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Virtualization Enters the Mainstream

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Deploying Dell iSCSI Storage with VMware Infrastructure 3

Streamlining Virtualization Management Using Microsoft System Center and Dell OpenManage

Hosting and Managing Virtual Machines with XenSource XenEnterprise 3.2 Paravirtualization Features

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August 2007

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By Jeanne Feldkamp, Deb McDonald, and Tom Kolnowski

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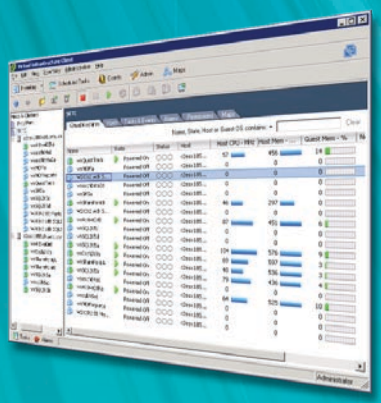

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Now Playing: Dell Datacenter of the Future Podcast Series

When planning a virtualized server environment, many businesses don't realize how complex it can be to address the storage component. Why? Because there is so much data in so many places. "Improving Storage in a Virtualized Server Environment" explores how iSCSI factors into the equation with cost-effective, easy-to-manage connections that enhance virtual machine mobility. For more information, visit www.dell.com/podcast.

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Virtual Tools of the Trade

Tom Kolnowski
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In the *Dell Power Solutions* editorial offices, we take our artwork just as seriously as we do the words on each page. And our front cover is generally among the most time-consuming and intricately detailed pieces of art we produce for each issue. We use an entirely digital process to produce the magazine, but small fragments of our process are decidedly old-school. For example, cover artwork design begins with a series of concept sketches that play off the editorial content in the feature section. These sketches are hand drawn by our art director using low-tech vellum paper and pencil.

In the cover design session for this issue, we settled on the black-and-white concept shown above, with its flowing stream effect in the background and roughed-in foreground rectangles that would become virtual machines (VMs) in the final rendering. At this stage, the tool sets make an about-face toward the digital domain for rendering in the Adobe® Creative Suite. But wait: We determined the need for approximately a dozen VM screen images to reinforce the desired concept of virtualized enterprise applications entering the mainstream. In the recent past, capturing images such as these usually dictated an old-school trip by automobile—with Dell™ Latitude™ notebook and USB keys in tow—to a remote site that hosts the labs of our sister organization, the Dell Enterprise Technology Center, or TechCenter. Once inside the labs, we would navigate a complex labyrinth of KVM (keyboard, video, mouse) switches and connect to the desired Dell PowerEdge™ server, capture the needed images, and repeat as necessary.

Enter virtualization. For this issue, we remotely connected to the TechCenter lab directly from our editorial offices, and attached to an exceedingly well-stocked VM farm. Through the VMware® VirtualCenter tool, we pointed and clicked our way to the hosted VMs running the business applications, management tools, and operating systems we needed for the cover art and easily captured the requisite images. What's more, VMs that were in a powered-down state in VirtualCenter were booted to life in moments via a right-click on the "Power On" command. Virtualization is sweet, and the cover art progressed quickly from an Adobe Photoshop® file to a final high-resolution, press-ready PDF created with Adobe InDesign® software.

If your organization has not looked seriously at server virtualization, now is the time. Our cover story, "Virtualization Enters the Mainstream," starting on page 10, provides insight into how standards-based server virtualization is changing the tides of IT with efficient cost-benefit models enabled by reduced infrastructure costs, simplified management, and unprecedented business response. We hope you find value in the cover story, as well as the additional 12 articles on virtualization that follow it.

