OPTIMIZING NETWORK INFRASTRUCTURES FOR VIRTUALIZATION

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To help meet the growing bandwidth demands of multi-core architectures and server virtualization, Dell, Intel, and VMware have collaborated to develop virtualization solutions built on Dell™ PowerEdge™ servers, Intel® Xeon® processors and 10 Gigabit Ethernet adapters, and VMware® ESX software. Utilizing Intel Virtual Machine Device Queues (VMDq) and VMware NetQueue technology, these solutions can enhance performance, increase flexibility, and simplify management in virtualized environments.

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Data centers and other enterprise IT environments are facing exponential growth in their business requirements and service-level agreements. In the past, IT departments may have deployed dedicated physical servers to help reliably support critical applications. As an organization's data needs grow, however, this approach can become increasingly costly and complex. Running dedicated physical servers at utilization levels significantly below their capacity, for example, drives up power consumption as well as the costs of maintaining the servers and the infrastructure to support them—including cooling systems to handle heat output and the physical space to house servers, storage, and networking equipment—and requires administrators to manage an increasingly complicated environment as the number of systems grows. Running multiple applications on individual servers, meanwhile, can rapidly become difficult to manage and potentially unreliable, and can leave applications battling each other for network bandwidth.

Virtualization provides a key way to overcome these challenges. By enabling organizations to run multiple virtual machines (VMs) on a single physical server, IT administrators can consolidate their systems onto a reduced number of physical platforms, increasing processor utilization to make efficient use of available resources while still maintaining the management and reliability advantages of isolated applications. This approach not only helps reduce the costs of physical hardware and infrastructure, but also helps simplify management and provide flexible, dynamic load balancing of workloads across multiple physical servers.

Combining consolidation with the need to access large amounts of data, however, has also made high-bandwidth, high-performance networks a critical requirement in enterprise data centers. Dell, Intel, and VMware have worked together to create collaborative virtualization solutions based on 10 Gigabit Ethernet (10GbE) technology and optimized for powerful multi-core processors. By deploying key technologies such as Intel Virtual Machine Device Queues (VMDq) and VMware NetQueue on Dell PowerEdge servers with multi-core Intel Xeon processors and 10GbE adapters, enterprises can implement optimized, high-performance virtualized environments designed for simplified management and flexible resource utilization.

10 GIGABIT ETHERNET HELPS MEET INCREASING BANDWIDTH DEMANDS

Both data-intensive applications and the ever-increasing amount of data stored on enterprise networks are driving up the need for high levels of I/O performance and network bandwidth. In addition, as powerful multi-core processors enable each server to support an increasing number of VMs, the need for bandwidth to support those VMs and avoid network I/O bottlenecks also increases.

10GbE has become the medium of choice to help meet the ever-increasing need for high performance in virtualized environments. It can provide reliable links in ranges from 30 m to 300 m depending on the specific cabling medium. When deployed as part of the network infrastructure in a virtualized server environment, 10GbE helps provide the bandwidth and performance to support more VMs per server than would be possible with a standard Gigabit Ethernet infrastructure. By doing so, it also enables high consolidation ratios to help organizations maximize the advantages of virtualization on servers with multi-core processors, helping reduce overall power consumption, heat output, and hardware footprint.

VIRTUALIZATION TAKES ADVANTAGE OF MULTI-CORE PROCESSORS

Non-virtualized servers are relatively simple from a networking perspective: the processor communicates with the OS, which communicates with the adapter. The one-to-one relationship between the server and processor helps minimize the complexity of directing network traffic to and from the system.

Virtualized servers, in contrast, introduce additional complexities, because an individual host server now supports multiple independent VMs: servers with multi-core processors, for example, may assign multiple cores to a single VM, a single core to each VM, or multiple VMs

to each core. The dynamic nature of virtualized environments—in which VMs may migrate across different host servers to help provide load balancing and high availability—only adds to this complexity.

Adding a VMware ESX hypervisor on top of multi-core Intel Xeon processors enables enterprises to maximize the advantages offered by multiple cores while helping efficiently handle the specific needs of virtualized environments. The VMware ESX layer, for example, enables each VM to run on its own core, with the ESX software managing the network traffic to each VM (see Figure 1).

Managing traffic at the hypervisor level, however, comes at the cost of additional processor overhead, which can reduce overall performance. The collaborative virtualization solutions from Dell, Intel, and VMware are designed in part to address this problem, enabling enterprises to take advantage of the benefits of virtualization on multi-core processors while minimizing the overhead associated with network traffic management.

