Building Cloud-Optimized Data Center Networks

HP's FlexNetwork Architecture Meets the Stringent Performance, Security and Agility Demands of Cloud Computing

Technical white paper

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Executive Summary

Enterprises are turning to the Cloud to improve business agility, reduce expenses and accelerate business innovation. Cloud computing redefines the way IT assets are deployed and consumed and dramatically affects the way data center networks are architected and managed. Conventional hierarchical data center networks built to support traditional siloed IT architectures can't meet the security, agility and price/performance requirements of virtualized cloud computing environments. Public cloud service providers and enterprises deploying private clouds must implement flatter, simpler data center networks to support the bandwidth-intensive, delay-sensitive server-to-server traffic flows that accompany cloud computing. Enterprises must also evolve and adopt new management systems and practices to administer and secure virtual resources and orchestrate on-demand services.

HP CloudSystem is the industry's most complete, integrated, and open system for building and managing services across private, public and hybrid environments. CloudSystem leverages best-of-breed HP FlexNetwork networking solutions that enable the construction of simpler and more efficient data center networks with fewer layers and greater port densities to address the increased price/performance and scalability demands of these new highly virtualized data centers. In addition, the solutions deliver advanced management capabilities that unify security and administration across virtualized and physical resources and accelerate the delivery of on-demand applications and services.

This white paper reviews the impact of cloud computing on data center networks and describes HP's approach to building simpler, more secure and automated networks that fully meet the stringent performance, security, reliability and agility demands of the new data center in the Cloud.

Accelerating Business Innovation with Cloud Computing

Businesses of every size and industry are looking to the Cloud to boost business agility, reduce expenses and risks, and improve business innovation. Cloud computing provides on-demand access to an elastic pool of shared computing, storage and networking resources over a private IP network or the Internet. Cloud services can be deployed in several different ways.

In a **public cloud** model, a service provider establishes a cloud-based service as a commercial offering. IT assets are shared, and services are provided to multiple enterprises, often on a per-use basis. By leveraging the experience and capital investments of a trusted cloud service provider, enterprises can reduce CAPEX, respond more quickly to rapidly evolving business requirements, and focus valuable IT resources on business innovation rather than underlying IT infrastructure. According to IDC the overall market for public cloud services will grow from $16.5 billion in 2009 to more than $55 billion by 2014.

In a **private cloud** deployment model, services are delivered to users and groups within an individual enterprise. An enterprise IT organization may set up a private cloud to provide on-demand applications and services to internal consumers and business units. By implementing private clouds, enterprises can reduce CAPEX and OPEX by leveraging economies of scale and eliminating redundancies plus allow business units to improve business agility and concentrate on business innovation rather than underlying IT services.

In a **hybrid model** an enterprise employs a combination of private and public cloud services - sometimes in conjunction with traditional on-premises IT solutions. Many larger enterprises are adopting hybrid deployment models.

Cloud computing alters traditional data center traffic flows, increases bandwidth and performance demands, and introduces new security, SLA and service orchestration requirements. Enterprises and service providers must implement more agile, efficient and scalable data center networks and adopt new management systems and practices to support the move to cloud computing.

HP CloudSystem – A Single Platform for Private, Public and Hybrid Clouds

HP CloudSystem is the industry's most complete, integrated and open system for building and managing cloud services. Only HP delivers a comprehensive, integrated cloud solution on a single platform, with all the attributes so prized by CIOs, service providers and IT professionals.

Based on proven, market-leading HP Cloud Service Automation and Converged Infrastructure, HP CloudSystem combines servers, storage, networking, and security together with automated system and hybrid service delivery management. The result is a complete cloud solution that's prepared to fulfill the promise of "cloud driven" services and revenue for enterprises and service providers alike in minutes, and manages the services throughout their lifecycle.

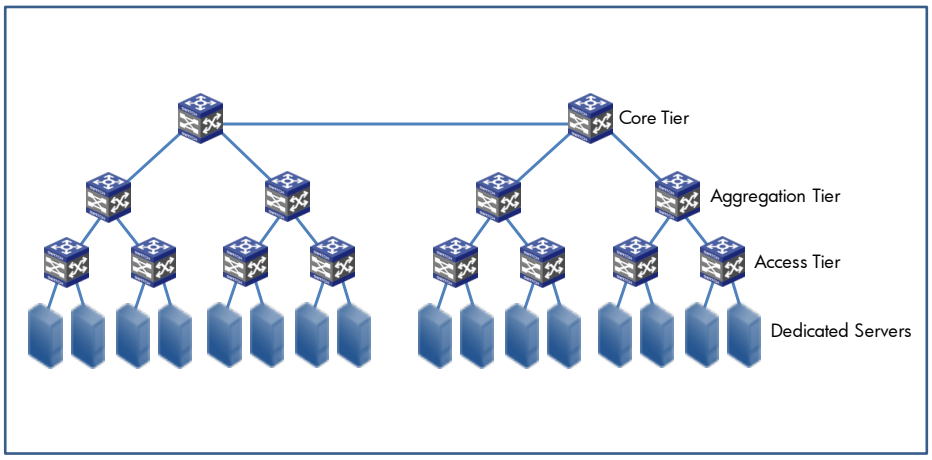
HP CloudSystem is the product of HP's experience in delivering industry-leading automation, application management, and converged infrastructure capabilities. It enables customers to build, manage, and consume cloud services across private clouds, public clouds, and traditional IT environments—without having to know, or care, whether those services come from HP CloudSystem's own "on-premises" resources or from the public domain.

