WHITE PAPER

Exploring Software-Defined Networking with Brocade

This paper provides an overview of Software-Defined Networking (SDN), expected use cases, and Brocade contributions to SDN innovation.

Software-Defined Networking is a concept that proposes to disaggregate the traditional vertically integrated networking stack in order to improve network flexibility and manageability. SDN enables "mass customization" of network operations to better support differentiated services.

SDN is part of a group of technologies that open the data, control, and management planes of the network to participate more easily in broader orchestration frameworks through Application Programming Interfaces (APIs). These APIs also facilitate the development of a rich new set of network applications and services from a wider range of sources, including independent developers, Value-Added Resellers (VARs), and user organizations themselves.

Introduction

User organizations interested in Software-Defined Networking (SDN) typically cite two main reasons for exploring SDN:

- The ability to optimize their choices of networking platforms independently of their architectural needs
- The need for programmability to support rapid service design, development, and teardown

Both of these needs have arisen within the larger movement towards more flexible, automated IT systems. Growing user expectations of customized, on-demand IT services—driven by the strength and ease of use of major public cloud providers—is fostering a new understanding of IT as a logical, distributed, and highly dynamic system. The IT infrastructure functions as a system in which a network can operate as a set of logical services to be instantiated as needed for a particular workload. SDN unbundles discrete, vertically integrated devices into their logical components in order to allow users to manage even multivendor networks as a single system.

In this paper you will learn about a range of SDN and SDN-related technologies and how you can apply them to a series of cloud-related challenges. In addition, this paper illustrates how Brocade is implementing SDN vertically—in data, control, and management planes—and across its portfolio.

OVERLAY PROTOCOLS

Virtual Extensive LAN (VXLAN), Network Virtualization using Generic Routing Encapsulation (NVGRE), and Stateless Transport Tunneling (STT) are three examples of proposed overlay protocols; each uses a different encapsulation method. Thus far, VXLAN has been adopted the most broadly, with the others largely confined to implementations within the proposing vendors' products.

All of these protocol proposals effectively acknowledge that the new network edge is not the access layer, but a hypervisor-based vSwitch, and that the tunnels terminate within virtualized hosts.

These protocols do not address physical connectivity or functioning, and the physical network does not automatically provide visibility into tunneled traffic. The physical network can still ensure network policies and services at the encapsulation and decapsulation points, but this can be only an intermediary step to full data plane abstraction.

Organizations deploying overlay tunnels should expect their network infrastructure providers to enable tunnel visibility as the tunnel protocols themselves mature.

SDN In The Data Plane

Software-defined networks and the network infrastructure that their traffic traverses have a deeply symbiotic relationship. Network virtualization has existed in various forms for several decades, but it is ultimately bounded by the physical constraints of existing network technology. Advances in other areas of IT tend to put particular pressure on existing network virtualization techniques. For example, Virtual Local Area Networks (VLANs) were invented in the 1980s in order to extend the physical reach and scale of Ethernet networks of that time, as well as to allow users or hosts to be brought together into logical groups that were less constrained by physical location. However, server virtualization has exposed several limitations of traditional VLANs. Server virtualization is I/O-intensive, but Layer 2 domains are limited to 4,000 VLANs. In addition, VLAN traffic cannot cross Layer 2 boundaries, which constrains Virtual Machine (VM) mobility. Finally, modern cloud providers have multi-tenancy isolation requirements that are much more granular than VLANs can support.

Fully virtualizing networks by creating overlay tunnels is one means around many of these limitations. More meaningfully, these modern tunneling techniques are designed specifically to meet the requirements of data centers with dense server virtualization and cloud architectures. Such techniques allow administrators to create logical overlay networks, linking or grouping virtual compute and storage resources as needed to rapidly deliver a desired IT service. Workload-specific policies are automatically applied as part of the tunnel setup. This work can be conducted without interfering with the functioning of the physical network, which reduces overall deployment time and confines potential errors or disruptions to the logical service in question. In sum, you can deploy overlay networks rapidly in a fine-grained, workload-centric way, as part of a specific end-to-end IT service.

Network Virtualization and Ethernet Fabrics

While network virtualization clearly solves a number of challenges for modern virtualized data centers, it does add complexity of a different sort. Both physical and overlay networks now need to be managed concurrently, but at present they have limited visibility of one another. In order to take full advantage of overlay networks, automation of basic tasks in the physical network therefore becomes critical. Ethernet fabrics are an evolutionary form of Ethernet that provide a flatter, highly available network architecture. Brocade® VCS® Fabric technology provides a particularly resilient, automated fabric architecture with intrinsic VM awareness, native multi-tenancy features, and logically centralized management.