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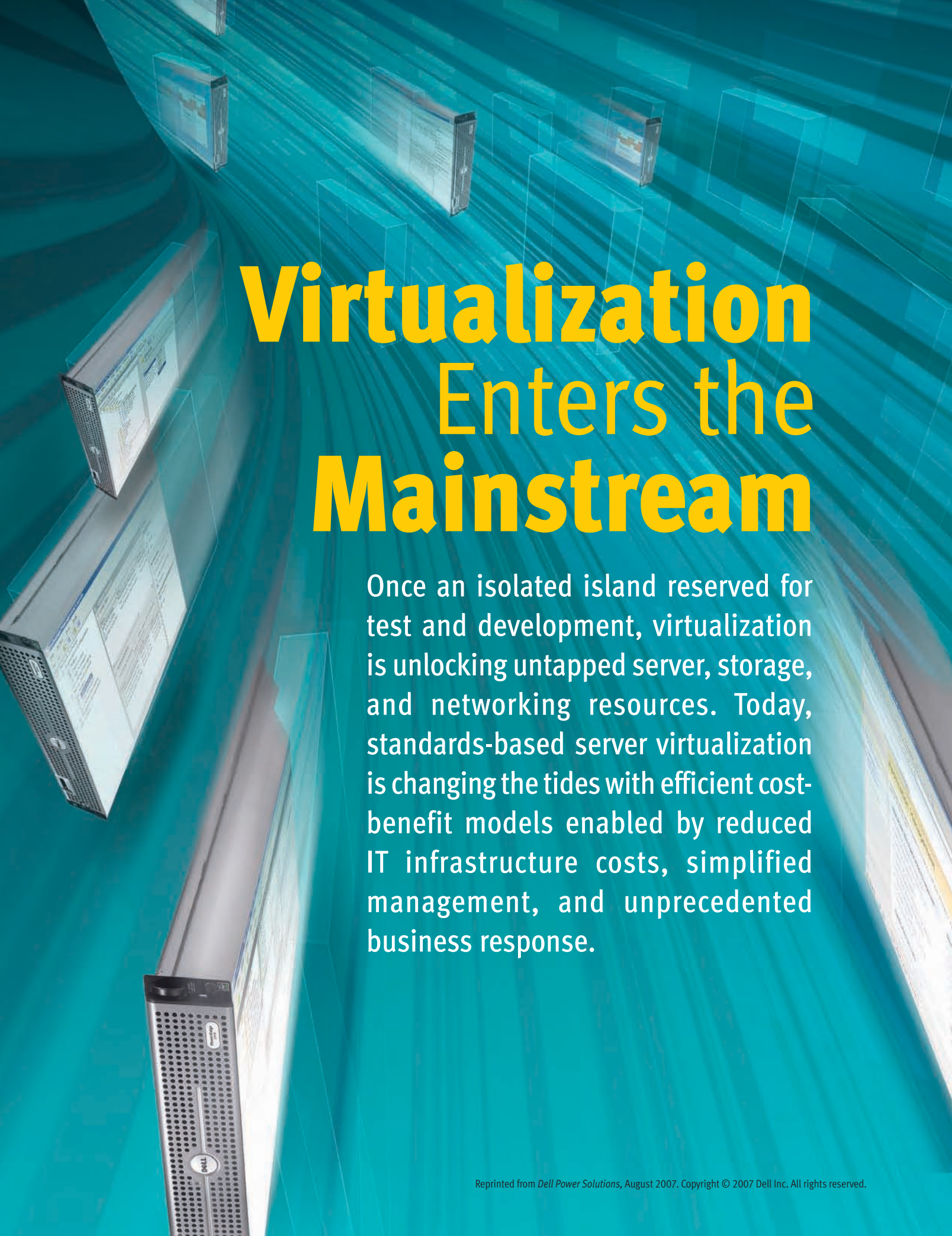

Virtualization Enters the Mainstream

Once an isolated island reserved for test and development, virtualization is unlocking untapped server, storage, and networking resources. Today, standards-based server virtualization is changing the tides with efficient cost-benefit models enabled by reduced IT infrastructure costs, simplified management, and unprecedented business response.