HP CloudSystem Matrix is the core CloudSystem platform. It is built on our renowned, field-proven BladeSystem platform with HP Virtual Connect and Cloud Service Automation products. That core platform is fully extensible via HP's Converged Infrastructure portfolio, including HP 3PAR utility storage, HP TippingPoint Security, and core-to-edge HP Networking.

Cloud-Optimized Data Center Network Requirements

Today's data center networks were designed to support conventional siloed IT architectures in which servers are dedicated to specific functions or organizations and the vast majority of traffic flows in and out of the data center. Most data center networks are based on hierarchical designs comprised of an access tier, an aggregation tier and a core tier (figure 1).

Figure 1: Customary three-tier data center network architecture



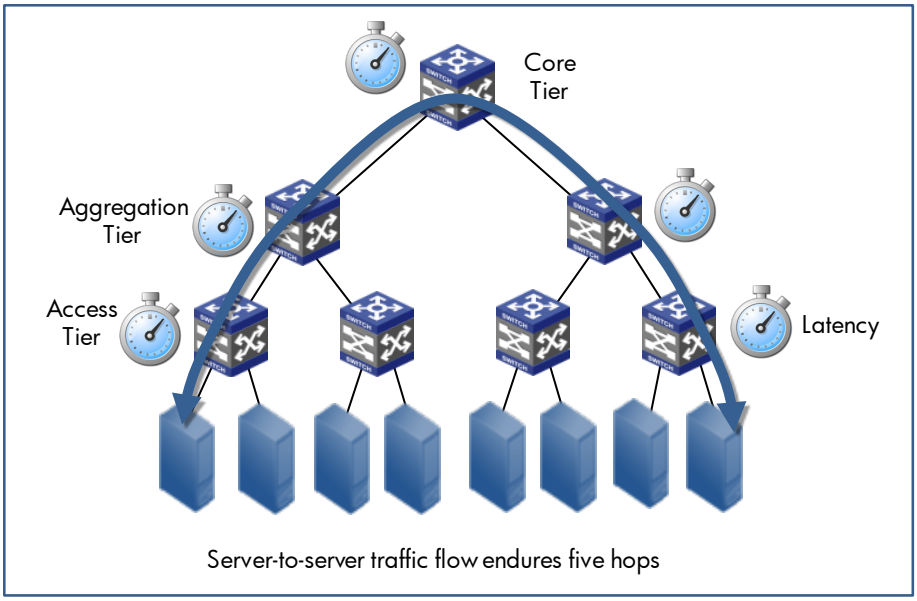
The access tier is made up of cost-effective Ethernet switches connecting rack servers and IP-based storage devices (typically 10/100Mbps or 1GbE connections). The access switches are connected via Ethernet to a set of aggregation switches (typically 1/10GbE connections) which in turn are connected to a layer of core switches or routers that forward traffic to an intranet, the Internet and between aggregation switches. Layer 2 VLANs are typically implemented across the access tier and aggregation tier, and Layer 3 routing is implemented in the core. Bandwidth is typically over-provisioned in the access tier, and to a lesser extent in the aggregation tier.

The server infrastructure and the networking infrastructure are typically administered independently, by separate teams using distinct toolsets. Each server is typically dedicated to a specific function (i.e. Web server, application server, database server) and can be reasonably well protected using conventional security solutions such as intrusion prevention systems.

Contemporary data center networks designed to support siloed IT architectures simply can't meet the performance, security, availability and agility requirements of the Cloud. Public cloud service providers and enterprises deploying private clouds must implement simpler and more efficient networks that support the bandwidth-intensive, delay-sensitive server-to-server traffic flows and stringent SLA and security demands that accompany cloud computing and they must adopt new management systems and practices to orchestrate on-demand services and administer and isolate virtual resources. Requirements for the new cloud-optimized data center network include the following:

- **Low-latency server-to-server connections:** Today's three-tier hierarchical networks aren't well suited for high-volume server-to-server communications. Inter-server traffic is forced to traverse multiple layers of switches, and each switch adds latency to the connection (figure 2). Enterprises and service providers must implement flat, low-latency data center networks to accommodate the delay-sensitive, volume-intensive server-to-server traffic flows that accompany cloud computing models.

