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Higher Education Campus

Solution Design Guide

BROCADE

Contents

Preface

This solution design guide is intended to provide design guidance for architects and engineers at universities and colleges who are looking to upgrade their campus network infrastructure.

Overview

Higher education is an important catalyst for improving the quality of life of an individual and a community. The network can be an integral part of that catalytic process. There are many trends that motivate institutions of higher education to upgrade their network infrastructure to meet the demands of research: transitioning to a digital curriculum, connecting multiple geographies with distance learning, improving collaboration with social media, and supporting the proliferation of bring your own device (BYOD).

Upgrading the network of an institution of higher education can be very challenging and disruptive, especially when there may be large and complex infrastructures and resource limitations. Our aim is to make the upgrade process as effortless as possible, with appropriate architectures, products, solutions, and business practices.

Purpose of this document

This document highlights purpose-built features, products, and architectures that make it easier for customers to upgrade their campus infrastructures and to lengthen the longevity of their campus network investments.

Audience

The target audience for this document is network designers, network architects, and network engineers who are looking for architectural reference information about Brocade campus solutions.

Objectives

The objective of this document is to provide design guidance, that can apply to a variety of universities and colleges. Higher education campus networks can span diverse physical configurations, from small community colleges to large internationally prominent universities with multiple locations. We'll focus on campus requirements, which, unlike the data center, need to support a diverse variety of devices across a wider geographic area. The wired infrastructure will be highlighted. Brocade maintains multiple relationships with leading wireless vendors; and many customers value this best-of-breed approach to infrastructure development.

Document history

Date	Version	History
August 2015	1.0	Initial version

Related documents

- Higher Education Campus Solution Brief

Current Higher Education IT Trends Impacting the Network

There are many trends causing universities to upgrade their wired infrastructure, including the proliferation of mobile devices, support of big research data, evolution of online learning, transition to a digital curriculum, connection to larger research networks, collaborative video, and social media as a platform for collaboration. These trends, in unison, are increasing the demands on the network infrastructure in higher education and are motivating many institutions to upgrade.

One of the biggest trends in higher education IT is the proliferation of mobile devices, including laptops, tablets, and smart phones. Mobile device support was surveyed as the number one priority for higher education in the Center for Digital Education 2015 survey of higher education IT priorities. As another data point, for example, Texas A&M University , in its 2013 IT annual report, reported a 21-percent ncrease in its wireless usage (a new record), with 74,878 unique users in a 24-hour period, up from 61,736 unique users last year. It is not uncommon to see at least seven different types of BYOD devices in a university or college environment: laptop, smart phone, PC, tablet, web cam, WiFi-enabled camera, and game console.

The effect of mobile device proliferation is especially challenging when considering the dimensions of peak usage and usage density. Peak usage is commonly seen when students return from holidays or when there are university events. Increased usage density can occur with events like a football game and midterms and finals.

Online learning has proliferated. Online learning's video-rich content substantially adds to bandwidth requirements. For example, the University of New Mexico reported, in its 2014 annual report, that usage of Lynda.com by faculty in instruction increased 34 perdect to 7,000 courses viewed. Texas A&M transitioned to eCampus, the next-generation learning management system powered by Blackboard Learn. In the fall of 2013, 85 percent of students (45,472) used eCampus for at least one course.

Collaboration technology fuels additional bandwidth requirements because many are video based. As an example, Texas A&M's new TTVN WebMeeting provides enterprise online web-conferencing and collaboration services. During the first semester of use, over 5,000 users enrolled for the new service.

Social media apps have increased demand on the network, because they are eclipsing all other modes of communication for the student population. Usage of social media in higher education has evolved into creative uses for course management and increasing classroom engagement with backchanneling, where students participate in class discussion by submitting real-time comments, questions, and polling.

