HP Advanced Data Center Network Architectures

Key Requirements for Building Modern, Virtualization-Optimized Data Center Networks

Technical white paper

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Introduction

New application architectures and software deployment models are fundamentally transforming the data center. Server virtualization, cloud computing and XaaS imperatives are altering data center traffic flows, escalating bandwidth and performance demands and introducing new security and service orchestration requirements. Legacy data center networks are simply too complex, costly and rigid to meet the needs of the new on-demand world. Tomorrow's virtualized data center demands more agile, efficient and scalable networking solutions.

HP believes customers should take a long-term view towards data center modernization and pursue strategies that protect and extend existing investments and minimize disruptions. Customers should seek approaches that maintain continuity with existing storage, server and network management practices, and choose standards-based solutions that gracefully evolve to meet emerging scalability and performance needs.

HP offers a flexible, virtualization-optimized data center network architecture that requires far fewer devices, interconnections, layers and discrete appliances. HP Networking solutions streamline network operations and accelerate application and service delivery; reduce space, power, cooling and capital requirements; and protect investments while providing a solid foundation for the future.

This white paper reviews data center trends and describes HP solutions for building cost-effective, advanced data center networks that meet the evolving performance, reliability and agility demands of the 21st century.

Key Business and Technology Drivers for a New Data Center Network Architecture

Large-scale Data Center Consolidation

For many enterprise customers, the Data Center IS the business. With mission-critical applications and services deployed to provide the foundation for day-to-day operations and delivery of end-customer services, the data center must deliver unquestioned availability and meet stringent service level agreements. Exploiting server virtualization and low-cost computing power, customers are deploying more and more sophisticated applications on a larger scale. To reduce the sheer complexity and improve operations of these deployments, customers are seeking to consolidate fragmented, dispersed facilities into fewer, centralized locations.

These new 'mega data centers' are fundamentally challenging how networks must be built. Today's networks must be designed to deliver much higher levels of performance, scalability, and availability than before to meet service-level agreements and maintain continuity of operations. Beyond sheer performance, these data center networks must quickly recover from hardware- or software-related faults and protect against server, storage, network, and application vulnerabilities to ensure continued performance and minimize service disruptions.

BladeSystems and Server Virtualization Technologies

The adoption of increasingly powerful multi-core-processor servers, higher-bandwidth interfaces and BladeSystems is dramatically increasing the scale of data center deployments. Now, thousands of virtual machines can be deployed in a single data center to consolidate infrastructure and streamline operations. These large-scale solutions are dramatically increasing network performance requirements at the server edge and across the extended network. Likewise, virtualization and VMotion/Live Migration tools for moving virtual servers are introducing high-volume machine-to-machine traffic flows

and impacting existing administrative practices creating a new "virtual edge" that blurs the traditional boundaries between network and server administration.

New Application Deployment and Delivery Models

Traditional client-server software and infrastructure deployment models are being displaced by new application architectures and service delivery models that are reshaping the data center. Web 2.0 mashups, SOA solutions and other federated applications are being widely deployed to deliver integrated, content-correlated, context-specific information and services to end-users within the enterprise and beyond. These deployments drive new, bandwidth-intensive traffic flows within the data center and demand low-latency, high-performance server-to-server and intra-server, virtual machine-to-virtual machine connections. At the same time, cloud computing and XaaS initiatives are introducing more stringent service level and security demands and driving requirements for a more agile and dynamic infrastructure.

HP's Solution: FlexFabric Networks - Wire-Once, Virtual I/O Data Center Network

HP Networking solutions are built from the ground up to meet the demanding needs of tomorrow's highly-virtualized, highly-available, large-scale application environments. HP FlexFabric networks leverage industry standards to deliver high-performance connectivity to storage and server resources using a single network fabric and wire-once simplicity. FlexFabric networks combine a virtualization-optimized network architecture built to deliver high-speed, direct-flight server-to-server connectivity with advanced security and management tools that enable virtualization-aware threat management, and dynamic, virtualization-integrated network provisioning. The solutions are specifically designed to address the unique networking challenges that accompany the deployment of large-scale server virtualization and federated applications. HP FlexFabric networks provide the following:

- A simpler, more resilient, more secure data center network that delivers high-performance, low-latency server-to-server connectivity
- Agile service delivery to support virtual server migration and on-demand services
- Better value and economics with fewer devices and network layers, simplified operations and management, and lower power and cooling costs

Data Center Deployment Models

The adoption of more virtualized, dynamic application environments is impacting traditional enterprise and hosted/multi-tenant data center designs and enabling new cloud-based delivery models that drive a whole new set of technology requirements across servers, storage, and networking domains. These increasingly popular use models allow enterprises to provision applications more flexibly within a private/internal infrastructure, and enable hosted application and service providers to build entire businesses based on delivering services via a public cloud model. Given the range of use cases and options, customers often deploy a combination of architectures to address varied requirements and to optimize operations.