Using Brocade VCS Fabric technology as the physical underpinning of overlay networks can be especially beneficial for the following reasons:

- **Efficient, reliable delivery of tunneled traffic:** Network virtualization expands the scope and flexibility of virtual I/O aggregation by policy, but traffic still relies on the performance, resilience, and services of the physical infrastructure it traverses. Brocade VCS Fabric technology provides a highly resilient, low-latency physical transport foundation for network virtualization. VCS technology provides per-packet round-robin load balancing even within overlay environments, improving Link Aggregation Group (LAG) utilization and greatly reducing the potential for tunnel congestion problems.
- **Simplified concurrent management of physical and virtual networks:** VCS fabrics themselves are highly automated, from fabric formation to self-managing recovery mechanisms. In addition, VCS fabrics are automatically aware of all VMs (and other host devices) attached to them, and they maintain connectivity and appropriate policies wherever the VMs may be physically located or may move to. Brocade VCS Fabric technology facilitates visibility into tunneled flows for monitoring and troubleshooting, and it may in some use cases dynamically enable port profiles even within the tunnels. The Brocade VCS Logical Chassis management provides a single integration point for SDN controllers and orchestration frameworks, simplifying and scaling SDN policy implementation.
- **Service assurance for tunneled traffic:** Brocade VCS and Brocade MLX® support for overlay tunneling helps ensure that Quality of Service (QoS), access control, and other policies are consistently applied throughout the overlay environment. This can be performed at the encapsulation or decapsulation points, such as the Brocade VDX® 6740 Switch, or by switches traversed by tunnels, where the switch makes forwarding decisions based on the external header.

Brocade provides protocol-agnostic hardware support for tunnel visibility, as well as VXLAN termination, within Brocade VCS fabrics and the Brocade MLX Series core routers. In the future, Brocade may also develop additional support for other types of tunneling techniques, as tunneling protocols become more clearly defined and in response to customer interest.

SDN in the Control Plane

The previous section discussed new forms of data plane abstraction. However, the tunneling techniques discussed previously must be managed through an SDN controller. It is important to understand the control plane communication and controller options, as control plane choices must be informed by an IT organization's philosophy about sourcing and strategic vendors. Broadly speaking, control plane options are either vendor-centric (for example, VMware NSX and VXLAN control features in VMware vCenter and vCloud Director), or they use some form of open source-based and/or OpenFlow-based controller, such as the OpenDaylight Project and ODL distributions.

What Is OpenFlow?

OpenFlow is an open, standards-based communications protocol. OpenFlow provides access to the forwarding plane of a network switch or router, facilitating more sophisticated traffic management, especially for virtualized and cloud environments. The OpenFlow protocol is standardized and managed by the Open Networking Foundation (ONF), whose mission also includes the promotion of SDN technologies as a whole. OpenFlow does not specify any particular tunneling mechanism; instead, it provides extensions for developing to any desired tunneling protocol.

In a classical router or switch, the data plane and the control plane reside on the device. OpenFlow enables network platforms of various types to communicate with a common distributed control plane called a controller, which runs on external servers. In practice, an OpenFlow API is generally a feature that is added to commercial network devices, whose hardware architecture and features remain crucial to network performance. The standard control plane of the device remains in place and performs traditional routing or switching. Today, most OpenFlow-enabled devices can also support both OpenFlow traffic and non-OpenFlow traffic, with mechanisms for determining the pipeline to which each traffic flow should be routed.'