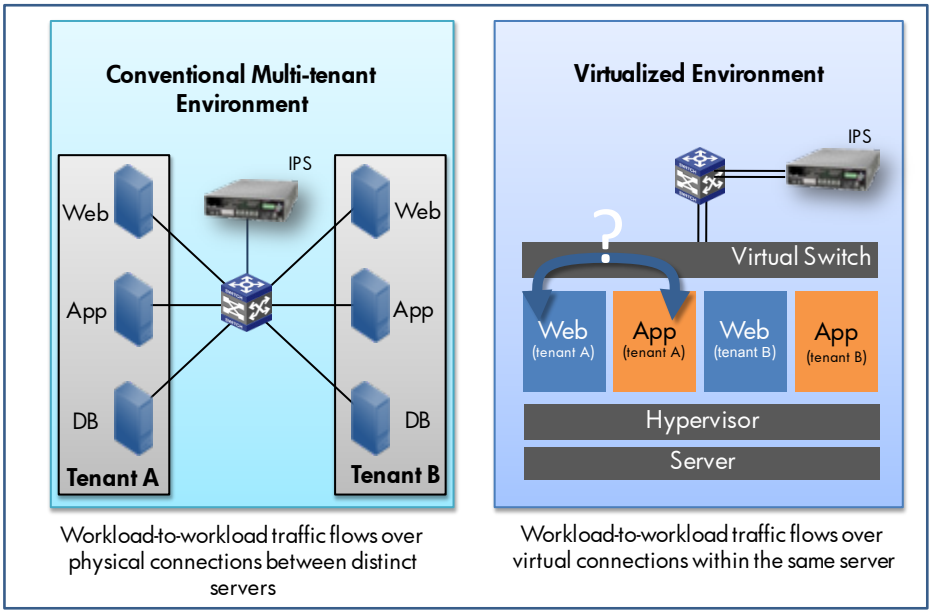
Figure 2: Hierarchical networks aren't well suited for server-to-server communications. Server-to-server traffic must traverse multiple layers of switches. Each hop adds delay.



- **Greater performance and resiliency:** Today's hierarchical data center networks typically rely on some variant of the spanning tree protocol (STP) for resiliency. STP is designed to allow only one active path from one switch to another, regardless of how many actual connections might exist in the network. If the active path fails, the protocol automatically selects a backup path. STP can take several seconds to recover from link failures and is not well suited for delay-sensitive applications. Cloud computing requires more efficient and resilient network designs that make full use of networking resources (no idle backup paths) and recover from failures in milliseconds to meet stringent resiliency requirements.
- **Large layer 2 domains:** VM migration (VMotion/Live Migration) - the ability to seamlessly move VMs from one physical server to another without impacting applications or users - is driving the requirement for large-scale Layer 2 domains that offer high throughput and low latency. VM migration is critical for executing routine maintenance, business continuity and disaster recovery functions in the Cloud.
- **Higher bandwidth at the server edge:** Blade servers and server virtualization pack more and more computational power into smaller and smaller form-factors - increasing bandwidth demands at the server edge, driving requirements for new switching solutions that offer better performance and greater port densities.

- **Stringent availability requirements:** For public cloud service providers the data center is the lifeblood of the business. Providers must deliver carrier-class network services to honor SLA contracts and meet core business objectives. Similarly, IT organizations responsible for private cloud services must deliver predictable and reliable network services to support mission-critical business applications, address internal service level commitments, and meet P&L objectives.
- **Unified management:** Server virtualization creates a new 'virtual edge' that blurs the traditional boundaries between network and server administration and introduces a variety of operational challenges. New tools are required for efficiently administering virtual switches, servers and connections; for orchestrating on-demand applications and services, and for ensuring SLAs and enforcing service policies as VMs migrate across the data center.
- **Virtualization-aware security:** The virtual edge is beyond the scope of existing security systems and practices. In contemporary data centers, distinct workloads (database, application, web-hosting) and tenants are deployed on discrete physical servers. Workload-to-workload communications always occurs over physical connections and can be secured using conventional intrusion prevention tools (figure 3). With server virtualization, workloads can communicate over virtual connections within the same server in a manner transparent to existing network-based intrusion prevention systems. Cloud service providers must implement new 'virtualization-aware' security solutions to police intra-server communications flows, protect virtual resources and partition multi-tenant environments.

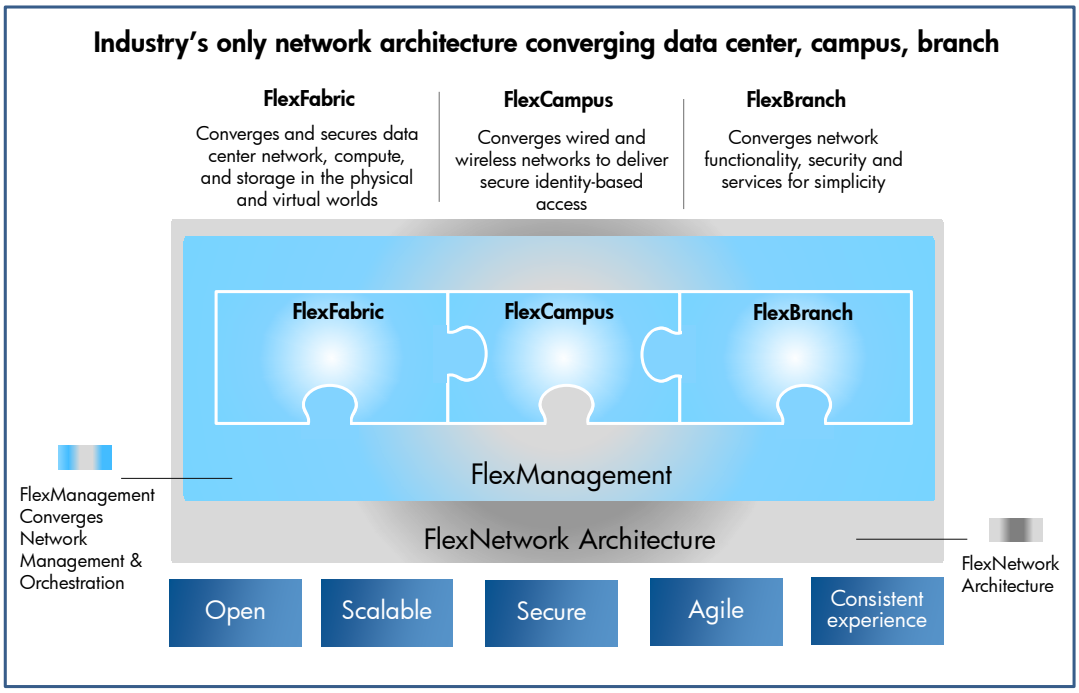
Figure 3: Conventional security tools and practices built around physical servers and physical switches can't safeguard intra-server, workload-to-workload communications.