Table 1 summarizes some of the most important networking focus areas that emerge as customers pursue these diverse deployment models. While all these imperatives play some role across all the deployment models regardless of market or industry, certain initiatives figure more prominently in specific use cases.

Table 1: Data center deployment models and corresponding key networking imperatives

Deployment Model	Characteristics	Key Networking Focus Areas
Traditional Enterprise Data Center	DC services are a critical complement to the company's core business Complex application environment Security, cost and flexibility are key Evolving towards private cloud over time	Converged Networking Virtualization Scale-out Managing/Provisioning the Virtual Server Edge
Traditional Multi-tenant Data Center	DC services are the company's core business Complex application environment Security, SLAs and flexibility are key Evolving towards public cloud over time	Virtualization Scale-out Securing the Virtual Server Edge Managing/Provisioning the Virtual Server Edge
Multi-tenant XaaS/ Cloud Computing Data Center	DC services may be the company's core business Heavy use of blade servers Cost, latency and scalability are key	Virtualization Scale-out Securing the Virtual Server Edge Managing/Provisioning the Virtual Server Edge
High-performance Computing Data Center	DC services may be the company's core business Heavy use of blade servers Cost, latency, performance and scalability are key	Low Latency

Key Data Center Networking Requirements

Virtualization Scale-out: Layer 2 Performance, Scaling, High Availability, and Multi-site Extension

Federated applications, server virtualization and on-demand services are pushing conventional hierarchical data center networks to their limits. Legacy networks designed to enable client-server communications (so-called 'north-south' traffic, in and out of the data center) can't accommodate the bandwidth-intensive, latency-sensitive server-to-server flows ('east-west' traffic, within the data center) imposed by these new technologies and deployment models. Legacy networks can't support intra-data center traffic patterns and can't meet the latency, performance and scalability requirements associated with these new deployment models.

Beyond driving the need for better server-to-server connections, server virtualization provides customers flexible tools for migrating virtual machines within the data to optimize operations and improve availability. These use models dictate very specific network design requirements: networks must be 'flat'–designed to connect potentially hundreds of physical servers hosting thousands of virtual machines within a single Layer 2 network domain. Network platforms and architectures not built to scale to these levels can limit deployment flexibility and increase management complexity.

With hundreds or even thousands of virtualized applications now in play across multiple, consolidated data centers, network resiliency and high availability take on a new, heightened level of importance. Network platforms and designs must be able to recover quickly from hardware and software faults to maintain continuity of service and business continuity.

Server virtualization also provides the means to dramatically improve business agility and continuity across a multi-site enterprise infrastructure. Today most enterprises implement cold or warm standby

solutions in which applications and data are backed up at a secondary site for disaster recovery purposes. An entire shadow infrastructure sits dormant most of the time. By employing virtual machines and distributing workloads across data centers enterprises can implement innovative new deployment models, which enable the following:

- Virtual server migration – move VMs and balance workloads in response to changing demands
- Business continuity – perform upgrades and maintenance functions in a non-disruptive fashion
- Disaster recovery – maintain normal business operations during catastrophic events
- Data center migration – seamlessly move applications from one data center to another to support consolidation or modernization initiatives

However, enabling distributed workloads and replicating data and applications across multiple, geographically-dispersed data centers are a challenge. Conventional Layer 3-oriented WAN solutions can't meet the stringent performance and latency requirements–and server virtualization technologies require contiguous network domains. Customers wishing to extend and connect Layer 2 networks across data centers require connectivity and technologies that stretch those networks across multiple, physical sites.

HP Solutions: Virtualization-optimized Network Designs

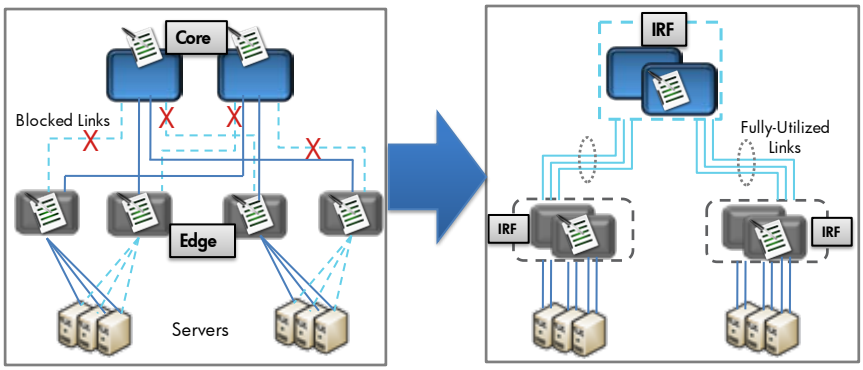
HP's virtualization-optimized network designs deliver high-performance, direct-flight server-to-server connectivity for high-volume server-to-server communications and enable large Layer 2 domains for flexible virtual server migration. These designs also enable high-performance scalability and the means to seamlessly extend Layer 2 domains across multiple data center sites.