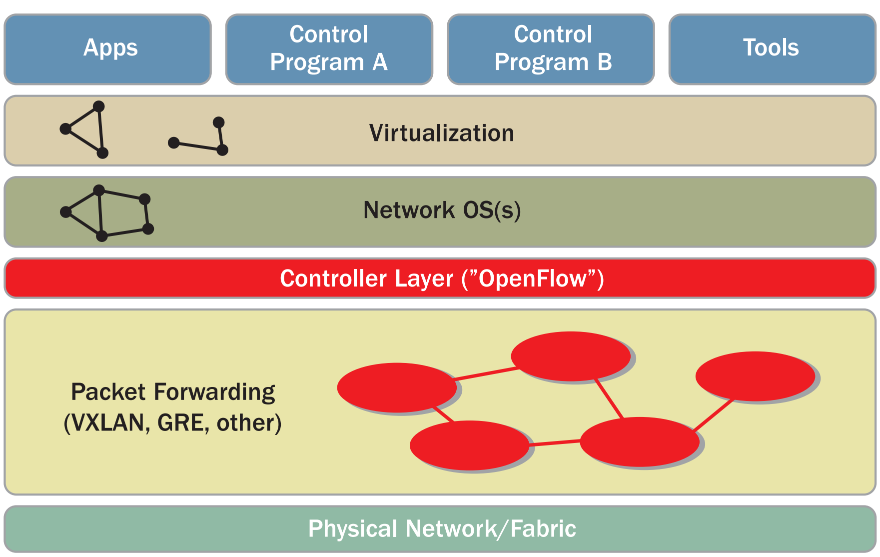

Figure 1: OpenFlow-based SDN stack.

The real benefit of OpenFlow lies in the applications that it can enable. New forms of traditional control plane applications such as security or specialized QoS functions—and even entirely new applications—may be written to these controllers, as shown in Figure 1 below. This enables cloud and hosting providers, in particular, to develop and market more truly differentiated services to their clients. Traditional enterprises can also benefit from this type of third-party network application development, for example, when developing capabilities that help meet the operational or regulatory requirements of their industries.

Brocade and OpenFlow

Brocade has made significant OpenFlow investments on its own platforms, but Brocade also supports data plane overlay protocols such as VXLAN, which is used by the VMWare NSX controller. The Brocade VDX Switches, which are optimized for highly virtualized data centers and cloud environments, provide encapsulation and decapsulation of VXLAN traffic at the network edge, as well as high-performance transit platforms that maintain visibility of tunneled traffic.

Brocade foresaw that the earliest adopters of SDN would have extremely demanding expectations of their physical networks. Thus Brocade prioritized OpenFlow development on its carrier-grade Brocade MLX Series core routers, along with the Brocade CES Series and Brocade CER/CER-RT Series edge switches and routers. To date, Brocade has shipped over one million OpenFlow-enabled ports. Brocade is extending OpenFlow support across its IP portfolio of routing and switching products to the Brocade ICX® and VDX switch families, enabling customers to achieve new agility and programmability across the network—from the data center to the campus to the WAN.

Brocade products support OpenFlow 1.3, allowing operators to address complex network behavior, optimize performance, and leverage a richer set of capabilities. OpenFlow 1.3 enables a broad set of use cases for production in commercial and enterprise networks. Brocade supports OpenFlow 1.3 features such as QoS (Metering, Enqueue), Group Table (Select, Fast Failover), QinQ (Outer tag), Active-Standby Controller, and Time to Live (TTL). Brocade has implemented OpenFlow at scale by supporting speeds up to 100 gigabits per second (Gbps) line rate and support for up to 128 K flows.

Brocade has taken an innovative approach by implementing native OpenFlow in the industry's first hybrid port mode. With hybrid port mode, organizations can simultaneously deploy traditional routing or switching with OpenFlow on the same port. This unique capability provides a pragmatic path to SDN by providing network operators with the ability to integrate OpenFlow into existing networks. Hybrid port mode also gives operators the programmatic control offered by SDN for specific flows, while the remaining traffic is routed as before. In addition, hybrid port mode provides efficient utilization of existing uplinks for SDN by eliminating the need for separate SDN-enabled uplink ports. Brocade hybrid port mode also supports an optional "VLAN protection" feature in hardware, which enables initial OpenFlow overlay service development without risk to the production network.

What is an SDN Controller?

In an SDN environment, the controller or controller cluster serves as a logically centralized control plane for all of the network devices within its domain. It distributes and executes policies defined by the network operator in a way that can be both highly granular and scaled across a vast number of devices.

Most importantly, controllers introduce programmability into networking for the first time. Network programmability allows users to make use of libraries of predefined policies and provides a platform on which to independently develop new networking features and applications to meet the specific service needs of a particular organization.

A variety of SDN controllers are available in the market today. These controllers may use OpenFlow but usually not exclusively; NETCONF, OVSDB, and other standard and even proprietary methods may also be supported. Some SDN controllers have platform dependencies that limit the use of the controller to a single vendor's gear and may even require users to displace existing serviceable gear before it has depreciated. Platform-independent controllers may be proprietary software applications, often linked instead to a host OS, or they may be open source-based, such as those built on code from the OpenDaylight Project.