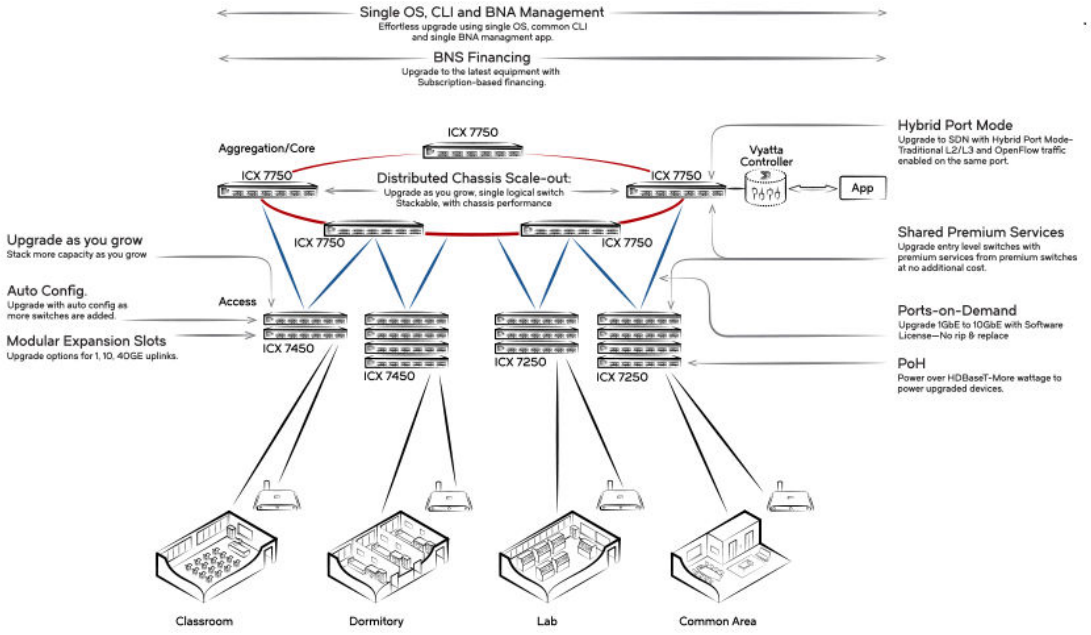
There is indeed a rich combination of innovate trends in higher education that is increasing demands on the network, motivating many universities and colleges to upgrade their campus infrastructure.

Planned Upgradeability and Lengthening the Longevity of the Network

There are a myriad of purpose-built features in Brocade routers, switches, and software products available to customers to improve their ability to more easily upgrade their campus infrastructure and to lengthen the time between upgrades.

Examples of purpose-built upgradeability features are shown in the figure below.

FIGURE 1 Examples of purpose-built upgradeability features



The upgradeability features can be categorized into those that:

- Future-proof the network
- Reduce network complexity
- Add premium services at no additional cost
- Improve scaling as you grow
- Provide customer-friendly business practices

These categories and features are summarized in the table below.

TABLE 1 Higher education upgrade requirements, matched with key planned upgradeability features

Higher education requirements for infrastructure upgrading	Brocade planned upgradeability
Future proof the network investment	**SDN and open standards Support** • Brocade Flow Optimizer. • SDN OpenFlow support. • Hybrid port mode support: Ethernet/OpenFlow. • Products developed with Open standards. • Multivendor OpenDaylight controller now available.
Higher education architectural requirements	**Brocade HypeEdge architecture**
Reduce complexity • Reduce network complexity and management. • Consolidate provisioning and monitoring with centralized management.	**Consolidated management** • Collapse network layers with high-performance and high-density Brocade ICX switches. • Brocade Network Advisor consolidates network management. sFlow is used for monitoring.
Add premium services at no additional cost • Upgrade to premium services at no additional cost.	**Shared network services** • Switch Port Extender share premium L3 services with entry-level L2 switches at no additional cost.
Scale as you grow • Upgrade as you grow. No up-front chassis investment required. • Increase bandwidth by aggregating links. • Increase resiliency as you scale. • Upgrade bandwidth with no physical change.	**Scale-out networking** • Upgrade as you grow distributed scaleout stackable switches with chassis-level performance. • Scale with link aggregation. • Scale resiliency with Multi-Chassis Trunking • Port-on-demand upgrade 1 G to 10 G using a software license. No change to physical infrastructure.
Customer business-friendly requirement • Acquire the latest features and products with ease. • Extend product longevity.	**Brocade business-friendly philosophy** • Brocade network subscription: Upgrade to the latest products using subscription financing. • Available lifetime warranty.

Future-proof the network investment

Many educational institutions are looking to future-proof their network investment by evaluating solutions and products that are positioned for the future, that are built with open standards, and that support software-defined networking (SDN). These educational institutions also view open standards as a means to mitigate vendor lock-in and reduce vendor-specific training requirements.