An Intelligent Server Edge: HP Virtual Connect, A-series Top-of-rack Switches with HP Intelligent Resilient Framework (IRF)

HP Virtual Connect is an innovative, HP BladeSystem c-Class–integrated server edge solution that delivers direct server-to-server connectivity within the rack. The solution enables wire-speed, machine-to-machine communications for delay-sensitive, bandwidth-intensive traffic. HP Virtual Connect Flex-10 and FlexFabric modules further allow enterprises to dynamically fine-tune application-specific performance–across server and storage networks–to make best use of shared connectivity resources and improve scale.

For traditional top-of-rack server edge deployments, HP A-series switches with innovative Intelligent Resilient Framework (IRF) virtualization technology provide incredibly flexible tools for building flat, high-performance, highly resilient, ease-to-manage data center networks (figure 1). With IRF, multiple switches can be virtualized and logically combined to enable ultra-resilient virtual switching fabrics comprising hundreds or even thousands of 1GbE or 10GbE switch ports–all managed via a single IP address per IRF logical switch.

Figure 1: HP simplified network designs using A-series switches with IRF virtualization technology



Legacy Network

- Mgmt Complexity (discrete configs)
- Poor Performance (blocked links)
- Network Downtime (slow re-convergence)

HP IRF Network

- Mgmt Simplicity (one config per IRF virtual switch)
- High Performance (all links utilized)
- Increased Uptime (seamless recovery)

By deploying IRF in conjunction with high-performance A-series server edge switches, enterprises can directly interconnect hundreds of virtual machines at the edge of the network, eliminating unnecessary network hops, reducing latency and improving performance for large intra-data center workloads.

Flexible Core Networking and Multi-site Extension: A-series Modular Switches with HP Intelligent Resilient Framework (IRF)

In the core of the network, HP leverages highly-scalable modular platforms and the same IRF technologies deployed at the server edge to significantly improve scalability and provide unified, high-performance, multi-data center network extension.

IRF overcomes the limitations of legacy spanning tree networks providing rapid failover for delay-sensitive, mission-critical applications and dramatically improving network utilization and performance in the network core. By deploying IRF in conjunction with highly-scalable A-series modular switches customers can completely eliminate the requirement for a dedicated aggregation layer as they scale-out data centers, and enjoy the benefits of large Layer 2 domains with increased network uptime and simplified management.

To support inter-data center virtual machine mobility HP offers options for flexibly and reliably extending large-scale Layer 2 domains across geographically dispersed sites (table 2). Leveraging legacy approaches to multi-site connectivity, HP supports today's most popular LAN extension technologies including Ethernet over MPLS, Virtual Private LAN Service (VPLS), and GRE tunneling. With native, high-performance, ASIC-based support for MPLS/VPLS technologies and software license-free deployment, HP can offer traditional LAN extension solutions that are both cost-effective and easy-to-deploy.

HP also supports IRF for multi-site extension. Because it supports connectivity over long-range 10GbE distances, IRF can be extended across dark fiber networks to bring switches dispersed among multiple sites into a single IRF virtual domain. This approach can be used to extend both LANs and SANs across disparate data centers.

Table 2: HP supports a wide range of multi-site extension options

Option	Key Advantages	Limitations
GRE tunneling	Cost-effective and simple	Low performance
EoMPLS/VPLS	Standards-based solution	More complex than GRE and Ethernet/Dark Fiber solutions
Ethernet/dark fiber with HP IRF	High performance Supports converged LAN/SAN traffic Easy to manage	Physical distance limitations with 10GbE optics