The Brocade Vyatta Controller

Brocade was a founding member of the OpenDaylight Project, started in April 2013. The OpenDaylight controller, operated by the Linux Foundation, has quickly become the leading open source SDN controller in the industry, benefitting from the support and expertise of most major networking providers, leading SDN startups, IT professional services firms, and individual developers and users.

The Brocade Vyatta® Controller is the first commercial SDN controller built directly from OpenDaylight Helium code, without any proprietary extensions or platform dependencies. Users can freely optimize their network infrastructure to match the needs of their workloads and can develop network applications that can run on any OpenDaylight-based controller. The Brocade Vyatta Controller package includes the tools and services to quickly and confidently implement software-defined networks within existing environments and is backed by the expertise of Brocade leaders within the OpenDaylight developer community.

Brocade is completely committed to OpenDaylight and to the success of the OpenDaylight community; Brocade has no secondary controller investments. Using openness as a guiding principle, Brocade conducts interoperability testing with other controllers of all types and provides single-source support for Brocade Vyatta Controller domains that encompass multivendor networks and hypervisors. To learn more about the Brocade Vyatta Controller, go to www.brocade.com/sdncontroller.

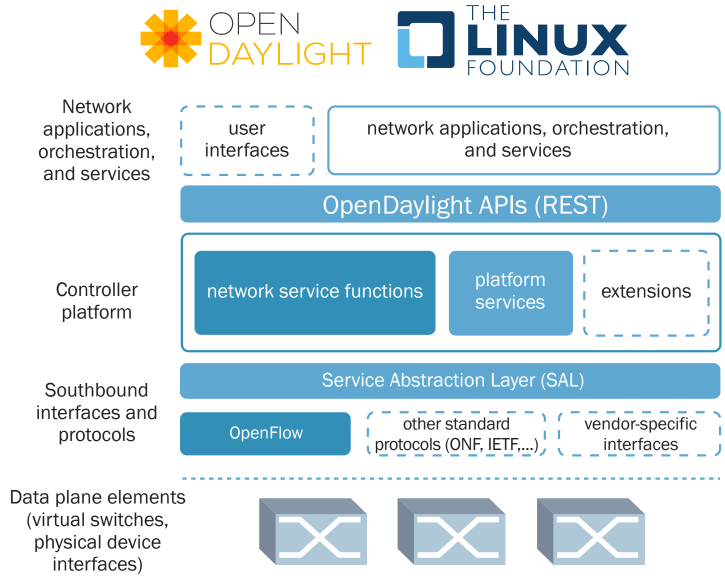

Figure 2: The Open Daylight Architecture

Use Cases for SDN

Many network operators expect the near-term benefits of SDN to be operational in nature: greater management efficiency, fewer interoperability challenges, possible OpEx reduction. However, the original promise of SDN—faster, custom innovation through programmability—provides new opportunities for rapid service innovation and monetization for organizations with the resources and processes in place to develop and deploy them. Not surprisingly, SDN has seen early adoption in service providers and large enterprises with early-adopter IT cultures and active cloud deployments. On the other hand, smaller organizations with very finite infrastructure resources and staff are using SDN to manage traffic spikes and large flows in more efficient ways.

SDN will enable a wide variety of use cases as the technologies mature. In the near term, these are some of the most commonly envisioned scenarios:

- **Service assurance through flow optimization in the Wide Area Network (WAN):** Public cloud providers may wish to ensure their SLAs by maintaining visibility and control of traffic all the way to the client's network edge. This can be achieved by deploying SDN-enabled devices both at the cloud provider edge and client ingress, with both devices communicating to the cloud provider SDN controllers. SDN can also help provide granular control of interdata center traffic, including backup or disaster recovery operations.
- **Improved security:** Administrators can predefine per-user access policies in Zero-Trust environments. Global threat thresholds can be implemented via an SDN controller and automatically monitored across disparate network and security systems, with predefined remediation actions.

- **Service improvement and velocity through easily orchestrated virtual network services:** By defining within the controller a set of policies that can be applied to configure virtual network functions, the operator is able to truly divorce the service delivered to the client from the limitations of the infrastructure that supports it. The SDN controller can be programmed to support known or predictable large flows or to quickly bring new physical or virtual devices online in the event of spikes, without increasing demand on limited administrator time.
- **Service differentiation through rapid customization.** The ability to develop new features quickly for highly specialized use cases appeals to many, particularly in the cloud and hosting space, as it can provide opportunities for timely service differentiation and incremental monetization of the network. Such use cases might take the form of new security offerings, service levels, or bandwidth on demand.