HP FlexNetwork - An Architectural Blueprint for Cloud-Optimized Networking

HP FlexNetwork architecture - HP's blueprint for cloud-optimized networking - enables enterprises to align their networks with their business needs - even as needs change. With FlexNetwork, enterprises can segment their networks into the four interrelated modular building blocks: FlexFabric, FlexCampus, FlexBranch and FlexManagement (figure 4).

Figure 4: HP FlexNetwork lets enterprises align networks with business needs



HP FlexFabric and HP FlexCampus enable the construction of flat, low-latency data center and campus networks with fewer layers, less equipment and cabling, and greater port densities. **HP FlexBranch** includes comprehensive WAN optimization and routing solutions for delivering dynamic cloud-based services to geographically-distributed enterprises. **HP FlexManagement** provides a unified view into the virtual and physical network infrastructure that accelerates application and service delivery, simplifies operations and management, and boosts network availability.

HP FlexNetwork lets enterprises securely deploy and centrally orchestrate cloud-optimized architectures that scale from the data center to the network edge. It enables the construction of flatter, simpler data center networks to support the bandwidth-intensive, delay-sensitive server-to-server virtual machine and workload traffic flows that accompany cloud computing, and it provides rich management tools for administering and securing virtual resources, and orchestrating on-demand services.

FlexFabric: Cloud-Optimized Data Center Networks

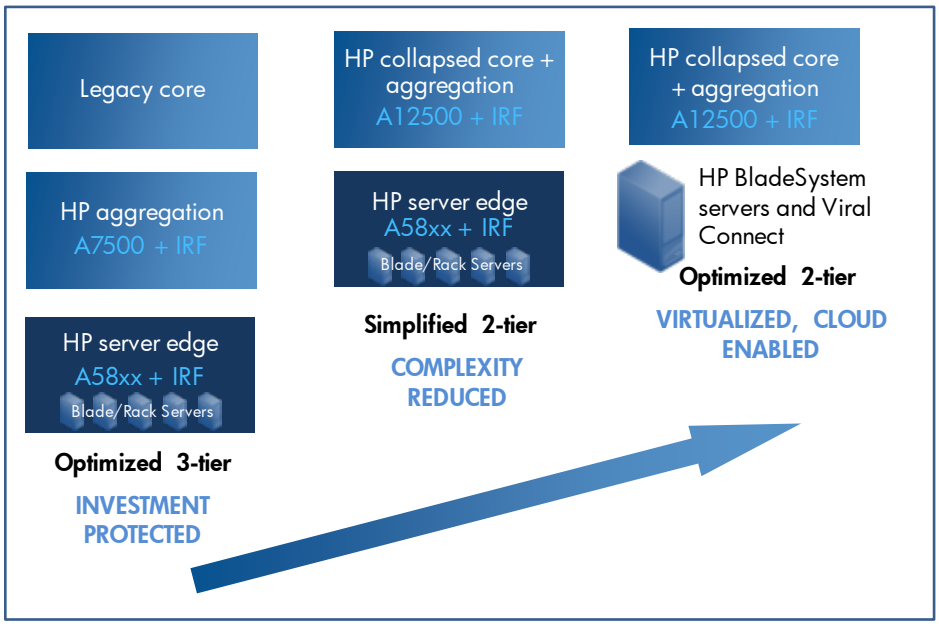
The Cloud fundamentally changes the ways in which applications are deployed, administered and consumed. Cloud computing makes heavy use of server virtualization technology which reshapes data center traffic flows, and blade server technology which increases bandwidth demands at the server edge, and drives requirements for denser switching equipment and more efficient network designs. HP FlexFabric helps cloud providers and enterprises deploying private clouds implement flatter, simpler data center networks to support the bandwidth-intensive, delay-sensitive server-to-server traffic flows that accompany cloud computing.