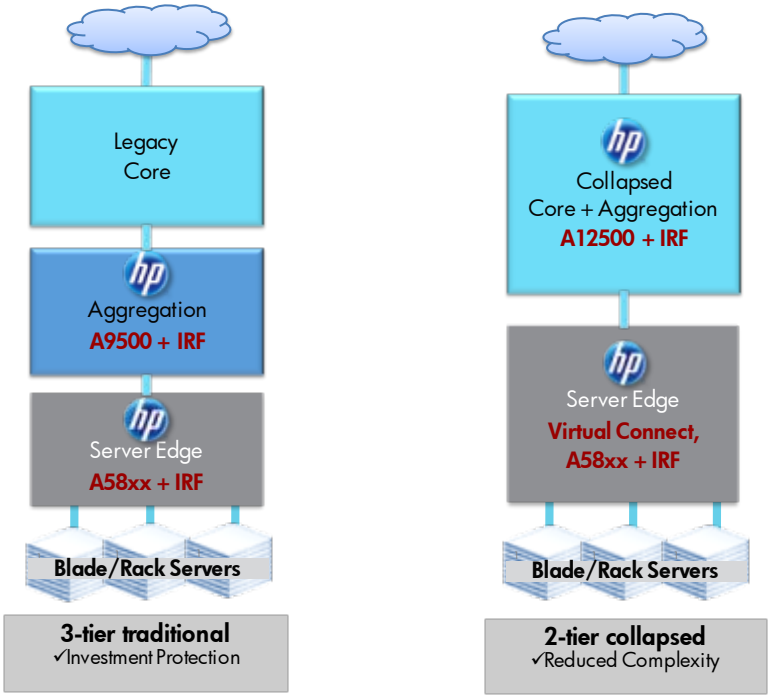
Bringing It Together: Flexible Network Designs

At the core to HP's approach to building data center networking solutions, HP Networking platforms are built using open-standards technologies and built to interoperate with the entire range of 3rd party server interfaces and standards-based switches and routers across Layer 2, Layer 3, IPv4, IPv6, MPLS, and VPLS protocol deployments. This ensures compatibility with existing network infrastructures and provides flexibility to integrate best-in-class 3rd-party capabilities.

HP offers flexible network designs to meet diverse customer requirements (figure 2). Customers looking to protect investments in legacy core infrastructures 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 protect existing investments 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.

With a more comprehensive approach focused on dramatically reducing complexity and providing enhanced scalability, HP can provide a solution that completely eliminates a dedicated aggregation layer: a two-tier collapsed network design. These designs provide for 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. Not only do these flat network designs ensure direct-flight server-to-server performance but they also dramatically reduce overall network port counts–since significantly fewer links have to be provisioned in the absence of an aggregation layer set of switches. A two-tier collapsed design also simplifies and streamlines network management, and reduces capital expense and energy consumption.

Figure 2: HP offers flexible network designs focused on investment protection and network simplification, agility and cost reduction



Emerging Solutions

Over time, the trend towards even larger-scale server virtualization solutions to increase flexibility and utilization, along with more extensive deployment of federated applications to provide more sophisticated end-user services will continue. These trends will expand the need for large-scale, more reliable Layer 2 networks and high-performance Layer 2-oriented inter-data center connectivity to support increased virtual server migration and escalating numbers of server-to-server connections.

Building on HP's current capabilities using IRF, Virtual Connect and traditional multi-site extension technologies, HP is taking active roles in both the IEEE and the IETF efforts to standardize new Layer 2 intra and inter-data center connectivity technologies, respectively 802.1aq SPB (Shortest Path Bridging) and TRILL (Transparent Interconnection of Lots of Links). These technologies will allow customers to build even larger-scale Layer 2 networks and enable multi-site extension using industry standards as the foundation. Both emerging technologies implement existing routing protocols at Layer 2 to provide full network utilization, fast network re-convergence and radically improved Layer 2 scaling. While SPB and TRILL use different approaches to address networking challenges that arise when scaling Layer 2 networks, the technologies will together provide a flexible set of tools to meet the requirement. HP's data center networking product and solutions portfolio will mature to bring these technologies to market in validated, standards-based offerings.

Securing the Virtual Server Edge

Server virtualization introduces a new 'virtual edge' that significantly impacts traditional network and server security systems and practices. Previously, database, application, and web-hosting workloads were deployed on discrete physical servers. Traffic flows between workloads were wholly-contained within a single physical server allowing straightforward, physical-network-based threat management using traditional intrusion prevention tools.

Server virtualization introduced the ability to host multiple workloads on a single physical server and initiated the concept of virtual switches (vSwitches) to facilitate intra-server communications. VMs can communicate directly with each other and pass traffic in a manner that never traverses the physical network fabric and is transparent to conventional security systems. Practically speaking, the virtualized nature of these intra-server communications makes applying security policies or monitoring the network very difficult. Existing security tools and practices built around physical servers and physical switches are unaware of these traffic flows.

Specifically, virtualization introduces a wide variety of new security challenges:

- Hypervisor security – new security procedures are needed to safeguard the VM hypervisor
- VM-to-VM threats – traffic moving from one virtual machine to another inside the same physical host is not visible to the external network, meaning the traffic cannot be subjected to security, QoS, management or mirroring policies.
- VM mobility – security policies must be preserved as VMs migrate from host to host within the data center
- Host-to-host threats – virtualization increases host-to-host communications. Cost-effective solutions are required to inspect and control server-to-server traffic. Deploying an IPS in front of every server is impractical.

