Building Virtualization-Optimized Data Center Networks

HP’s Advanced Networking Solutions Meet the Stringent Performance, Scalability and Agility Demands of the new Virtualized Data Center

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Executive Summary

Server virtualization initiatives are reshaping data center traffic flows, increasing bandwidth densities at the server edge and pushing conventional data center networks to the brink. Hierarchical data center networks designed to support traditional client-server software deployment models can’t meet the performance and scalability requirements of the new virtualized data center. Enterprises must implement flatter, simpler networks to support high-volume server-to-server traffic flows, and they must adopt new management systems and security practices to administer virtual resources and enable on-demand services. HP networking solutions let enterprises build flatter and more efficient data center networks with fewer layers, less equipment and cabling, and greater port densities to address the escalating performance and scalability demands of the virtualized data center, along with advanced security and management capabilities to unify security and administration across virtualized and physical resources.

This white paper reviews the impact of server virtualization on the data center and describes HP’s approach to building simpler, more secure and automated networks that fully meet the stringent performance, availability and agility demands of the new virtualized data center.

Contemporary Data Center Networks

Most contemporary data center networks are based on three-tier architectures designed to support conventional “north-south” client-server traffic flows in and out of the data center. A typical three-tier data center network is comprised of an access tier, an aggregation tier and a core tier (figure 1). The access tier is made up of cost-effective Ethernet switches connecting rack servers and IP-based storage devices (typically 100 Mbps or 1GbE connections). The access switches are connected via Ethernet to a set of aggregation switches (typically 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 and aggregation tiers, 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 system.

Figure 1: Customary three-tier data center network architecture.
Next Generation Data Center Network Drivers

Several trends are driving the requirement for next-generation data center networks that offer greater performance, scalability and resiliency. Enterprises are deploying new software application architectures and service delivery models to improve productivity and business agility, and leveraging innovations in server technology to reduce OPEX and CAPEX. The implementation of federated applications and on-demand service delivery models and the adoption of blade servers and server virtualization solutions are reshaping data center traffic flows, increasing bandwidth densities at the server edge and pushing contemporary data center networks to the limit. Trends impacting existing data center networks include the following:

- **Adoption of new software application architectures**: Traditional client-server software deployment models are being displaced by peer-to-peer applications. Web 2.0 mashups, SOA solutions and other federated applications are introducing high-volume server-to-server traffic flows within the data center (figure 2). Conventional data center networks optimized to enable traffic in and out of the data center can’t accommodate the influx of intra-data center traffic.

**Figure 2**: North-South traffic flows are giving way to East-West traffic flows.
• **Advancements in server technology:** The adoption of increasingly-powerful multi-core-processor servers, higher-bandwidth interfaces, and blade servers is increasing connection densities and escalating bandwidth requirements at the server edge (figure 3). Access switches need to support growing numbers of 1GbE and 10GbE downlinks as well as 40/100GbE uplinks as more and more compute resources are packed into the rack.

**Figure 3:** Blade servers are increasing bandwidth demands and connection densities at the server edge.

* Assumes 10 VMs/Server, 300 Mbps/VM

• **Advent of server virtualization:** Server virtualization is altering data center traffic flows and impacting existing security and management practices. High-volume VM-to-VM traffic flows demand low-latency, high-throughput server-to-server connections (figure 4). New management tools are needed for administering virtual machines, and configuring virtual switches and virtual connections on the fly. New security solutions are required to safeguard intra-server communications and protect virtual resources.

**Figure 4:** VMotion/Live Migration requires low-latency, high-throughput server-to-server connectivity.
Virtualization-Optimized Data Center Network Requirements

Enterprises must evolve their networks to meet the performance, scalability and agility demands of the new virtualized data center. Next generation data center network requirements 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. Server-to-server traffic is forced to traverse multiple layers of switches, and each switch adds latency to the connection (figure 5). Enterprises must implement flat, low-latency networks to accommodate delay-sensitive, volume-intensive east-west traffic flows.

  
  
  **Figure 5**: 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. Enterprises must seek 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 the stringent availability and performance demands of the new virtualized data center.

