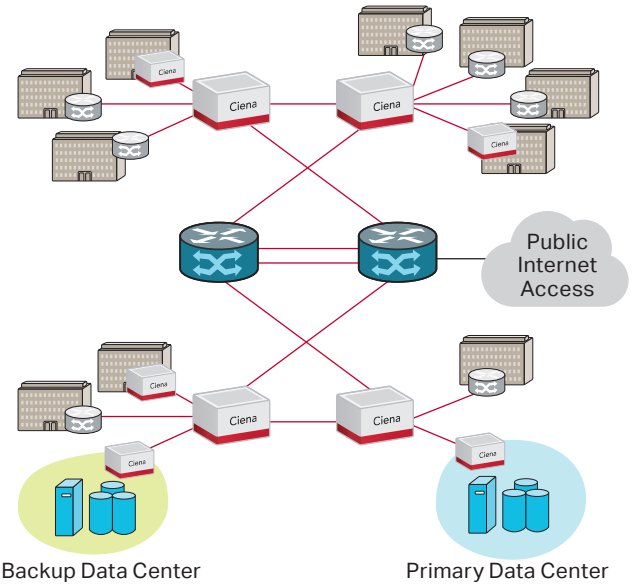

Figure 3. Optimized Ethernet and IP routing network

Campus Networks for the 21st Century

Figure 3 illustrates traffic access and aggregation strategy that leverages converged Ethernet and optical technologies to lower overall campus network costs and optimize the architecture, while preserving the needed IP routing functionality of the network.

In this scenario, Ethernet switches are deployed to buildings in place of end-of-life routers or where bandwidth upgrades are needed, becoming an extension of the campus core IP routers and providing virtual router reach with lower cost and complexity. Ethernet access and switching provide traffic QoS guarantees to ensure application performance. IP services, such as IP VPN, are extended to remote locations through a resilient Layer 2 Ethernet access and aggregation functionality, continuing Layer 3 service functionality. However, IP traffic in this scenario is otherwise contained within the Ethernet layer, freeing up router capacity for network growth.

A Layer 2 network architecture ideally suits the creation of a rich menu of IP-based applications, whether they are Layer 3 services such as IP-based VPNs and VPLS connections, or simply Layer 2 transport of Layer 3 functions such as Web access, video transmission, or data center connectivity. In other words, the use of a Layer 2-based infrastructure does not limit support for IP applications; on the contrary, it complements it nicely while significantly simplifying the overall network design. Ethernet access and aggregation avoids unnecessary protocol conversions and is ideally suited for a wide range of critical campus applications such as latency-sensitive storage applications, high-definition video applications, critical infrastructure protection, and rich media applications.

The connection-oriented Ethernet approach also ensures traffic is delivered only where it should be. Spanning Tree Protocol (STP) is no longer used, as the deterministic tunnels do not require the traditional learning or restoration functions performed in a traditional Ethernet LAN. Snooping of traffic is therefore less of a concern, as an inherent layer of security is built in, with layers of visibility and control of the Ethernet Virtual Circuit (EVC). Scalability is provided architecturally by using virtual switches within physical switches to provide secure, end-to-end traffic separation. End-users control their own network assets without being able to interfere with other users or the larger enterprise infrastructure.

Improving the Enterprise Network
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Layer 3 IP routing, while necessary, is and will always be a higher-cost-per-bit transport approach. It should be used only where and when required. With the emergence of converged packet-optical switching platforms, lower-cost architectures can result in significant savings in both capital and operational costs. Figure 3 illustrates an architecture that minimizes the overall cost of operations, drives optimal performance, extends the life of existing routers, and assures network reliability while providing a lower-cost-per-bit solution that enables a more economically feasible upgrade to a higher-capacity core network. This Layer 2 access and aggregation approach directly connects most core routers over a packet transport layer so transit traffic is switched by the packet-optical transport platform at Layer 2 (Ethernet or MPLS-TP), 1 (OTN), or 0 (wavelength), instead of routed via Layer 3 routing platforms.

Meeting Growing Demand while Driving Down Cost

When evaluating options to upgrade part or all of a campus network to enhance performance or capacity, upgrading existing routers may not be feasible or even possible given platform and cost limitations.