HP Solutions: Unified Physical and Virtual Network Security

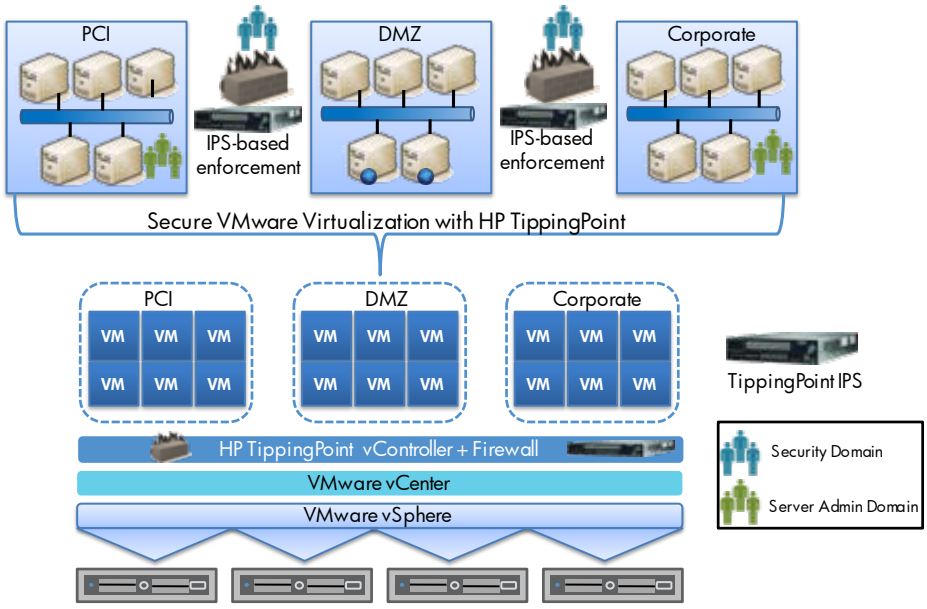
HP TippingPoint Secure Virtualization Framework

The HP TippingPoint Secure Virtualization Framework (SVF) extends HP's industry-leading TippingPoint security capabilities to virtualized data centers–delivering consistent, unified security across virtualized and physical domains, enabling enterprises to secure VM-to-VM as well as inter-server and inter-network traffic from a common platform. The solution streamlines administration and reduces operations expenses by centralizing and automating security management functions. Administrators define rich, infrastructure-wide security policies that are implemented across virtual machines and virtual switches in a transparent fashion. SVF brings best-of-breed TippingPoint intrusion prevention, threat mitigation and security management features to the virtual edge–safeguarding IT assets and preserving business continuity in today's on-demand, virtualized world. The framework provides a comprehensive architecture to address today's data center security needs while providing a seamless on-ramp to secure private, hybrid and public cloud computing.

As an integral component of SVF, vController and vController plus Firewall build upon more than a decade of HP TippingPoint's industry-leading Intrusion Prevention technology (figure 3). Taking an evolutionary approach to addressing virtualization-specific security challenges provides a practical solution for securing today's mixed physical and virtual data centers within a cloud-ready framework.

HP TippingPoint vController + Firewall, in conjunction with HP TippingPoint N-Series IPS platforms, provides the ability to extend existing security controls deep within the virtual infrastructure. By providing an industry-leading IPS and segmentation/zone firewalling, vController + Firewall ensures that the virtual infrastructure is equally secure, or more secure than its physical counterparts. Addressing virtualization-specific security challenges such as VM sprawl, rogue VMs, VMotion, patch management, templates and snapshotting, vController + Firewall provides purpose-built virtualization security controls.

Figure 3: vController + Firewall is purpose-built for virtualization and extends proven HP TippingPoint Intrusion Prevention Systems for physical/perimeter security to the virtual network domain



Network security controls within the virtual environment must address several broadly-recognized virtualization-specific security challenges. And while virtualization implications within data center environments are vast, organizational responsibilities and best practices for separating duties remain generally unchanged. vController + Firewall enables security teams to deploy, monitor and maintain security controls regardless of the underlying infrastructure, seamlessly bridging the gap between physical and virtual domains.

Perhaps the most commonly-discussed challenge is the 'air-gap' created when VMs on a common host are allowed to communicate via a shared vSwitch port group. This may, or may not, be a security risk depending upon the workload's (VM's) risk profile and/or network zone policies. However, as organizations move to consolidate workloads from different zones in a common virtual cluster or cloud, enforcing these network zones requires virtualization-specific security controls.