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BY JEANNE FELDKAMP
DEB MCDONALD
TOM KOLNOWSKI

Soaring energy prices have hit business where it hurts: in the bottom line. Because power is often the single largest data center operating expense, executives are searching for ways to increase the cost-effectiveness of IT infrastructures, often by upgrading to equipment designed for high energy efficiency. Still, unless performance per watt increases or energy prices decline, data center power and cooling costs are likely to overtake hardware costs in many organizations.

At the same time that executives are under pressure to cap data center power consumption, they are facing exponential growth in demand for processing power and data storage capacity. Exacting service-level agreements also create pressure to heighten system availability and resilience. In addition, legacy data centers usually lack the proper design, build, infrastructure, or location characteristics to support emerging regulatory and business requirements. For many organizations, these factors mean only one thing: additional data centers.

Unfortunately, additional data centers compound IT power costs and add complexity to already-complex global enterprise networks. In some cases, data center expansion follows merger or acquisition activity, which brings the extra complication of integrating heterogeneous and sometimes overlapping software environments.

Server consolidation can begin to address the problem of climbing data center power costs and complexity. But containing server sprawl is just a first step. Enterprises also need to confront the issue of efficiency within the overall IT infrastructure.[1] Based on a traditional model of one application per server, up to 80 to 90 percent of x86 computing capacity may be unused at any one time—and this unused capacity needs to be managed. It takes up data center space, and it requires power and cooling.

Exploring x86 virtualization technology

Virtualization technologies in the x86 world, once an isolated island reserved for test and development environments, are now gaining traction as a mainstream choice for the enterprise IT infrastructure. Virtualization techniques have the potential not only to unlock underutilized server capacity, but also to expedite software deployment, reduce downtime, enhance disaster recovery, enable variable usage accounting and charge-backs, support holistic enterprise-wide capacity planning, and dampen the effects of skyrocketing energy costs.

At the heart of virtualization technology are *hypervisor* architectures, that is, virtualization platforms or virtual machine (VM) monitors that allow multiple occurrences of operating systems—VMs—to run on the same physical host computer at the same time (see Figure 1). Hypervisors use a thin layer of code to help achieve fine-grained, dynamic resource sharing and are generally categorized into two distinct camps:

- **Type 1 hypervisor:** The virtualization software is, in effect, a purpose-built OS that runs natively on the hardware platform for the sole purpose of hosting and managing VMs. Once the type 1 hypervisor is running on the hardware platform, multiple VMs can be hosted on top of it as guests—these may be Microsoft® Windows®, Linux®, or other standard operating systems. Type 1 hypervisors fall into two subcategories: those with hardware emulation virtualization (where the hypervisor interacts with the VM through a hardware emulation layer) and those with paravirtualization (where the hypervisor interacts with the VM through a special application programming interface). An example of a type 1 hypervisor with hardware emulation virtualization is VMware® ESX Server 3, while the XenSource XenEnterprise platform on Linux offers paravirtualization features.[2]
- **Type 2 hypervisor:** The virtualization software runs as another application within a standard OS. A prominent type 2 hypervisor for server virtualization is Microsoft Virtual Server 2005 Release 2 (R2), which runs on top of the Microsoft Windows Server® 2003 OS and uses hardware emulation virtualization.

[1] For more information, see "Data Center Efficiency in the Scalable Enterprise," by John Pflueger, Ph.D., and Sharon Hanson, in *Dell Power Solutions*, February 2007, www.dell.com/downloads/global/power/ps1q07-20070210-CoverStory.pdf.

[2] For more information on hardware emulation versus paravirtualization, see "Using XenSource XenEnterprise with Dell Servers and Dell OpenManage," by Victor Mashayekhi, Ph.D.; Puneet Dhawan; Simon Crosby; and Roger B. A. Klorese, in *Dell Power Solutions*, August 2007, www.dell.com/downloads/global/power/ps3q07-20070385-Dhawan.pdf.