FlexFabric supports a wide range of network designs to meet diverse customer requirements (figure 5). Customers looking to protect investments in legacy core infrastructure can implement a three-tier traditional network design, and deploy cost-effective HP A-Series Top-of-rack server edge and aggregation platforms that interoperate with their existing core switches. This approach allows customers to preserve existing assets and gradually migrate to a more agile network design over time while enjoying the benefits of IRF switch virtualization and cost-effective, energy-efficient HP A-Series switches in the server edge and aggregation layers.

Customers looking to reduce cost and complexity can implement a two-tier collapsed network design that completely eliminates a dedicated aggregation layer. These designs leverage HP Virtual Connect or HP A58XX series switches at the server edge along with highly-scalable HP A12500 series core switches as a collapsed core/aggregation layer. These flat network designs ensure direct-flight server-to-server performance while dramatically reducing network port counts. A two-tier collapsed design also simplifies and streamlines network management, and reduces capital expense and energy consumption.

Customers can reduce CAPEX and OPEX even further by implementing an optimized two-tier collapsed network design using HP BladeSystem servers and HP Virtual Connect. This solution provides the ultimate in simplification, agility and cost optimization.

Figure 5: FlexFabric supports a range of network designs to support diverse customer requirements



HP A-Series Ethernet Switches and innovative Intelligent Resilient Framework (IRF) technology enable flat, low-latency network designs to support highly virtualized data centers. In addition, A-Series switches offer industry-leading server edge port density to meet the increased bandwidth demands that accompany the implementation of server virtualization and blade server technology.

HP A-Series Ethernet Switches

HP A-Series 12500 core switches leverage the latest generation of ASICs and a fully non-blocking design based on a CLOS architecture to deliver ultimate performance, density and scalability. The product family delivers 6.66Tbps performance and offers very high port density today (512 10GbE or 128 10GbE ports per rack) with support for 40GbE and 100GbE connections in the future.

HP A-Series 58XX ToR switches leverage cut-through switching technology and a high-availability architecture to deliver line-rate, low-latency performance and outstanding reliability at the server edge. The product family's high port density (up to 24 10GbE ports per unit) meets escalating bandwidth demands at the server edge.

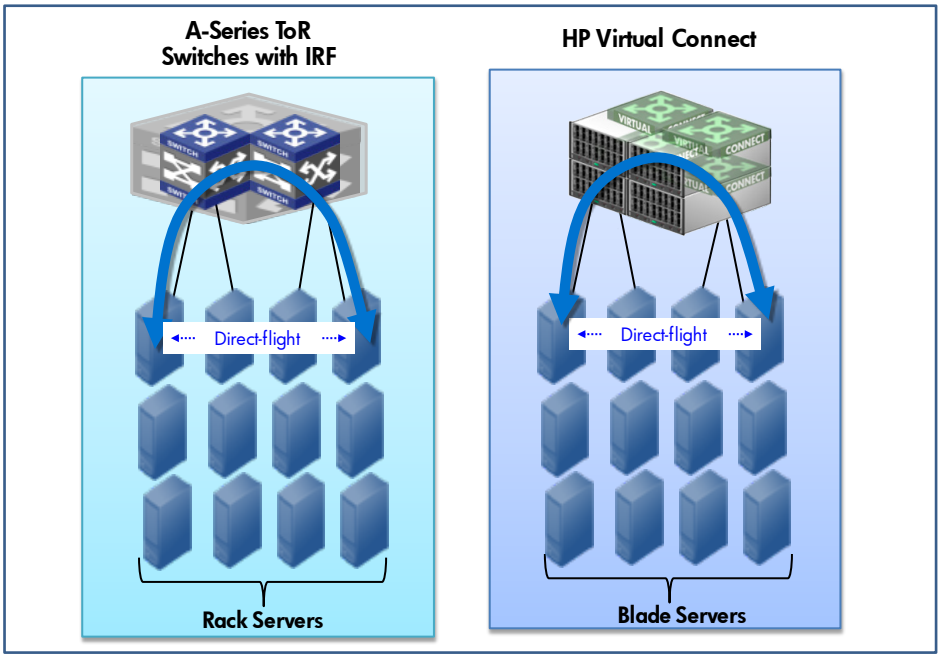
Virtualization-Optimized Server Edge Solutions

HP provides flexible solutions for delivering high-performance server-to-server connectivity at the server edge (figure 6). HP solutions can directly interconnect hundreds of virtual machines at the edge of the network, eliminating unnecessary network hops, reducing latency and optimizing performance for high-volume server-to-server traffic flows.

For traditional top-of-rack server edge installations, HP A-Series 58XX ToR switches can be deployed with IRF virtualization technology to provide high-throughput, low-latency server-to-server connectivity at the server edge. With IRF, multiple switches can be virtualized and logically combined to enable low-latency, ultra-resilient virtual switching fabrics comprising hundreds or even thousands of 1GbE or 10GbE switch ports–all managed via a single IP address.

For BladeSystem deployments, HP Virtual Connect delivers direct server-to-server connectivity within the rack, enabling wire-speed, machine-to-machine communications for delay-sensitive, bandwidth-intensive traffic. In addition, HP Virtual Connect Flex-10 and FlexFabric modules can be leveraged to dynamically fine-tune application-specific performance across server and storage networks to improve scale and make best use of shared connectivity resources.