HP TippingPoint vController + Firewall is a hypervisor-aware VMsafe Loadable Kernel Module(LKM) that enables security teams to enforce IPS and stateful firewall policies to enforce network zones within the virtual environment. Network traffic flowing purely within the virtual environment can be monitored and proactively controlled, ensuring compliance with organizational security policies, thus eliminating the virtual network air-gap. Across the extended, multi-site enterprise VMotion and other virtualization capabilities such as cloning and templates require that security policies are 'sticky' to VMs regardless of location or operating state. vController + Firewall security policies are bound VMs, remaining intact and enforced throughout the VM's lifecycle or location.

HP TippingPoint Secure Virtualization Framework supports today's leading virtualization platform and network fabrics. Built for high demand virtualized data centers, vController + Firewall provides high-speed, low-latency IPS and firewall capabilities purpose-built for virtualization. Operating in the hypervisor, firewall allow and deny actions are enforced locally yielding ultra-high performance

operation. Layer 2 tunneling via VLAN Translation provides high-speed transport for IPS inspection off-loading to TippingPoint N-Series platforms. This greatly reduces the resources consumed on the virtual hosts for compute-intensive deep packet inspection. With flexible deployment options, vController + Firewall integrates with high-availability network fabrics and automated vSphere deployment provides streamlined installation and configuration of the virtual environment.

Integrated within the Secure Virtualization Framework, and included with vController + Firewall, is the HP TippingPoint Virtualization Management Center (VMC). VMC allows security teams to monitor and enforce security policies throughout the virtual environment. This enables integration of virtualization security within organizations' existing roles, responsibilities and best practices. Tightly integrated with vSphere, VMC provides real-time visualization of all vCenter managed virtual environments. With the ability to scale across multiple vCenter servers, VMC provides a single unified environment for efficiently managing security across the entire virtual environment. VMC provides the unique capability to define virtual security zones and policies using VMware attributes in addition to traditional Layer 2 and Layer 3 traffic attributes. This enables security teams to develop highly automated zones and policy definitions that adapt to the ever-changing virtual environment in real time.

These management solutions enable organizations to build security zones and policies based on VM and/or infrastructure attributes to enhance security and implement best practices for separating duties. Attribute-based definitions provide protection from accidental or malicious configuration changes that may otherwise create security vulnerabilities. And as a VMware Global Technology Alliance Partner, HP works closely with VMware to validate product integration and interoperability.

Emerging Solutions

While addressing today's virtual security challenges, SVF provides a comprehensive architecture and seamless on-ramp to securing private, hybrid and public cloud computing. As organizations look to leverage future cloud strategies, new solutions are required to safeguard hosted workloads and the data contained. While sharing many characteristics with today's virtual security solutions, future cloud security solutions must seamlessly integrate with the elastic nature of cloud environments. Cloud security solutions must support massive real-time scalability, fully automated stand-up/tear-down using self-service orchestration tools, multi-tenant layered policies and flexible reporting and chargeback. All of these capabilities must function equally well in private cloud and public cloud scenarios. Furthermore, to maximize the benefits of a flexible and elastic cloud strategy, future cloud security solutions must operate uniformly across hybrid hypervisor environments.

As the world's leading Information Technology company, HP is committed to building upon the SVF architecture to anticipate, enable and accelerate future cloud computing strategies.

Managing and Provisioning the Virtual Server Edge

As described in the previous section, server virtualization introduces a new virtual edge that blurs the traditional demarcation between network and server administration. Previously, the network edge was defined as the point where the server connected to the switch, with servers statically deployed with a single operating system and a set of interfaces. With virtualization and the insertion of vSwitches in the server, system administrators now have greater ability to control, configure and manage server connectivity. Most importantly, since administrators can easily migrate virtual servers between physical servers the tools for managing connections to workloads must evolve to be more agile and accommodating of the dynamic nature of the environment.

Managing an increasingly virtual data center has become a daunting task for data center managers. Managing the assignment and allocation of highly dynamic and mobile virtual servers across physical and virtual networks has added tremendous complexity to overall data center network operations and administration. The configuration of servers, virtual machines and physical and virtual networks (vSwitches) can often be complex and difficult to coordinate across IT staff. Server adds, moves and

changes can be time-consuming and error-prone. The lack of a single pane view of the virtual and physical network infrastructure makes troubleshooting difficult if not impossible.

In summary, virtualization introduces a host of new network management challenges and requirements:

- Configuring servers, virtual machines and physical and virtual switches is a complex, time-consuming undertaking requiring coordination between network and server teams
- Implementing adds, moves and changes is a manual, error-prone process involving multiple applications and data center teams
- Isolating and resolving problems is an arduous process involving multiple management systems with overlapping functionality

HP Solutions: Unified Physical and Virtual Network Management

HP Intelligent Management Center

HP Intelligent Management Center (IMC) unifies physical and virtual network management and helps IT overcome the challenges of 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 boosts network availability. Capabilities include the following:

- 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 a single pane of glass and accelerate the delivery of new applications and services by automating configuration of virtual and physical network infrastructure.