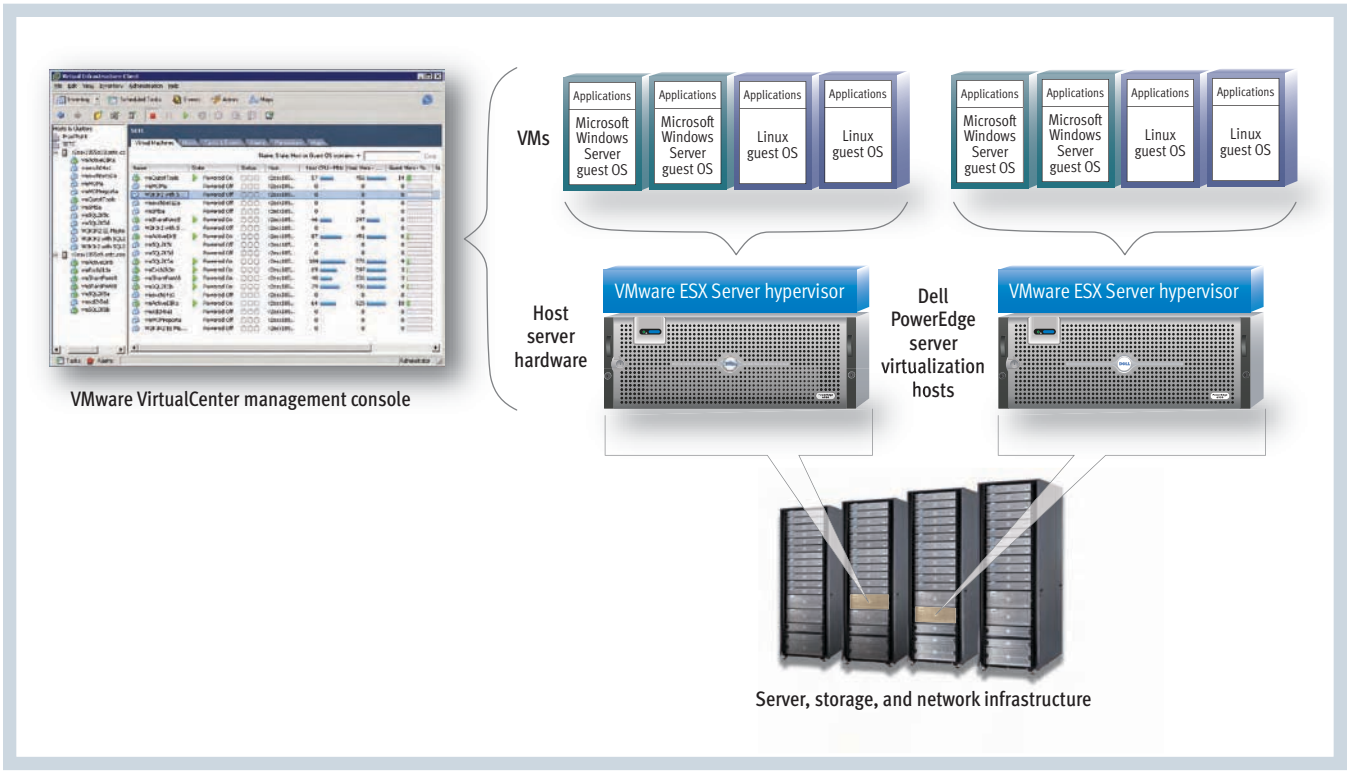

Figure 1. *VMware Infrastructure 3 server virtualization software enables organizations to host and manage multiple virtual machines on each physical server*

The lineage of x86 virtualization goes back through VMware Workstation and VMware Server (formerly VMware GSX Server); this workstation virtualization software was an early example of a type 2 hypervisor. VMware workstation software gave early adopters a practical way to virtualize their desktop systems, and set in motion a rapid progression of virtualization technology.