Managing Software-Defined Networks Within Clouds

Most discussions of SDN stop at the control and data planes. However, abstraction and programmability of the management layer of the network is critical to enable cloud orchestration applications to manage, end-to-end, all the infrastructure elements of the cloud-—compute, storage, and network—for more rapid application delivery. Rich Representation State Transfer (REST) and XML APIs provide access and programmability for Brocade networking equipment operating within cloud environments. In particular, the Network Operating System for the Brocade VDX Switches provides a fabric-level API, improving orchestration efficiency for higher-level constructs. The APIs may be used by SDN controllers, network automation tools, and cloud orchestration platforms of all types: delivered by in-house developers, commercial entities, and open source communities.

OpenStack is now the leading open source cloud orchestration framework. Formed in July 2010 by Rackspace Hosting and NASA, the OpenStack community hosts a range of projects or components—including Compute (Nova), Storage (Swift and Cinder), Network (Neutron), and Dashboard (Horizon)—with incremental releases made on a regular basis. OpenStack is optimized for the cloud, as it enables interoperability between different vendor clouds. OpenStack is designed to be massively scalable, and it provides seamless management between private and public clouds.

Brocade is committed to the OpenStack community and to supporting its users through their cloud deployment lifecycles in three ways:

- Brocade plug-ins for OpenStack Neutron and Cinder
- Partnerships with leading open source providers to offer a consumable, supported path to orchestrating the On-Demand Data Center powered by Brocade
- Architectural contributions to the OpenStack community that leverage Brocade networking expertise

For more information about Brocade OpenStack initiatives, refer to www.brocade.com/openstack. Brocade provides a scale-out networking platform with robust APIs as a foundation for cloud orchestration with OpenStack and other cloud frameworks, facilitating automation of resource deployment by policy for a wide range of applications in cloud data centers.

KEY ELEMENTS OF THE OPENSTACK SOLUTION

Key elements of the Brocade solution include:

- NETCONF and REST APIs via the VCS Logical Chassis
- REST APIs for Brocade Vyatta vRouter solutions
- SOAP APIs for the Brocade ADX® Application Delivery Series

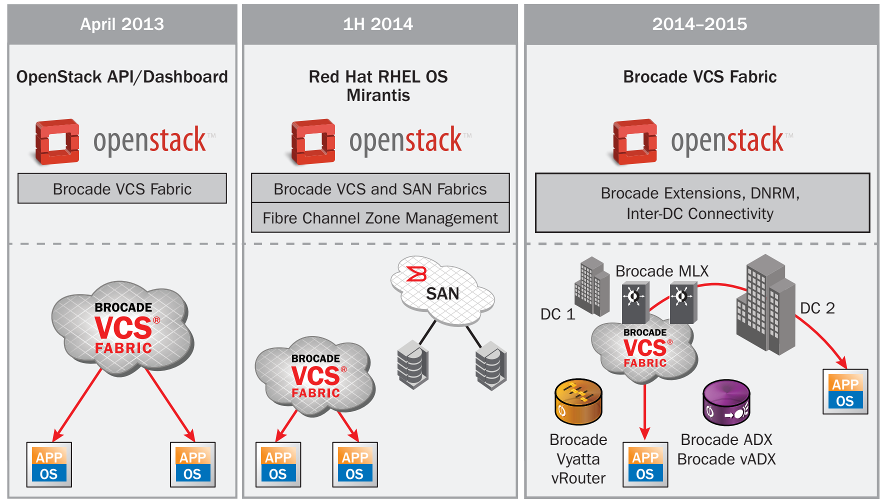

Figure 3: The Brocade commitment to OpenStack.

SDN and the Brocade Portfolio

SDN and Brocade VCS Fabric Technology

Brocade networking solutions offer unmatched automation and are built to support scale-out infrastructure, making them ideal for cloud infrastructures that must scale outward rather than upward.

Brocade VCS Fabric technology is built on three core design principles:

- Simplicity and automation
- Efficiency and resilience
- Built for the cloud

Brocade VCS Fabric technology is embedded in the Brocade VDX Switches, which enables IT organizations to build Ethernet fabrics that support cloud-optimized networking and greater enterprise agility. The Brocade VCS plug-in operates under OpenStack Neutron ML2 and is certified with several leading commercial OpenStack distributions.

To learn more about the technical advantages of an SDN architecture built on Brocade VCS fabrics, read the Brocade VCS Fabrics: The Foundation for Software-Defined Networks white paper.