Emerging Solutions

In an effort to provide a more explicit, accessible and robust infrastructure for managing connectivity at the virtual network edge HP has co-authored the IEEE Virtual Ethernet Port Aggregator (VEPA) proposal. VEPA aims to provide multi-vendor, standardized discovery, configuration and forwarding for virtual switching. 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. By embracing standards-based solutions HP offers customers greater choice and flexibility in virtualization vendors and approaches.

HP will continue to evolve its data center network management tools using VEPA in conjunction with IMC to provide a holistic foundation for enabling efficient provisioning of virtual server edge connectivity. To further integrate physical and virtual management and streamline day-to-day network operations HP will bring these tools into closer alignment with an end-to-end data center orchestration framework. HP's vision for policy-driven, automated and end-to-end network provisioning will drive even higher levels of technology and business agility. This approach will let customers define a catalog of network connections, seamlessly integrated into data center-wide orchestration—to deliver

network connectivity quickly and efficiently, and optimize those connections as virtual servers migrate and change.

Converged Network Infrastructure: Unifying Data and Storage Networks

With the proliferation of virtualization and the escalating demand for communication and storage performance, I/O sprawl has IT at the breaking point. The traditional model of completely parallel, autonomous data and storage networks with dedicated interface cards, switches and cabling plants can be costly and inefficient. Enterprises are looking to consolidate server and storage connectivity to reduce equipment and operations expenses, eliminate clutter and complexity and make more efficient use of shared networking resources while ensuring continuity of service.

HP Solutions: Pragmatic Network Convergence

HP takes a pragmatic approach to converging data center networks that allow customers to adapt an evolutionary strategy–one that yields the most benefits over time, in keeping with continued maturation of related convergence technologies and the need to ensure continuity of operations. In this approach, customers start by leveraging the compelling simplicity of Fibre Channel over Ethernet (FCoE) technology at the server edge to consolidate server and storage network I/O and gradually transition to end-to-end convergence as FCoE (and Converged Enhanced Ethernet–CEE) protocols mature and become more practical. Complementing other widely-implemented Ethernet-based networking technologies such as Network-attach storage (NAS), Direct-attached storage (DAS) and iSCSI, HP Networking offers FCoE-based solutions that provide customers even greater flexibility to meet varying storage networking demands.

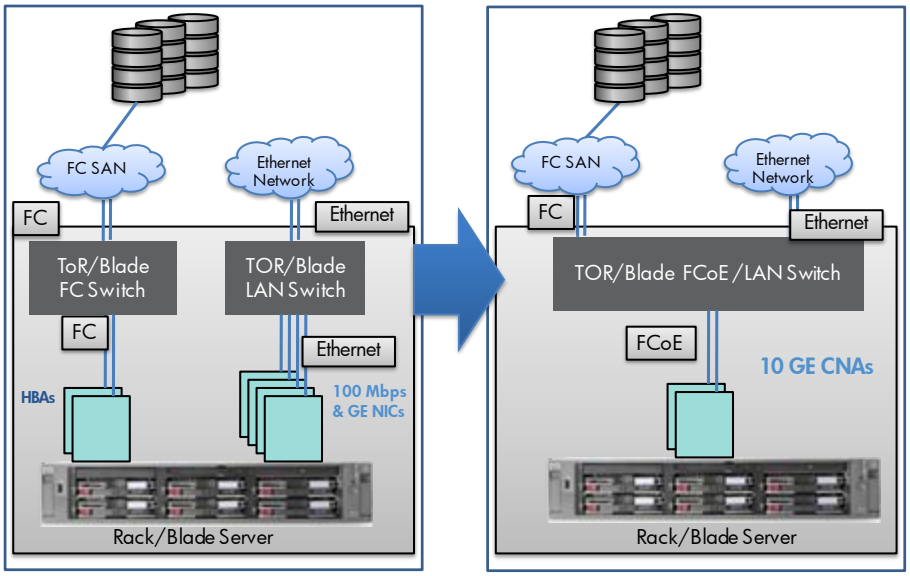
I/O Consolidation with FCoE/CEE: Virtual Connect FlexFabric Modules, HP A-series ToR Switches

With HP A-Series Top of Rack (ToR) data center switches and Virtual Connect FlexFabric modules enterprises can consolidate LAN and SAN I/O connectivity onto a common FCoE server edge fabric within the rack while preserving and protecting investments in extended LAN and SAN infrastructures. This approach allows customers to remove expense and complexity, and improve network performance without impacting the installed LAN/SAN infrastructure or disrupting existing management practices.