But it was not until the advent of VMware ESX Server—a dedicated type 1 virtualization platform that evolved from a Linux kernel—that server virtualization and the concept of VMs began to make definitive strides into the mainstream. Hypervisor technology, such as that included in VMware Infrastructure 3, has advanced to the point where it can begin to deliver on the promise of virtualization by enabling highly efficient, automated resource sharing. A centralized VMware VirtualCenter Management Server console helps ensure that systems throughout the enterprise data center have the necessary computing muscle and I/O bandwidth when they need it, while features such as VMware Distributed Resource Scheduler (DRS) and VMware VMotion™ technology help distribute resources and move VMs efficiently across physical hosts. As virtualization continues to evolve, the role of the hypervisor is expected to mature to a higher level of standardization than it has right now, particularly at the VM management level.

Today, virtualization techniques have become key to building a cost-effective, highly scalable enterprise IT infrastructure, because they enable flexible resource management and automated resource allocation based on strategic business policies. Virtualization technology can benefit the bottom line in several important ways:

- **Implementing production server consolidation and containment:** Virtualization techniques help contain server sprawl by running software applications in easily relocatable VMs on highly scalable enterprise-class servers. For example, VMware Infrastructure 3 enables Dell™ PowerEdge™ servers to consolidate numerous VMs on each physical server, which can lead to dramatic increases in server utilization. Additionally, Microsoft Virtual Server and Xen virtualization on Linux offer alternative platforms for virtualization.
- **Providing cost-effective protection for business continuity:** Organizations can help ensure high availability for critical applications using industry-standard virtualization-based solutions.[3] This approach also enables organizations to implement a unified disaster recovery platform that allows them to recover many production VMs in the event of a hardware failure without investing in costly one-to-one mapping of production and disaster recovery hardware.

[3] For example, see "Using VMware Cluster Features on Dell PowerEdge Servers," by Scott Hanson, in *Dell Power Solutions*, August 2007, www.dell.com/downloads/global/power/ps3q07-20070562-Hanson.pdf.

Virtualization in action

Virtualized Dell server infrastructures give Mazda North American Operations and Acuity Brands Lighting the competitive edge—allowing their IT teams to spend less time putting out fires and more time launching strategic business initiatives.

In a fiercely competitive auto industry, Mazda North American Operations depends on IT to inject the same "Zoom-Zoom" agility and acceleration that characterize its cars into its business operations. Key IT initiatives include enhancing supply chain efficiency, improving the effectiveness of field managers, and helping customers learn more about Mazda cars on the Web.

As Mazda's services grew, so did its server count—from 150 in 2003 to nearly 300 in 2007. "With a one-application-per-server approach, all we could see was never-ending server sprawl. Complexity had risen to the point where our IT staff was spending most of its time just maintaining those servers," says Jim DiMarzio, CIO of Mazda North American Operations.

To help solve the problem of server sprawl and escalating IT complexity, Mazda turned to Dell. "Dell provided us with a proven plan for implementing virtualization," says Kai Sookwongse, IT systems manager of Mazda North American Operations. "The Dell experts helped us assess our environment and identify applications that could be run on VMs. And when it came time to deploy the solution, the Dell team supported our IT team until our virtualized environment was up and running smoothly."

Using the VMware Infrastructure 3 suite, which includes ESX Server software and VirtualCenter management tools, Mazda consolidated 75 servers onto 5 quad-socket Dell PowerEdge 6850 servers. "We configured our virtualized servers for 50 percent processor utilization, so we have plenty of headroom for peaks in usage," explains Sookwongse. In addition, the IT team deployed quad-core Dell PowerEdge 2950 servers. "Two PowerEdge 2950 servers can host 20 VMs and still have plenty of capacity for peaks in demand," says Sookwongse.