COLLABORATIVE SOLUTIONS HELP OPTIMIZE VIRTUALIZED ENVIRONMENTS

Through strong, long-standing collaboration, Dell, Intel, and VMware have developed virtualization solutions designed for high levels of performance, efficiency, and flexibility as well as simplified management. Based on Dell PowerEdge server models 6850, 1950, 2950, 2970, 6950, R900, and R905 with multi-core Intel Xeon processors; Intel 10GbE adapters with Intel Virtualization Technology for Connectivity (Intel VT-c); and VMware ESX software, these solutions integrate advanced technologies such as Intel VMDq and VMware NetQueue to help optimize performance and simplify management in virtualized environments.

Intel 10GbE adapters are designed to provide several key advantages as part of virtualized environments based on Dell PowerEdge servers with multi-core Intel Xeon processors and VMware software. Their advanced networking features help efficiently distribute networking workloads across multiple processor cores,
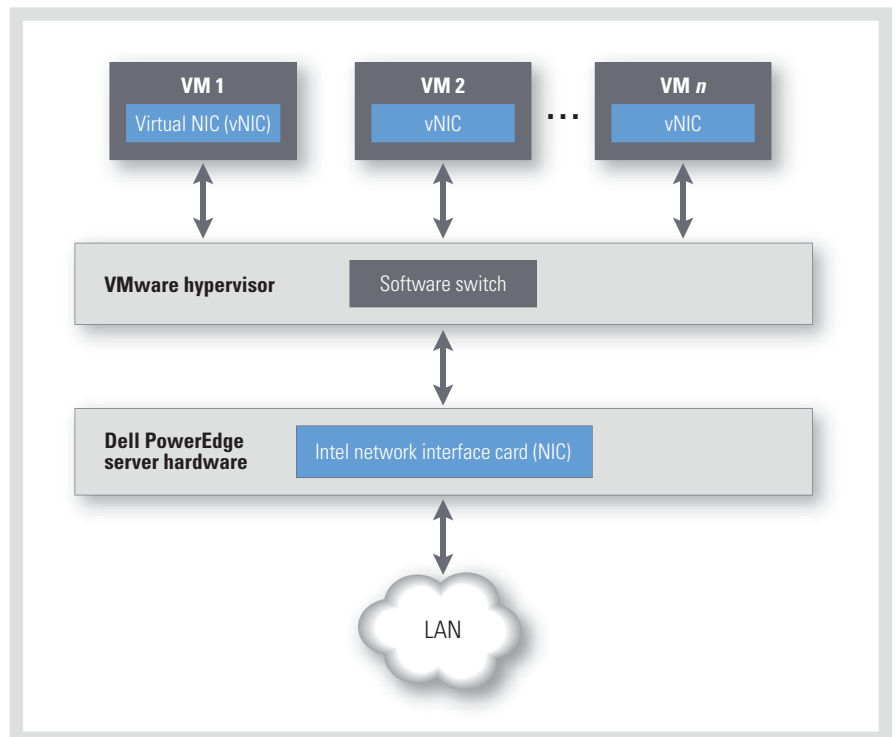

Figure 1. *In typical virtualization environments, the hypervisor manages network traffic to each virtual machine*

while their support for multiple queues helps alleviate I/O bottlenecks on servers hosting multiple VMs.

Intel VT-c, supported in Intel 10GbE controllers, is a set of virtualization-specific enhancements designed to accelerate network I/O performance and reduce processor utilization. Intel VT-c incorporates two key technologies that help reduce latency, accelerate I/O throughput, and offload network overhead tasks for virtualized servers: Intel I/O Acceleration Technology (Intel I/OAT) and Intel VMDq. Using Intel 10GbE adapters that support these features in combination with the VMware NetQueue technology in VMware ESX 3.5 Update 1 enables organizations to enhance performance across platforms, optimize network traffic management in virtualized servers, and efficiently balance adapter workloads.

Figure 2. *Intel VMDq technology offloads network I/O data sorting from the hypervisor to the network silicon to enhance I/O performance*

Intel I/O Acceleration Technology enhances performance across platforms

Intel I/OAT is a suite of features that helps enhance data acceleration across a platform—including the network adapters, memory, and chipset—independent of the specific OS on the server. It includes features such as checksum and segmentation offloads, Message Signaled Interrupts Extended (MSI-X), receive-side scaling, receive-side coalescing, Intel QuickData Technology, low-latency interrupts, and more.

Available on Dell PowerEdge servers with dual-core and quad-core Intel Xeon processors, Intel I/OAT is designed to both enhance I/O traffic across an entire platform and increase network scalability seamlessly across ports in Intel 10GbE adapters. These features also help improve I/O performance in VMware virtualized environments, although currently only a subset of features—such as MSI-X and checksum and segmentation offload—are supported for use with VMware software.