Advantages and benefits include the following:

- **Eliminate cost and complexity –** consolidate switches and modules, simplify cabling, save rack space, reduce power and cooling costs
- **Maintain business continuity –** preserve existing LAN/SAN infrastructure and management systems and avoid wholesale equipment replacement
- **Provide a path to boosted network performance –** replace 100M/GbE NICs and 2/4 GBps HBAs with 10GbE CNAs
- **Protect investments –** open, standards-based solution works with any SAN vendor and supports FC and iSCSI SANs

Figure 4: HP I/O consolidation deployments using FCoE reduce cost and complexity while ensuring operational continuity



Before

- 6-8 NICs/HBAs per server
- Design/cabling complexity, rack space
- Low performance (100M/GE, 2/4 Gbps FC)
- High cost (switches, power)

I/O Consolidation

- 1-2 CNAs per server, reduced cabling
- High performance (10GbE/8G FC)
- Lower CAPEX, SAN agnostic
- Keep current SAN/FC mgt in place

Emerging Solutions

HP has played a key role in driving FCoE and the set of emerging CEE standards in the IEEE and IETF. By committing to delivering proven, standards-based solutions, HP Networking products give customers a seamless path to data center network consolidation that delivers convergence within the rack today, and provides an orderly migration to a fully converged LAN/SAN infrastructure as FCoE and CEE gain maturity in the market and become commercially available across the full spectrum of data center products.

In addition to having the potential to reduce complexity at the network edge, FCoE also promises to reduce equipment costs beyond the access layer by enabling convergence in the extended network. However, given the critical nature of storage networking and its central importance to the integrity of the end-to-end data center architecture, customers should carefully evaluate the implications of these solutions when considering more extensive FCoE deployments.

Beyond the network infrastructure itself, management solutions have also evolved over time to help SAN administrators monitor, manage, and troubleshoot traditional, dedicated Fibre Channel storage networks. Comparable tools for isolating and explicitly managing storage-specific traffic flows within a shared Ethernet-based infrastructure are critical for ensuring storage performance and continuity of operations in an end-to-end converged network.

A completely unified, end-to-end shared infrastructure built to transport server and storage traffic over a common Ethernet-based network also requires much more stringent maintenance and upgrade practices as these activities now have the potential to affect ALL traffic in the data center. This inherent risk will be mitigated over time with the advent of mature, tested solutions based on ratified industry standards that yield robust, fault-tolerant network designs and assured operations. In the interim, a 'common but separate' approach–where customers continue to deploy separate extended server and storage networks using common, FCoE-enabled networking building blocks–will allow customers to

enjoy the incremental cost savings of Ethernet-based technologies deployed uniformly across both network infrastructures. This approach can also simplify operations by enabling common equipment sparing and unified Ethernet network-based management tools.

In a common but separate model, storage networks can be independently designed and tuned to address unique storage traffic patterns, giving storage network designers more freedom to manage network congestion compared to a completely shared network infrastructure. The end result is reduced risk and management complexity in the short term with a solid foundation for transitioning from dedicated Fibre Channel–based networking to Ethernet-based networking over the long term.

As FCoE-based solutions continue to evolve, so too will a wider array of Ethernet-based storage networking technologies. Customers should carefully characterize consolidation/simplification opportunities and consider FCoE alongside NAS, DAS and iSCSI as potential viable approaches. In those instances where FCoE is a good choice, HP recommends customers start at the server edge where the real-world savings are most substantial and then extend the solution over time. An evolutionary approach reduces cost and complexity in the near term while maintaining continuity of operations and maximizing investments over the long haul.

Summary

The fundamental nature of data center computing is rapidly changing. Today's data center networks must evolve to support tomorrow's on-demand, virtualized IT environments. HP delivers the foundation for the data center of the future, today, by providing a unified, virtualization-optimized infrastructure. HP Networking solutions enable the following:

- Breakthrough cost reductions by converging and consolidating server, storage and network connectivity onto a common fabric with a flatter topology and fewer switches
- Predictable performance and low latency for bandwidth-intensive server-to-server communications
- Improved business agility, faster time-to-service and higher resource utilization by dynamically scaling capacity and provisioning connections to meet virtualized application demands
- Removal of costly, time-consuming and error-prone change management processes
- Modular, scalable, industry standards-based platforms and multi-site, multi-vendor management tools to connect and manage thousands of physical and virtual resources from a single pane of glass

To learn more about how the HP Networking can help your business enjoy the benefits of a Converged Infrastructure, please contact your HP account manager or reseller.

HP Networking Services

HP offers a comprehensive set of network services to help design, deploy, integrate, manage and support your next-generation connectivity and communications environment. HP Services for Data Center Transformation can help you simplify, optimize and integrate your existing facilities and implement a next-generation data center that is efficient, virtualized and highly available. Contact your HP account manager or reseller to find out how HP Networking Services can help you implement an automated, high-performance data center network.

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