- SDN support

  SDN-enabled networks support application-aware dynamic resource allocation and can dynamically allocate network resources in real time to meet the needs of applications. SDN applications can use input from many sources (including application-specific security and QoS requirements, network statistics, user activity, security threat analysis) to allocate and protect network resources, set access control rules, and prioritize traffic in real time.

- Brocade Flow Optimizer

  The Brocade Flow Optimizer is an SDN application that empowers universities and colleges to gain insight into their network traffic, enabling policy-based detection and management of large Layer 2 through Layer 4 traffic flows. This SDN-based application addresses real-life network performance challenges that are critical to enabling cloud services. The application enables proactive network visibility and control while providing new levels of programmability and network automation. With this network intelligence, universities and colleges can now increase network efficiency through better network capacity planning and resource utilization, they can mitigate network attacks, and they can eliminate network congestion through policy-based traffic engineering, thus improving the overall end-user experience.

- OpenFlow

  OpenFlow is an initial enabler of SDN. Brocade supports the SDN OpenFlow protocol, which provides communication between an OpenFlow controller and an OpenFlow-enabled switch. OpenFlow is an emerging, industry-standard SDN communications protocol that provides access between the forwarding plane of a network switch or router and a network controller, facilitating more sophisticated traffic management and engineering. OpenFlow provides greater programmatic control of the network, enabling new network applications to be developed for virtualized environments. Brocade delivers OpenFlow-enabled products across all its flagship routing and switching product families, including Brocade MLX Series routers, Brocade ICX switches, and Brocade VDX switches.

  Specifically, Brocade supports OpenFlow 1.3, allowing higher education network operators to address complex network behavior, optimize performance for dynamic SDN applications, and leverage a richer set of features. These features include Quality of Service (QoS), Q-in-Q, Group Tables, Active-Standby Controller, IPv6, and more.

- Hybrid port mode

  Brocade has uniquely delivered OpenFlow using a true hybrid port mode, on the MLX and ICX, where traditional Layer 2/Layer 3 and OpenFlow forwarding can work on the same port at line rate. This unique capability provides a pragmatic path to SDN by enabling network administrators to progressively integrate OpenFlow into existing networks, giving them the programmatic control offered by SDN for specific flows while the remaining traffic is forwarded as before-with no physical change to the infrastructure. No separate network is required for SDN.

- Open standards and multivendor controller

  Brocade continues open-standards-based product development by supporting OpenFlow 1.3, across our ICX and MLX product portfolio, and by introducing the Vyatta Controller, the industry's first commercial multivendor SDN controller built directly from OpenDaylight code, without any proprietary extensions or platform dependencies. Brocade also supports of myriad of 802.1x and RFC specified switching, routing, and security functionality.

Meeting higher education's architectural requirements with Brocade HyperEdge

The Brocade HyperEdge architecture was specifically developed for the campus. It provides three key design principles for upgrading the network that are especially beneficial for universities and colleges looking to reduce complexity, improve ROI, and improve future scalability:

1. Consolidated management: Reduces unnecessary network layers to create large HyperEdge management domains that eliminate individual switch touch points to mitigate maintenance and costs. Options include collapsing a three-tier network into a two-tier network (collapsing the core and aggregation layers), or even into a one-tier network, offering a single point of management across the campus. Simplification is also achieved with the elimination of Spanning Tree Protocol (STP).
2. Shared network services: Allows premium and entry-level switches that share a common HyperEdge management domain to share advanced L2/L3 services achieving a lower price per port functionality, at no additional cost.
3. Scale-out networking: Integrates high-performance fixed-form-factor switches to create a single logical device independent of physical location by scaling ports when and where needed across the campus.

The Brocade HyperEdge architecture integrates the access and aggregation campus network layers to simplify service deployment and increase performance. All traffic is managed within the HyperEdge domain, thus eliminating the need for complex legacy protocols such as STP. HyperEdge domains can be scaled together and seamlessly integrate with a legacy campus network infrastructure. This design approach enables simplified device management, while providing an agile infrastructure optimized for application and service delivery.