CAPEX comparisons tend to rely on very specific deal structuring. However, generalized studies indicate the lower the layer technology, the simpler the hardware, and the fewer modalities of operation, and hence, the lower the cost. An IP or IP/MPLS infrastructure requires routers at all sites, while Ethernet can make use of Ethernet switches with a subset of the router functionality. By continuing to add router capacity to scale and support new applications, campus network managers are incurring unnecessary CAPEX and OPEX. Ciena's customer experience has shown CAPEX savings of more than 30 to 50

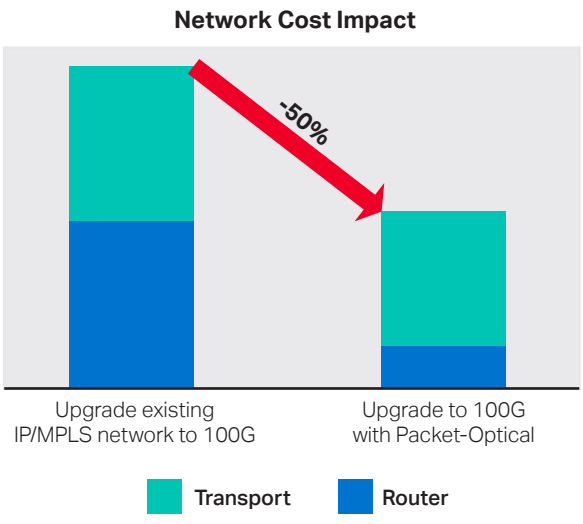

Figure 4. Packet-optical cost savings moving to 100G

percent by using Layer 2 switching where possible and Layer 3 routing only where absolutely necessary. Figure 4 illustrates one scenario in which a customer realized 50 percent CAPEX savings while upgrading their core network capacity from 10G to 100G by leveraging a Layer 2 packet-optical solution to offload transit traffic, leaving routing to core routers at 10G capacity.

Formal OPEX studies are hard to come by, but it is clear that installation and commissioning tasks for new services are a key component of such costs. The remote configuration and service turn-up and testing benefits of a Ciena Ethernet access and aggregation solution allow high confidence that the right parameters have been established for each connection, and that the end-user or application is receiving the requisite Quality of Service (QoS).

Ciena Solution

Leveraging Converged Platforms for Packet-optical Scale

As the network converges, functions such as photonic transmission and Ethernet switching have converged into flexible modular platforms that enable the creation of flattened regional network architectures.

Packet Networking

Ciena's Packet Networking products offer a flexible set of platforms for Carrier Ethernet access (Ciena's 39xx family) and aggregation (Ciena's 51xx family) addressing today's key campus networking challenges. The products address growing costs, are rapidly deployable, and offer the ultimate in OAM tooling for proactive management of exploding traffic loads. These interoperable, MEF-certified platforms improve the IT department's ability to confidently deploy, provision, and manage cost-effective infrastructure that provides scalability, reliability, QoS, and service management. Combined, these features significantly accelerate and automate scalable Ethernet network creation and activation.

In addition, they provide Ethernet flexibility and transport-grade reliability with an array of protection mechanisms including Link Aggregation (LAG), protected MPLS-TP tunnels, and ITU-T G.8032 resilient Ethernet rings. These options simplify the provisioning and ongoing maintenance effort, reducing operations costs. In order to contain growing costs, superior QoS controls provide predictable traffic delivery—be it best-effort or guaranteed. The solution provides hierarchical QoS for unprecedented levels of traffic classification, enabling rich flow stratification for broader application of the common infrastructure to the differing types of traffic in today's campus environment.

The 8700 Packetwave™ Platform is a fully programmable packet-over-coherent DWDM product that provides integrated full-function Carrier Ethernet capabilities, enabling a pure packet-over-light network architecture. The integration of coherent DWDM optics lowers costs by eliminating the high price of back-to-back 10G or 100G client-side handoffs between switching and optical transport platforms, a significant savings. In addition, the platform is MEF CE 2.0-certified, guaranteeing robust, highly reliable Ethernet-based services. Each Ethernet or MPLS-TP service can be assigned a deterministic amount of bandwidth and associated Service Level Agreement (SLA) guarantees to meet stringent QoS requirements tailored to the needs of a specific application. Ethernet services provide secure traffic separation with full-service transparency, allowing R&E network operators to maintain in-house control over routing information and security and encryption techniques.