Intel Virtual Machine Device Queues optimize network traffic

Intel VMDq technology is a key element in virtualized environments based on Dell PowerEdge servers with multi-core Intel Xeon processors, Intel 10GbE server adapters, and VMware ESX software. It is designed to offload data packet sorting from the hypervisor to the network silicon, helping optimize performance in virtualized environments by releasing processor cycles for application processing rather than network I/O processing to make efficient use of available resources (see Figure 2).

VMDq technology offloads the data sorting functionality to the network silicon and sorts the data packets to the respective queues based on Media Access Control (MAC) addresses and/or virtual LAN tags. Each queue is typically associated with an individual VM. The network controller transmits the queued packets to the wire using a round-robin service, which minimizes head-of-the-line blocking
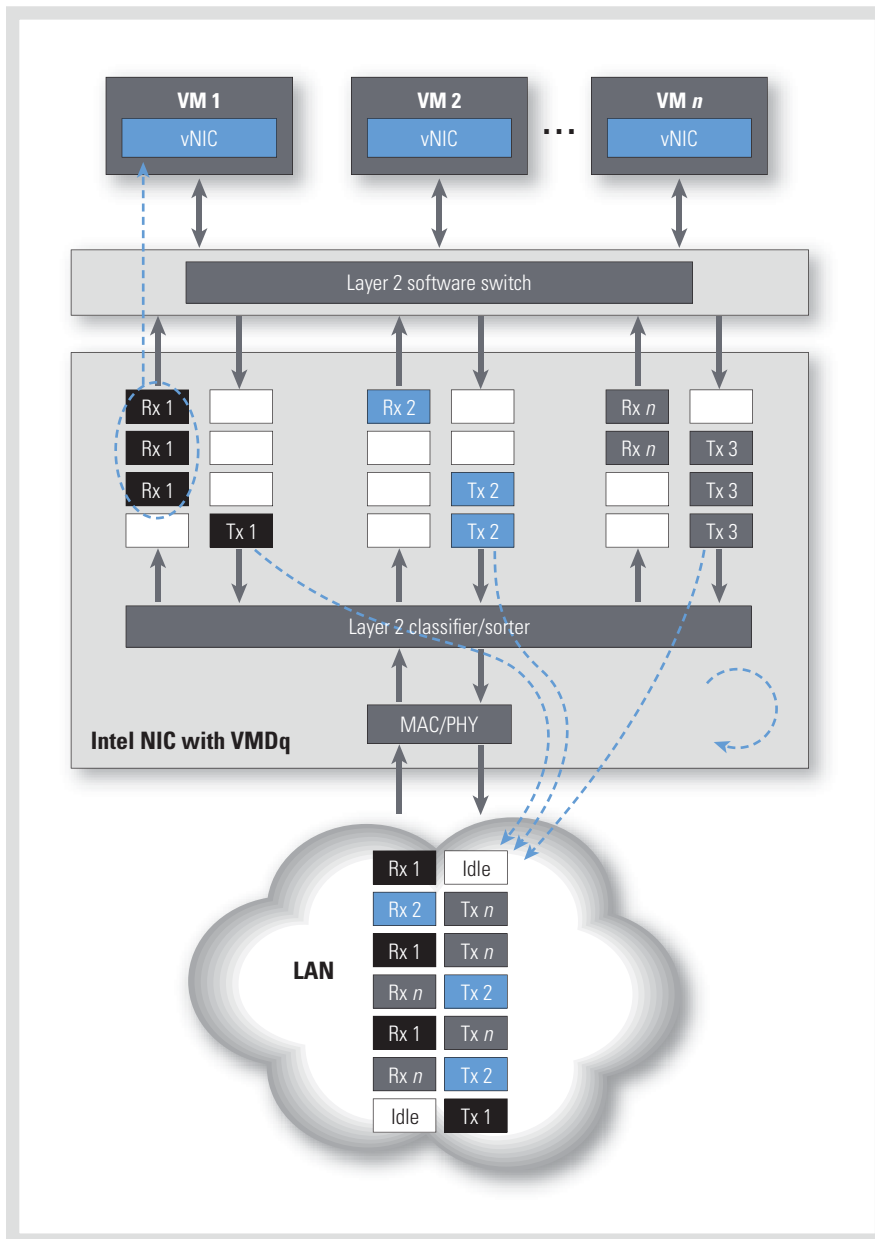
and helps ensure sufficient quality of service for each VM.