- Reducing complexity is an architectural design consideration for many higher education network architects. It is quite common for many universities and colleges to look for opportunities to reduce network complexity and management as they undergo campus network infrastructure refreshes. There are opportunities to consolidate management, with centralized provisioning and monitoring.
- Consolidated management

  Brocade provides a comprehensive management platform, with BNA. Given the inherently dispersed nature of the university campus and the diversity of client devices, centralized and uniform management is essential for maintaining performance and availability and for enforcing corporate security policies. Brocade Network Advisor is a powerful tool that helps organizations manage the entire network lifecycle, including monitoring, diagnostics, change management, troubleshooting, and remediation.

  Brocade Network Advisor provides several key capabilities that support unified management, including:

  - Presents an at-a-glance summary of all discovered Brocade devices and third-party IP devices, including inventory and event summary information used to identify problem areas and help prevent network downtime.
  - Allows flexible definitions of administrator roles and responsibilities with RBAC for both SAN and IP management. This capability is seamlessly integrated with leading Authentication, Authorization, and Accounting (AAA) solutions.
  - Provides an interface to configure and deploy CLI-based configuration templates across one or more IP devices.
  - Utilizes an easy-to-use device configuration wizard to configure and manage dynamically updated groups of devices. Using this feature, network administrators can manage software

images and perform multiswitch management, including Power over Ethernet (PoE) management and Virtual LAN (VLAN) configuration.
- Provides comprehensive management of the MPLS services through the MPLS Manager. This includes an end-to-end visualization of MPLS topology across core and access networks, and the ability to drill down for advanced troubleshooting.

- sFlow

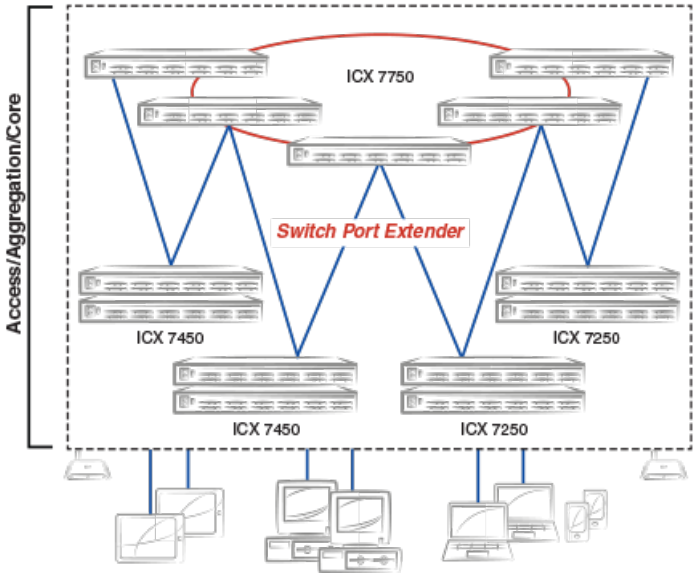
  As the scale and reach of the campus network increases, real-time monitoring of traffic flows using open standards such as sFlow is becoming important. With device mobility and real-time variation in traffic created by unified communications and VDI, traffic monitoring that scales from the individual device and application to LAG links and router ports provides proactive control of traffic to avoid bottlenecks and hot spots.

  sFlow is a valuable, non-CPU-impacting sampling-based technology that can identify traffic types, and it is a standards-based network export protocol (RFC 3176). By embedding sFlow into Brocade products, Brocade delivers an "always-on" technology that operates with wire-speed performance. sFlow dramatically reduces implementation costs compared to traditional network monitoring solutions that rely on mirrored ports, probes, and line-tap technologies. Moreover, sFlow gives organizations full, enterprise-wide monitoring capability for every port in the network.

- Switch Port Extender

  The centrally managed Switch Port Extender enables the Brocade ICX 7250 and 7450 switches to inherit advanced Brocade ICX 7750 features and capabilities, at no additional cost, simplifying management and greatly reducing OpEx. This capability eliminates the need for "rip and replace" upgrades, because Brocade ICX 7250 or ICX 7450 ports can inherit premium services. It enables the Brocade ICX 7250, as shown below, to extend ports in combination with Brocade ICX 7450 and 7750 switches, creating a complete campus network solution with consolidated management across aggregation and core layers, shared network services-adding advanced Layer 3 capabilities to all switches and scale-out flexibility to expand port density as needed. The Brocade ICX 7250 with Switch Port Extender provides an ideal network access solution for the campus network. Moreover, this feature enables collapsing network access, aggregation, and core layers into a single domain. This domain shares network services while reducing management touch points and network hops through a single-layer design.