- **Large layer 2 domains**: VM migration (VMotion/Live Migration) is driving the requirement for large-scale layer 2 domains so VMs can be moved seamlessly across servers without impacting applications or users.
- **Higher bandwidth at the server edge:** The adoption of blade servers and the implementation of server virtualization technology are increasing bandwidth demands at the server edge. Blade servers pack more and more computational power into smaller and smaller form-factors—increasing server edge port utilization. Virtualization solutions enable multiple virtual machines on a single server driving more and more traffic in and out of a given server. Enterprises must increase bandwidth and port densities at the server edge to accommodate the expanding traffic demands.

- **Unified management:** Server virtualization introduces a new “virtual edge” that blurs the traditional demarcation between network and server administration and complicates provisioning and troubleshooting tasks. Server administrators can now create workloads on-demand in response to rapidly changing business conditions. Network administrators need new tools to enable virtual connections and manage policies quickly, reliably and efficiently as VMs migrate across the data center.

Figure 6: Server virtualization introduces a new virtual edge that is beyond the scope of existing administrative systems and practices. New tools are required for managing VMs, virtual switches and virtual connections.

- **Virtualization-aware security:** The new virtual edge is beyond the scope of existing security systems and practices. In contemporary data centers, distinct workloads (database, application, Web-hosting) are carried out on discrete physical servers. Workload-to-workload communications always occurs over physical connections and can be secured using conventional intrusion prevention tools (figure 7). With server virtualization, workloads can communicate over virtual connections within the same server in a manner transparent to existing network-based intrusion prevention systems. Enterprises must implement new “virtualization-aware” security solutions to police intra-server communications flows and protect virtual resources.
**Figure 7:** Conventional security tools and practices built around physical servers and physical switches can’t safeguard intra-server, workload-to-workload communications.

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**HP Virtualization-Optimized Data Center Networking Solutions**

HP provides a comprehensive collection of switching, security and management solutions that fully address the stringent performance, scalability and agility demands of the new virtualized data center. HP A-Switch Series enables the construction of flat, low-latency networks with fewer layers, less equipment and cabling, and greater port densities. The HP TippingPoint Secure Virtualization Framework (SVF) unifies security across virtualized and physical domains, safeguarding VM-to-VM, server-to-server, and inter-network traffic. The HP Intelligent Management Center (IMC) 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.

**Flat Low-latency Network Designs: A-Switch Series and IRF**

HP Ethernet A-Switch Series and innovative Intelligent Resilient Framework (IRF) technology enable flat, low-latency network designs to support federated applications and server virtualization imperatives. In addition, A-Switch Series offer industry-leading server edge port density to meet the escalating bandwidth demands that accompany server virtualization and blade server deployments.

**HP Ethernet A-Switch Series**

HP 12500 A-Switch Series leverages 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 6.66 Tbps 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 58xx ToR A-Switch Series leverages 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 8). 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 the high-volume server-to-server traffic flows.

Figure 8: High performance server-to-server connectivity: HP ToR A-Switch Series with IRF for Rack Servers; HP Virtual Connect for Blade Servers.

For traditional top-of-rack server edge installations, HP 58xx ToR A-Switch Series 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 blade server deployments, HP Virtual Connect for the HP BladeSystem c-Class portfolio 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.
Collapsed Two-tier Data Center Network Architecture

In the core of the network, HP 12500 A-Switch Series can be deployed in conjunction with IRF to completely eliminate the aggregation layer found in conventional three-tier data center networks (figure 9). 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 10).

**Figure 9:** 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).
Virtualization-aware Security: Secure Virtualization Framework

HP TippingPoint Secure Virtualization Framework (SVF) enables 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 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. 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.

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 11). 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.

**Figure 10:** IRF overcomes STP limitations dramatically improving network utilization and performance in the network core.

- **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)
Unified Virtual and Physical 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:

- 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 new applications and services by automating the configuration of virtual and physical network infrastructure.
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 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 protect intra-server communications flows and virtual resources.
- Unified administration to remove costly, time-consuming and error-prone change management processes and improve business agility
- 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 virtualization-optimized data center network, please contact your HP account manager or reseller.
For More Information

HP FlexFabric
HP FlexFabric white papers and videos
hp.com/go/flexfabric

HP A-Switch Series
HP A-Switch Series data sheets and product details

HP Intelligent Resilient Framework
HP IRF White Paper—Reducing network complexity, boosting performance with HP IRF technology

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4AA3-3346ENW, Created February 2011; Updated June 2012, Rev. 1