Brocade ADX Series of Application Delivery Switches

The Brocade ADX Series helps dramatically reduce both OpEx and CapEx to enable the cost-effective, reliable delivery of cloud services by providing these benefits:

- Runs Brocade Virtual ADX on industry-standard x86 servers to enable fast provisioning of application delivery services
- Allows for on-demand performance and capacity scalability, with a pay-as-you-grow licensing model for Brocade ADX fixed platforms and fully interchangeable modules for chassis systems
- Enables control of application management and provisioning via a set of rich XML APIs and plug-ins, simplifying integration with third-party or open orchestration framework and automation tools

Brocade Vyatta vRouter

SDN helps you design, provision, and scale Layer 2 networks to meet rapidly changing business needs. For example, virtual routers, firewalls, and VPNs enable you to connect the L2 "islands" to each other, as well as to the broader infrastructure. The software is a single image with a virtual router, firewall, and VPS residing in a VM, which means that you can put routers wherever you need to in a virtualized environment.

In a multi-tenant cloud service environment, the Brocade Vyatta vRouter solution presents all the networking inside the tenant, so that you can design a more complex tenant with multiple subnets connected by a router. Since the virtual router lives in a VM, it has all the advantages and flexibility of a software product to move around and to scale up as necessary. Brocade currently provides a private OpenStack plug-in for the Vyatta vRouter solution.

Brocade ICX Switches

Traditional campus network environments require application-specific policies such as security and access control, VLAN traffic isolation, and QoS policies to be deployed across the network one switch at a time. In contrast, SDN-enabled campus networks can dynamically allocate network resources in real time to meet the needs of running applications. Custom-built SDN applications running above the OpenFlow controller can use input from many sources to allocate and protect network resources, set access control rules, and prioritize traffic in real-time in a fully dynamic fashion.

The Brocade ICX Series with HyperEdge® technology provides enterprise-class stackable switches to consolidate network management and enable services sharing between premium and entry-level switches, reducing both complexity and costs while protecting capital investments. With OpenFlow-enabled Brocade ICX switches, network operators gain a cost-effective means of extending flexible flow control to the network edge while leveraging the operational simplicity that comes with a campus network built on Brocade ICX technology.

To learn more, read the Software-Defined Networking in the Campus Network white paper.

Brocade MLX Series Router

The Brocade MLX Series of advanced core routers delivers unprecedented scale and performance, high reliability, and cost-saving operational efficiency for the world's most demanding service provider and enterprise networks. The Brocade MLX Series supports SDN at scale by delivering OpenFlow 1.3 in hardware for high-density 100 Gigabit Ethernet (GbE), 40 GbE, and 10 GbE networks and by scaling up to 128 K flows per system. The Brocade MLX Series also delivers OpenFlow in true hybrid-port mode. With Brocade hybrid-port mode, organizations can simultaneously deploy traditional Layer 2/3 forwarding and Multiprotocol Label Switching (MPLS) with OpenFlow on the same port. This unique capability provides a pragmatic path to SDN by enabling network operators to improve traffic engineering for particular data flows or for customers using OpenFlow, without disrupting the existing production traffic.

Brocade CES and CER-RT Series

The Brocade CES Series of switches and Brocade CER-RT Series of routers deliver OpenFlow 1.3 for SDN, in addition to IP routing and advanced carrier Ethernet capabilities, in a flexible, compact form factor. The 10 GbE-capable Brocade CES and CER-RT Series support OpenFlow in hybrid switch mode. With Brocade hybrid switch mode, organizations can simultaneously deploy traditional switching and routing with OpenFlow on the same system. This unique capability enables network operators to integrate OpenFlow at the network edge, providing flexible flow control to respond to dynamic traffic patterns and quickly add new revenue-generating services.

Conclusion

In rethinking the traditional architectural paradigm of physical network tiers of discrete devices, Brocade first applied its fabric heritage to the Ethernet, extending the network's atomic unit from the single physical switch to multiple-node fabrics.

Now Brocade has undertaken to evolve its entire portfolio, decoupling and opening up the data, control, and management planes across multiple product lines in order to deliver truly cloud-optimized networks. The final result—a complete embrace of open source-based Software-Defined Networking—will ensure a customizable, organically responsive, highly resilient network that can participate naturally in modern virtualized environments.

Corporate Headquarters
San Jose, CA USA
T: +1-408-333-8000
info@brocade.com

European Headquarters
Geneva, Switzerland
T: +41-22-799-56-40
emea-info@brocade.com

Asia Pacific Headquarters
Singapore
T: +65-6538-4700
apac-info@brocade.com

BROCADE