FIGURE 2 Switch Port Extender enabling the ICX 7250 and ICX 7450 to inherit advanced Layer 3 and Layer 2 features from the ICX 7750



- Distributed Scale-out

  Distributed scale-out is a feature that is enabled on the ICX 7750, providing increased core scalability and enabling customers to pay as they grow. This feature enables the ICX 7750 to provide chassis class performance in a high-performance, highly scalable, stackable form factor.

  The ICX 7750 units can be stacked horizontally where needed across the campus with the required port densities and it enables the users to expand their future network with "pay as they grow." ICX 7750 switches with 40-GbE stacking links can be stacked long distance (separated by up to 10 km each), so network operators can disperse the Distributed Chassis over various locations within the campus and still manage it as one entity.

- Link Aggregation Group

  Link Aggregation Groups (LAGs) are commonly used to upgrade and scale bandwidth, and improve resiliency. A LAG allows multiple links at the same link rate to be combined into a single logical link. A LAG can be used between switches and also between servers and switches.

  Link distribution between the access and distribution layers uses the 802.1ad Link Aggregation Control Protocol (LACP). This provides automatic formation of LAGs. Each LAG includes multiple physical connections, providing resiliency and greater bandwidth than just a single physical link.

- Multi-Chassis Trunking

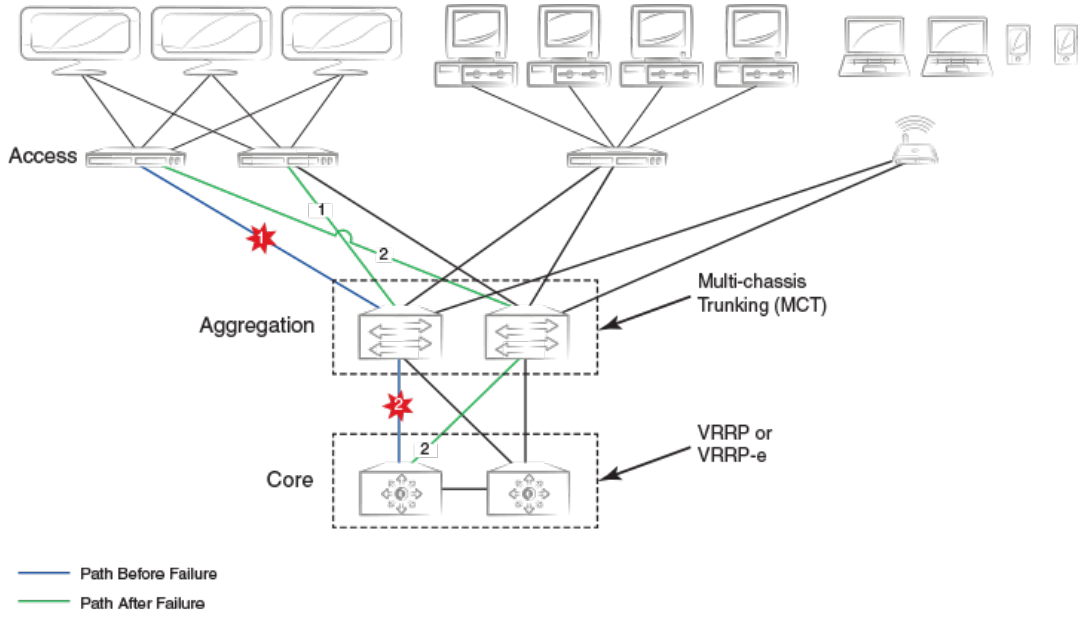
  Whereas a LAG provides greater bandwidth and improved resiliency within a link, Multi-Chassis Trunking (MCT) provides fault tolerance at the switch level. With MCT, two switches are connected using inter-chassis links (ICLs) and present themselves to other switches and hosts as a single logical switch. Should one switch go off-line, traffic continues to flow to the other switch without requiring STP to rebuild the topology.