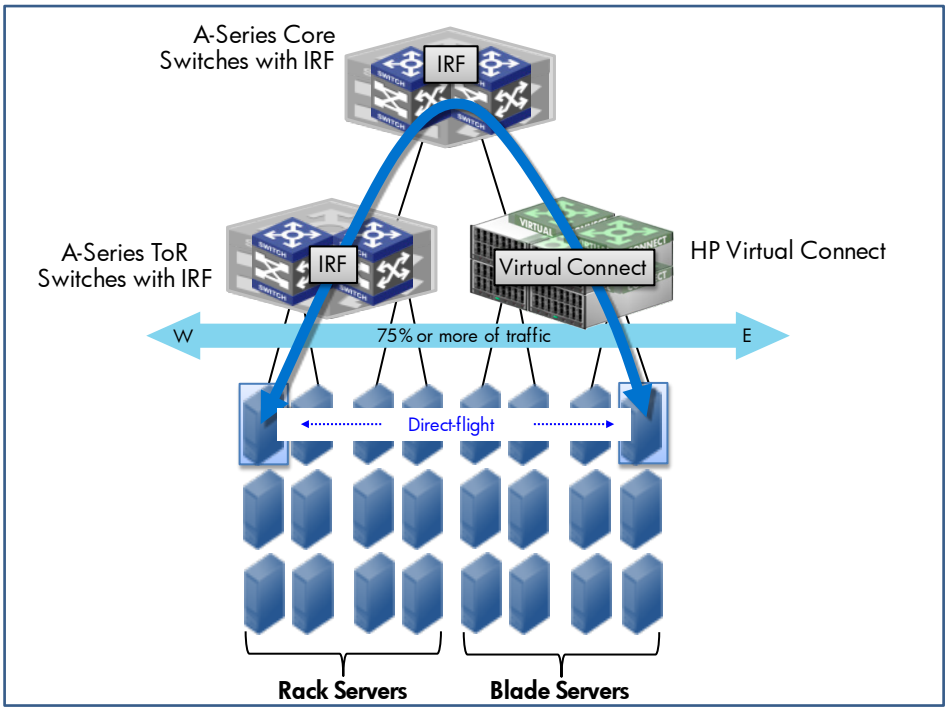
Figure 6: High performance server-to-server connectivity: HP A-Series ToR Switches with IRF for Rack Servers; HP Virtual Connect for Blade Servers



Collapsed Two-tier Data Center Network Architecture

In the core of the network, HP A-Series 12500 switches can be deployed in conjunction with IRF to completely eliminate the aggregation layer found in conventional three-tier data center networks (figure 7). IRF overcomes the limitations of legacy spanning tree networks by fully leveraging all network connectivity (no inactive backup paths) and by providing rapid failover to dramatically improve network utilization and performance in the network core.

Figure 7: A two-tier network design enables direct-flight server-to-server connectivity while reducing cost and complexity.



A collapsed, two-tier data center network architecture enables direct-flight server-to-server performance, requires significantly fewer connections and port counts (no aggregation switches), streamlines provisioning and network management, and reduces capital expense and energy consumption. In addition, these two-tier networks provide large Layer 2 domains to enable VM migration across the data center (move workloads from one server to another server in the same VLAN/IP subnet.)

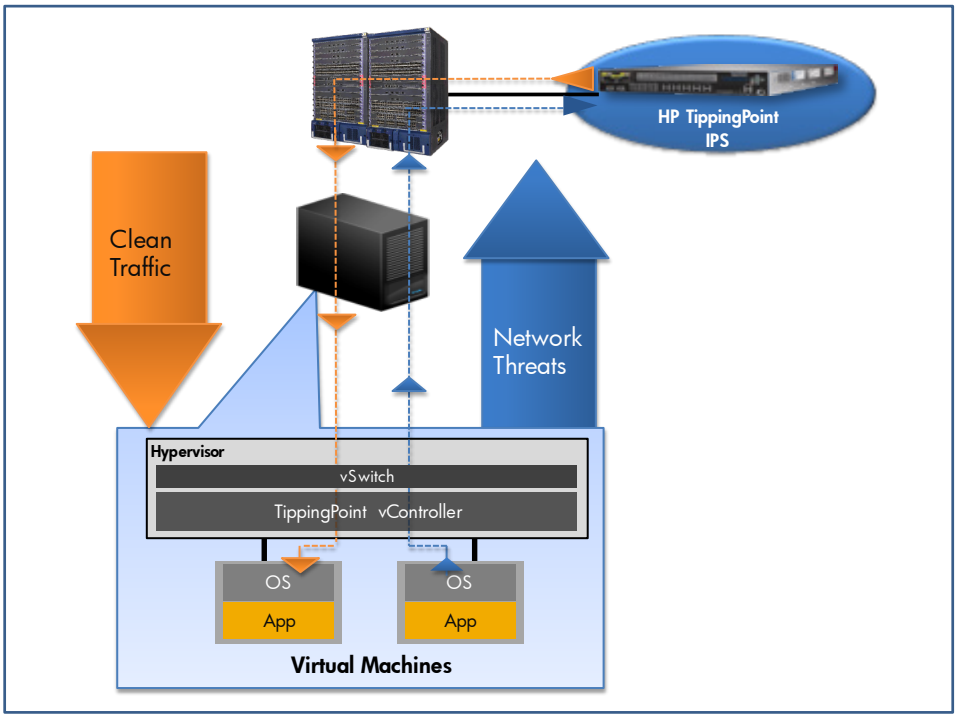
Securing the FlexFabric: HP TippingPoint Secure Virtualization Framework