The multiple-award-winning 8700 doubles the 10GbE density in a footprint that requires 50 percent less power and space compared to competing solutions. With up to 2 Tb/s of non-blocking switching capability supporting 1GbE, 10GbE, 40GbE, and 100GbE rates with deep buffers, Ciena's 8700 solutions can easily manage a massive amount of different traffic flows with massive fan-in capabilities. A broad and powerful set of embedded OAM and test capabilities allows network operators to proactively and reactively maintain the health of their networks in near-real-time, right down to each individual service.

Ready to reimagine your R&E network?

Converged Packet Optical

Ciena's 6500 Packet-Optical Platform is a multiservice product with integrated coherent optics that scales for exponential bandwidth growth at low cost, offering efficient transport of a wide range of services with operational simplicity. Leveraging a full range of photonic line system functionality and WaveLogic Coherent Optics with integrated packet and OTN switching, the 6500 provides the power to optimize transport efficiencies to scale network costs effectively and manage surging demand.

The 6500 offers the full breadth of Layers 0-2 capabilities via a single, scalable platform that can be tailored to best match

specific site capacity, space, and power requirements. It offers the full range of ROADM solutions, from conventional multi-degree ROADM to fully agile colorless, directionless, contentionless, and flexible grid ROADM solutions, providing full wavelength routing flexibility to accommodate any advanced research connectivity requirements.

Simplified, Automated, and Agile Management

Ciena's zero-touch provisioning capabilities allow for the fast, simple, and secure deployment and provisioning of multi-terabit Ethernet switching and aggregation by eliminating manual, error-prone operational procedures. Ciena's extensive OAM feature suite provides real-time intelligence of network activity. This embedded, software-based performance monitoring and OAM feature automatically monitors and troubleshoots the data path, confirming link and service throughput and quality via integrated line testing tools to provide faster fault isolation and service restoration. All of this comes in a single optical + L2 converged platform, minimizing space and power while enabling multilayer provisioning and management.

Software-driven Flexibility

Networks are moving from being rigid and inflexible toward a more agile and automated software-controlled environment. R&E networks tend to be at the forefront of this networking revolution. Ciena's Blue Planet software provides a vendor-agnostic solution that enables orchestration and management of network services from end to end, across both physical and virtual domains. Blue Planet reduces operational costs by abstracting network complexity, and drives greater competitive advantage through a previously unachievable level of service programmability. With Blue Planet, operators can orchestrate existing Software-Defined Networking (SDN) controllers (such as Openflow and OpenDaylight) and management platforms (cloud, network, and element managers) as one environment. This will enable a true end-to-end services deployment capability across hardware and software domains, combining Network Functions Virtualization (NFV) with traditional, hardware-based appliances. Blue Planet provides the 'single-pane-of-glass' view to help break down management silos and enable network operators to provision and manage services across networks composed of both legacy and new SDN/NFV-enabled components.

Rethinking R&E Networks

Bandwidth consumption shows no signs of slowing down. Although upgrading the network is necessary, scaling the existing routing infrastructure can add to an already complex network environment and often proves to be cost-prohibitive. R&E network organizations typically do more with fewer resources, which makes simplifying network design, provisioning, and management a key success factor. Converging the transport layer and Layer 2 switching provides a cost-effective means of accomplishing the task. Ciena's packet-optical network platforms provide a lower up-front capital investment, while reducing ongoing operational costs by consuming less space and power and simplifying network management. The platforms create a highly available and resilient foundation for a flexible, software-driven next-generation network.

Whether upgrading bandwidth to a single building on a single network link or migrating an end-of-life network, it might be time for R&E network operators to take a fresh look at their network traffic volumes, traffic types, and utilization trends to construct a holistic, long-term network strategy that leverages a converged optical and Layer 2 solution.

The Ciena Difference for Connected Collaboration

Ciena has proactively partnered with the global R&E community for decades. This collaboration helps drive the company's corporate focus on advancing R&D for the evolution of optical and packet networking technologies, helping to develop the networks of the future. A converged packet-optical solution from Ciena will provide a scalable, flexible, high-capacity transport of transit and protect traffic, from streaming video to massive data flow transfers, to support the changing demands of the R&E community.

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