  MCT and VRRP Extended (VRRP-E) complement high availability. MCT provides resiliency and high availability for Layer 2 traffic. VRRP-E provides similar resiliency and high availability for Layer 3 traffic. Where the access layer is forwarding Layer 2 traffic to the distribution layer, combining MCT with VRRP/VRRP-E on the distribution switches is a common method for providing rapid fail-over of traffic should a distribution switch go off-line.

  MCT is one way to ensure high availability for Layer 2 traffic by offering a choice of active/passive or active/active configurations. MCT creates a single logical switching device from two physical

chassis. LAG connections can terminate on either chassis, providing a cost-effective means of achieving high availability. As shown in the figure below, a link failure between an access and aggregation switch (event 1) causes traffic to reroute to the redundant LAG link. As more applications with high-quality user experience requirements push traffic onto the campus network, outages and disruptions will need to be avoided.

FIGURE 3 Increasing resiliency with MCT and VRRP



VRRP or VRRP-E can be used with core routers to provide high-availability and resiliency. As shown in the figure, a link between one of the core routers and distribution switches fails (event 2). Traffic automatically routes to the other distribution switch and takes the alternate LAG link to the access-layer switch.

- Ports-on-demand

  Ports-on-demand enables upgrading a 1 G port to a 10 G port, using a software license, on the ICX 7250. There is no physical change to the physical infrastructure. Other vendors require a "rip and replace" of the physical equipment. Customers benefit by upgrading their bandwidth when they are ready, with no physical swap-out.

- Brocade Network Subscription

  Brocade Network Subscription (BNS) provides a financing model to help customers upgrade, to additional capacity and the latest products, as they grow. BNS complements existing purchase and lease alternatives. Organizations can now acquire a fully supported cloud-optimized network infrastructure on their terms, without upfront capital investment. Instead, they pay monthly for the network infrastructure they use. BNS does not require multiyear term commitments, and risk is minimal because organizations have the flexibility to expand, contract, or refresh their network infrastructure as required. As a result, organizations now have a network acquisition model that provides the same level of flexibility as a cloud-based business model.

  The following are sample network diagrams that illustrate examples of topologies.