HP TippingPoint Secure Virtualization Framework (SVF) enables unified security across virtualized and physical domains, safeguarding VM-to-VM as well as inter-server and inter-network traffic in a common platform. The framework streamlines administration and reduces operations expenses by centralizing and automating security management functions. Administrators define rich, infrastructure-wide security policies which are implemented across virtual machines and virtual switches in a transparent fashion. The solution helps cloud service providers and enterprises implementing public clouds address the unique challenges associated with partitioning distinct user communities and securing multi-tenant environments.

SVF brings best-of-breed TippingPoint intrusion prevention, threat mitigation and security management features to the virtual edge, safeguarding IT assets and optimizing service availability. HP TippingPoint vController - an integral SVF component – works with an HP TippingPoint N-Platform IPS to provide high performance intrusion prevention for a virtualized server. A software-based solution that is easily installed in a virtualized server, vController directs virtual machine traffic to an N-Platform where robust intrusion protection services are applied with line-rate performance (figure 8). The solution segregates virtual resources and inspects and polices intra-server traffic flows providing consistent, unified security across virtualized and physical data center network infrastructures.

HP's high-performance security solutions allow enterprises to support dynamic traffic demands and service flows without adding devices and complexity or compromising security. Enterprise private cloud data centers may "burst" to public clouds from time-to-time to accommodate demand spikes. They must ensure real-time protection of both their private cloud and the virtual machines delivering burst capacity in the public cloud. HP TippingPoint's Secure Virtualization Framework delivers real-time security as virtual machines (VMs) are provisioned in the public cloud, automatically ensuring seamless, secure and context-aware protection, enabling enterprises to dynamically shift and re-allocate services without sacrificing security.

Figure 8: Virtualization-aware security: HP TippingPoint IPS + vController



FlexBranch: Cloud-Optimized Wide Area Networks

The Cloud transforms the way organizations deliver and consume IT services and alters traditional WAN traffic patterns. Many conventional enterprise WANs are based on a centralized architecture where branch office traffic is backhauled to a central corporate data center over a private IP network. Enterprises must evolve their WAN architectures to support the dynamic and distributed nature of cloud-based computing. FlexBranch provides flexible options for evolving enterprise WANs to support the Cloud.

HP offers a wide-ranging family of branch and remote office switching and routing solutions that address diverse performance, price and scalability requirements and offer customers a broad set of options. Using the HP E5400 Switch series enterprises can evolve their WANs to support a mix of centralized and distributed services – all secured and managed in a unified fashion. For example, with the HP E5400 a branch office could be configured to enable the delivery of certain cloud-based services over a public Internet connection and other services over a private network connection all under the control of a centralized policy management system. The connections can be adapted dynamically to accommodate shifting demands or service delivery models without compromising security or service integrity. For example an enterprise may shift certain services from a private cloud to a public cloud to accommodate peak workload demands, while preserving QoS and security policies.

Ensuring optimal WAN performance is critical for delivering high quality end-user experiences. HP provides rich WAN optimization capabilities that help enterprises make the most efficient use of WAN resources to optimize application performance and end-user QoE. The HP E5400 leverages industry-leading Steelhead WAN optimization technology from Riverbed to accelerate application performance and ensure fast, reliable access to cloud-based applications and services. In addition the solution helps save money by reducing bandwidth consumption – packing more traffic onto existing WAN capacity.

FlexManagement: Unified Virtual and Physical Management with HP Intelligent Management Center

HP Intelligent Management Center (IMC) unifies physical and virtual network management and helps overcome the challenges of managing cloud computing environments, orchestrating on-demand services and administering the new virtual server edge. The solution provides a unified view into the virtual and physical network infrastructure that accelerates application and service delivery, simplifies operations and management, and improves network availability. Capabilities include:

- Automatic discovery of virtual machines, virtual switches and their relationships with the physical network
- VM and virtual switch resource management, including creation of virtual switches and port groups
- Automatic and transparent configuration of virtual and physical network infrastructure
- Unified performance and alarm monitoring of hosts, workloads and virtual switches
- Topology views and status indicators for networks, workloads and virtual switches
- Automatic reconfiguration of network policies as workloads migrate across the data center

HP IMC can help eliminate service interruptions caused by virtual/physical network configuration errors; reduce administration and troubleshooting by providing unified management of physical and virtual network infrastructure through single pane of glass; and accelerate the delivery of on-demand applications and services by automating the configuration of virtual and physical network infrastructure.