Using Intel VMDq in conjunction with VMware NetQueue can help dramatically increase network I/O performance in virtualized environments. In tests using the NTttcp benchmark and a standard frame size of 1,500 bytes, the addition of VMDq more than doubled the throughput on a virtualized platform using VMware ESX 3.5 Update 1, from 4.0 Gbps to 8.8 Gbps (see Figure 3).[1]

Figure 3. *Intel VMDq technology helps dramatically increase network I/O performance in virtualized environments*

VMware NetQueue efficiently balances adapter workloads

Intel and VMware have collaborated to enable their respective queuing technologies to work together in a virtualized ecosystem, and using Intel VMDq technology with the VMware NetQueue technology in VMware ESX 3.5 Update 1 helps significantly improve I/O performance in 10GbE-based virtualized environment. VMware NetQueue uses MSI-X to help affinitize the data interrupts to a specific processor that is associated with individual VMs. Combining this feature with Intel VMDq provides efficient packet routing and helps maximize the advantages of multi-core architectures.

DELL, INTEL, AND VMWARE PROVIDE OPTIMIZED VIRTUALIZATION

Virtualized infrastructures built on powerful Dell PowerEdge servers with multi-core Intel Xeon processors, high-throughput Intel 10GbE adapters with VMDq technology, and VMware ESX software with VMware NetQueue technology can maximize the advantages of virtualization and multi-core architectures in enterprise IT environments. The collaborative virtualization solutions developed by Dell, Intel, and VMware can help organizations deploy virtualized environments designed for high levels of server and network performance, flexible and dynam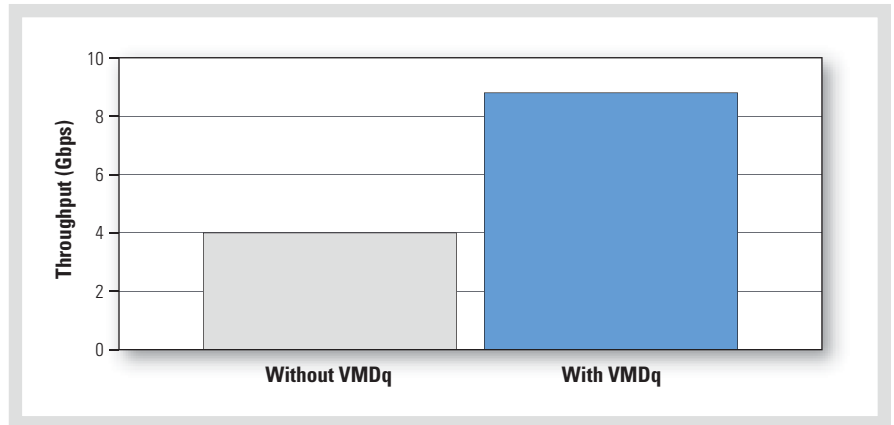ic workload management, efficient resource utilization, and simplified management to help meet the demanding requirements of critical enterprise applications. ⏻

Shefali Chinni is the marketing manager for I/O virtualization technologies and future Gigabit Ethernet silicon at Intel. Before joining Intel, she held various product marketing management and strategic planning positions at Hewlett-Packard, where she was responsible for managing a diverse portfolio of software, hardware products, and virtualization technologies. Shefali has an M.B.A. in Marketing from Osmania University.

Carl Hansen is the senior product manager for the original equipment manufacturer line of Intel Ethernet adapters with the Intel LAN Access Division. Carl has been with Intel for 12 years and has been responsible for a number of carrier-grade and enterprise products. Before joining Intel, he was a product manager at WordPerfect and Novell. He has a B.A. from the University of Colorado.

Bill Henderson is a staff systems engineer on the Dell Alliance team at VMware working as a technical alliance manager. Before joining VMware, he worked at Dell for 7 years in the Enterprise Product Group in various engineering and engineering management roles. He has an M.S. in Management, Computing, and Systems from Houston Baptist University.

Nelson Stewart is a storage and networking product manager for enterprise NICs and blade server I/O, and has over 29 years of experience in the computer industry. Before joining Dell, he was a product manager for embedded SAN switches at Brocade, served as a key member of Hewlett-Packard's BladeSystem Business team focused on increasing worldwide customer adoption and promoting industry-wide blade products and technologies, and was involved in various other roles over the course of more than 17 years at Compaq/Hewlett-Packard.

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[1] Based on tests performed in July 2008 by Intel using a Dell PowerEdge 2950 server with quad-core Intel Xeon X5460 processors at 3.16 GHz, 8 GB of RAM, and an Intel 10GbE XF SR dual-port server adapter running VMware ESX 3.5 Update 1 with VMware NetQueue technology, supporting eight VMs running the Microsoft® Windows Server® 2003 OS.