FIGURE 4 Sample design topology 1 with the ICX 7750 in the core

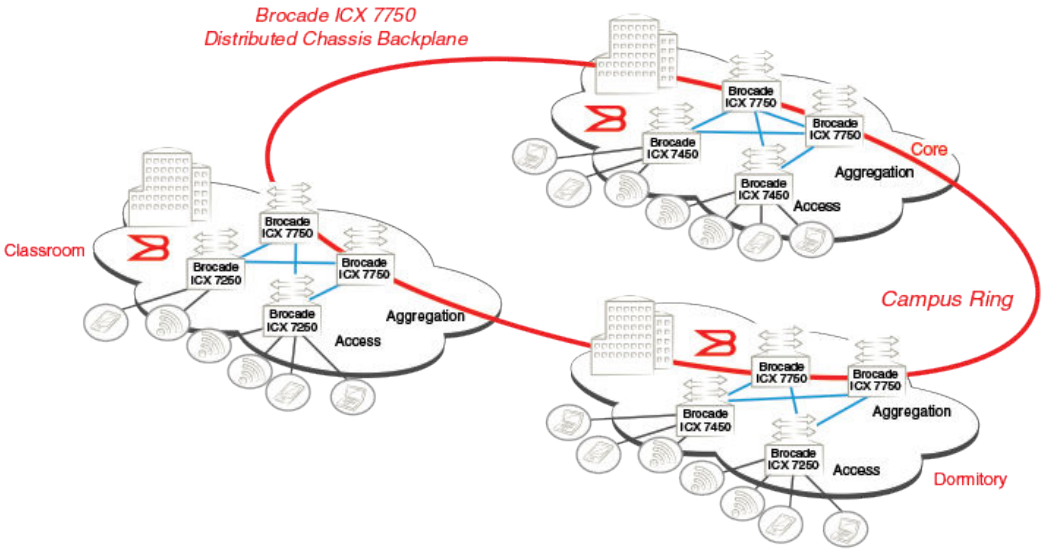
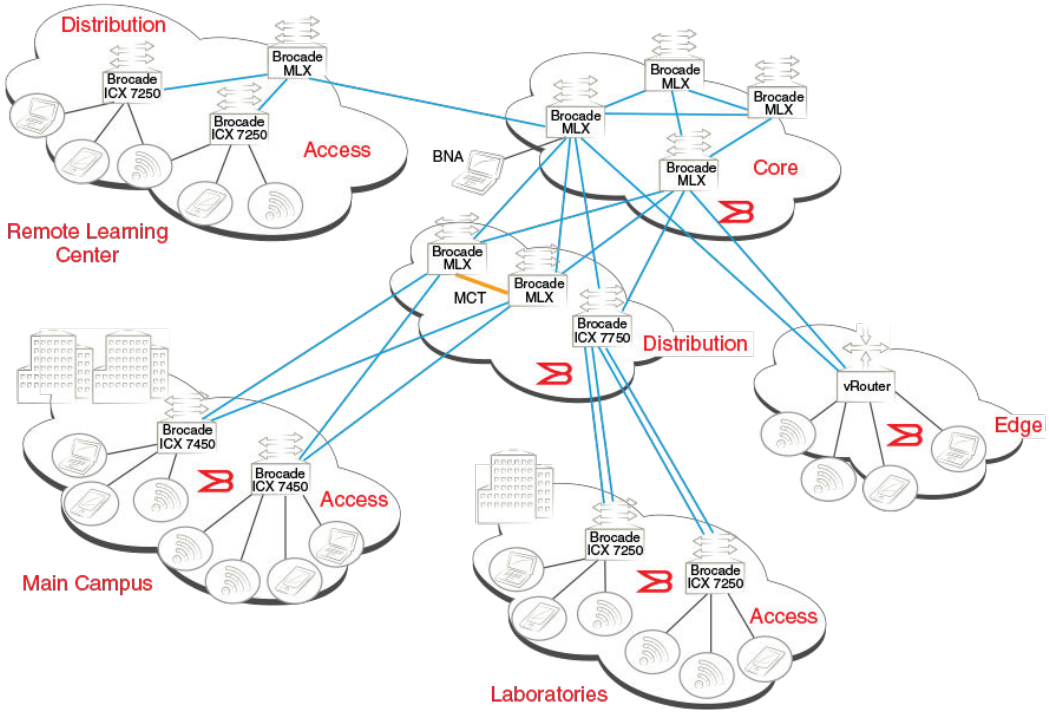


FIGURE 5 Sample Design Topology 2 with MLX in the core



The following tables provides guidance on the positioning of product families and product models commonly used in the campus.

TABLE 2 Positioning of product families for campus applications

	ICX	MLX	Vyatta
Form Factor	Stackable-Distributed Chassis	Chassis	vRouter
Primary Function	Switch	Router	Router
Key Feature	High-density 10, 40G	High-density 10, 40, 100G	NFV
Typical Placement	Access, Aggregation, Core	Core, WAN	WAN

TABLE 3 ICX product family and models

	ICX 7750	ICX 7450	ICX 7250
Typical Placement	Core, Aggregation	Aggregation, Access	Access
Form Factor for Ports	Fixed, Modular	Fixed, Modular	Modular
40G, Max Ports	96	3	-
10G, Max Ports	32	12	8
1G, Max Ports	-	48	48

The Brocade ICX 7750 is the flagship ICX 7000 series switch. It is a 1U core and aggregation switch that provides chassis performance in a pay-as-you- grow stackable form factor, with up to a 12-unit distributed chassis that support linear and ring topologies. It provides high 10/40-GbE port density, and rich Layer 3 features. The ICX 7750 delivers wire-speed, non-blocking performance across all ports. Hybrid port mode OpenFlow is also supported on the ICX 7750 and provides a migration path to SDN. The ICX 7750 can be deployed in a distributed chassis “campus ring” topology, collapsing aggregation and core layers, simplifying network operations, and dramatically reducing TCO. Long distance stacking on the ICX 7750, up to 100 meters, enables network operators to disperse the distributed chassis over various locations within the campus and still manage it as one entity. The ICX 7750 differs from traditional chassis switches, which have an initial high cost, large footprint and power consumption, and limited distance manageability.