Future Trends and Emerging Solutions

More Scalable and Robust Data Center Networks – TRILL and SPB

Going forward, cloud computing will drive requirements for larger-scale, more reliable Layer 2 data center networks that can support increased workload mobility and greater numbers of server-to-server connections. HP is promoting standards-based approaches for building cloud-enabled data center networks and is actively involved in the IEEE 802.1aq SPB (Shortest Path Bridging) and the IETF TRILL (Transparent Interconnection of Lots of Links) standardization efforts. Like IRF and Virtual Connect, SPB and TRILL overcome STP limitations, providing multi-path forwarding and localized failure resolution to enable full network utilization, fast network re-convergence and dramatically-improved Layer 2 scaling. HP intends to bring these standards-based technologies to market in future data center networking products.

Improved Virtual Edge Management – VEPA

Over time cloud computing will drive requirements for greater VM densities which will impact the performance and manageability of virtual switches. As more and more virtual machines are added to physical servers, less processing power will be available for networking tasks. In addition the challenges associated with configuring, troubleshooting and monitoring inter-VM communications will become more acute.

HP has co-authored the IEEE Virtual Ethernet Port Aggregator (VEPA) proposal to provide a more explicit, accessible and robust infrastructure for managing connectivity at the virtual network edge. VEPA allows virtual switching to be extracted from the server, improving server performance and increasing the number of VMs that can run on each server. In addition, with VEPA, traffic flows within the virtual network edge can be brought into the physical network edge so network security and management policies can be reliably and efficiently implemented using standard networking tools and processes. HP intends to support VEPA-compatible solutions when they are commercially available.

Ultimately, with VEPA and IMC, HP will deliver an automated, policy-driven, end-to-end orchestration framework for efficiently managing cloud-based resources and on-demand services.

Summary

Enterprises are turning to the Cloud to accelerate business innovation, improve business agility and contain costs. Cloud computing reshapes the way applications are deployed and consumed and influences data center network designs. HP helps service providers and enterprises build unified, virtualization-optimized data center networks that meet the rigorous performance, scalability, availability and agility demands of the Cloud. HP CloudSystem and HP FlexNetwork networking solutions deliver:

- Flatter and more efficient data center networks with fewer layers, less equipment and cabling, and greater port densities
- High performance, low latency intra-data center connectivity for VM migration and bandwidth-intensive server-to-server communications
- Virtualization-aware security to partition multi-tenant environments and isolate virtual resources and intra-server communications flows
- Optimal WAN performance for the highest quality end-user and application experiences and most efficient use of WAN resources.
- Unified administration and service orchestration to accelerate the delivery of cloud-based applications and services
- Multi-site, multi-vendor management to connect and control thousands of physical and virtual resources from a single pane of glass

To learn more about how HP can help you build a cloud-optimized data center network, please contact your HP account manager or reseller.

The Fast-Track Secret to Success in the Cloud: HP Services

We believe that most enterprises are likely to reach a hybrid cloud model in the long term, and that the mix across internal, private, and public sourcing will evolve over time. That is why we recommend starting with a solid strategy covering all the different options. For the surest route to a successful cloud strategy and implementation, we encourage clients to engage HP Services to help align business and operational needs to their cloud strategy, while speeding the path to the cloud.

Start with a holistic view and strategy

Through HP Cloud Discovery Workshop, HP helps clients gain clarity on cloud concepts, identify the cloud initiatives that can work for their business, discuss how a Converged Infrastructure and HP CloudSystem can lay the foundation for the cloud, and subsequently draw actionable steps. During this one-day workshop, senior HP consultants using highly visual displays cover topics such as cloud concepts, architecture, service portfolio, management, financials, governance, and more.

Build a private cloud in 30 days

Delivering a working private cloud service quickly and affordably is crucial; otherwise, IT risks the possibility that business stakeholders will deploy "shadow IT" services through the public cloud. HP CloudStart helps avoid this scenario with speedy implementation (within 30 days after installation and startup) of the first private cloud services based on HP CloudSystem Matrix. HP experts provide a series of workshops to shape and define the best CloudSystem Matrix configuration, develop up to four compute services, and provide service definitions and specifications for those compute services. Clients also receive full automation design, implementation, and testing of the four compute services, so they quickly become production-ready consumable services. In tandem with HP CloudSystem Matrix, HP CloudStart provides the core features of a public cloud service, including:

- Web-based self-service menus
- Ability to activate a service in minutes
- Flexibility to scale or cancel a service at any time
- Behind-the-scenes IT service management
- Real-time access to consumption and chargeback reports

For More Information

HP Networking Solutions

HP Networking Solutions home page
http://www.hp.com/go/networking

HP Cloud Solutions

HP Cloud Solutions home page
http://www.hp.com/go/cloud

HP CloudSystem

HP CloudSystem home page
http://www.hp.com/go/cloudsystem

HP A-Series Switches

HP A-Series Switches data sheets and product details
http://h17007.www1.hp.com/us/en/products/switches/index.aspx?tab=tab_A-Series

HP Intelligent Resilient Framework

HP IRF White Paper – Reducing network complexity, boosting performance with HP IRF technology
http://h10144.www1.hp.com/docs/irf/irf.pdf

HP Virtual Connect

HP Virtual Connect data sheets and videos
http://www.hp.com/go/virtualconnect

HP TippingPoint Security

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