ICX 7750 highlights:

- Supports advanced features such as VRRP-E, BGP, robust IPv4/IPv6 support, Multi-Chassis Trunking (MCT), and Virtual Routing and Forwarding (VRF).
- Provides up to 12 switches per stack and up to 480 Gbps of stacking bandwidth, limiting interswitch bottlenecks and supporting large-scale distributed chassis deployments.
- Offers industry-leading 10/40-GbE port density and flexibility in a 1U form factor with up to 32-40 GbE or 96-10 GbE ports per unit, saving valuable rack space and power in wiring closets.
- Provides chassis-class high availability with six full-duplex 40-Gbps stacking ports per switch, hitless stacking failover, and hot-swappable power supplies and fan assemblies.
- Includes dual internal redundant power supplies. These power supplies are hot-swappable and load-sharing with auto-sensing and auto-switching capabilities, which are critical for power redundancy and deployment flexibility.
- Enables SDN by supporting the OpenFlow 1.3 protocol, which allows communication between an OpenFlow controller and an OpenFlow-enabled switch, at line rate in 10-GbE and 40-GbE networks.
- Provides OpenFlow support in true hybrid port mode, enabling SDN for programmatic control of network data flows. Organizations can simultaneously deploy traditional Layer 2/3 forwarding with OpenFlow on the same port. This unique capability provides a pragmatic path to SDN by allowing network administrators to progressively integrate OpenFlow into existing networks, giving them the programmatic control offered by SDN for specific flows while the remaining traffic is forwarded as before.

The ICX 7450 is midlevel ICX 7000 series switch. It is a 1U modular and fixed form factor aggregation and access switch, which provides chassis performance, with up to 12-unit distributed-chassis stacking. It provides high 10/40-GbE port density.

ICX 7450 highlights:

- Provides a unique modular design with three expansion slots for a choice of 1-GbE, 10-GbE, or 40-GbE uplinks, allowing ultimate flexibility and "pay as you grow" scalability.
- Provides OpenFlow support in true hybrid port mode, enabling SDN for programmatic control of network data flows.
- Offers Power over HDBaseT (PoH).
- Switch Port Extender enables premium Layer 3 features at no additional cost.

The ICX 7250 is the entry level 1U fixed form factor access switch, which provides chassis performance, with up to 12-unit distributed-chassis stacking.

ICX 7250 highlights:

- Available in 24- and 48-port 10/100/1000-Mbps models with 1-GbE or 10-GbE dual-purpose uplink/stacking ports with or without PoE and PoE+.
- Up to 12 switches per stack and up to 80 Gbps of stacking bandwidth.
- Ports-on-demand software licensing of 1-GbE to 10-GbE ports.
- Switch Port Extender enabling premium Layer 3 features at no additional cost.
- OpenFlow support in true hybrid port mode.
- Offers full Power over Ethernet (PoE+).

The Brocade MLX Series is highly optimized router for IP Ethernet deployments, and provides symmetric scaling with chassis options that include 4-, 8-, 16-, and 32-slot systems.

TABLE 4 Positioning of the MLX models

Features	MLXe-4	MLXe-8	MLXe-16	MLXe-32
Interface slots	4	8	16	32
Switch fabric capacity	1.92 Tbps	3.84 Tbps	7.68 Tbps	15.36 Tbps
Data forwarding capacity	1.6 Tbps	3.2 Tbps	6.4 Tbps	12.8 Tbps
Packet routing performance	1.6 billion pps	2.38 billion pps	4.75 billion pps	9.5 billion pps
Maximum 100-GbE ports	8	16	32	64
Maximum 40-GbE ports	16	32	64	128
Maximum 10-GbE ports	96	192	384	768
Maximum 1-GbE ports	192	384	768	1,536

MLX highlights:

- Scalable multiservice IP/MPLS routers in 4-, 8-, 16-, and 32-slot chassis options.
- Fully distributed, nonblocking, and programmable architecture with up to 15.36-Tbps fabric capacity for maximum performance and investment protection.
- 64 100-GbE, 128 40-GbE, 768 10-GbE, and 1,536 10GbE ports in a single router.
- Wire-speed forwarding performance for all software features, including Ethernet, VLAN, IPv4, IPv6, MPLS, VPLS, IPsec, MACsec, and OpenFlow capabilities.
- High-availability design with redundant management modules, switch fabrics, power supplies, and fans; hitless failover; hitless software upgrades; and non-stop routing.