VMware VirtualCenter management software enables the IT team to move critical application instances to different physical servers to perform maintenance or to adjust the level of resources available to the application. "It used to take hours for an administrator to provision a server," says DiMarzio. "Now, with VMware software running on Dell servers, we can remotely provision a new virtual server with just a few clicks."

Thanks to a reduced number of physical servers, increased provisioning efficiency, and automated management and monitoring tools, Mazda's IT budget can focus on helping improve the business rather than on IT maintenance. "Before virtualization, it took eight people to manage 280 physical servers. Now, just five people manage almost 300 physical and virtual servers," says DiMarzio.

Lights out on server sprawl

Acuity Brands Lighting relies on rock-solid IT to provide outstanding logistics and support its sales and distribution network with advanced supply chain management and sales fulfillment processes. However, as business expanded, the company ended up with a hardware infrastructure that was distributed, costly, and difficult to manage.

To evaluate how virtualization could address the problem, Acuity deployed a consolidated, virtualized test infrastructure of 105 VMs running on approximately eight Dell PowerEdge 2950 servers. "We are getting roughly 13 VMs per physical server, which is a testament to the reliability of the Dell servers. One of the biggest benefits of this virtualized environment is ease of management," says Jim Draughn, director of enterprise engineering at Acuity Brands Lighting. "Now, we can run far more servers on far less hardware than we could previously—which means fewer physical servers to maintain and oversee and a reduction in provisioning time from three weeks down to three hours."

Another big advantage of the virtual pool of servers is the increase in processor utilization. "Previously, we were getting about 10 percent utilization on each server, but with virtualization, we are able to get 50 or 60 percent per server," notes Draughn.

To manage its virtualized environment, Acuity uses VMware VirtualCenter software, which enables rapid provisioning of VMs and helps monitor the performance of both physical servers and VMs. VirtualCenter intelligently optimizes resources and helps ensure high availability for virtualized applications. "We use VirtualCenter to conduct load balancing and control resources," notes Draughn. "The other day, we learned from VirtualCenter that one of our servers had a bit too much load on it, so we were able to move resources around to distribute the workload."

Acuity plans to move virtualization to a production environment in 2007.

"It used to take hours for an administrator to provision a server. Now, with VMware software running on Dell servers, we can remotely provision a new virtual server with just a few clicks."

—Jim DiMarzio
CIO, Mazda North American Operations
July 2007

VIRTUALIZATION STRATEGY: SIMPLIFY MIGRATION, SIMPLIFY MANAGEMENT

The Dell virtualization strategy is grounded in simplicity: simplify the migration to and life cycle management of the virtual IT infrastructure. Based on tested, virtualization-optimized solutions and a direct, uncomplicated approach, Dell offerings enable high performance, availability, and overall value. A virtual IT infrastructure based on industry-standard Dell server and storage hardware streamlines day-to-day operations while enabling organizations to grow and evolve in cost-effective, planned phases.

The Dell virtualization offering is based on three key objectives:

- **Enabling** virtualization through software certified on key server and storage infrastructure components, integrated support offerings, specialized deployment tools, expert knowledge transfer, and performance-tuning benchmarks
- **Standardizing** virtualization implementations to help simplify deployment and management, streamline life cycle services, and broaden the choice of technology and hardware offerings that are optimized for performance, price, and manageability
- **Integrating** virtualization technology seamlessly into the IT infrastructure through unified, standards-based management and vendor-independent choices

To accomplish these objectives, Dell provides solutions based on a range of virtualization-optimized infrastructure components, focusing on simplified management for virtualized infrastructures running on multi-core Intel® or AMD™ processor–based Dell PowerEdge servers as well as Dell PowerVault™ and Dell/EMC storage. For example, the Dell OpenManage™ systems management suite integrates with VMware VirtualCenter to help streamline VM management.

Dell is also helping facilitate seamless provisioning and management of virtual server resources through its partnership with Altiris and integration with Altiris® management consoles. Additional Dell and partner management tools from Nicus, PlateSpin, Symantec, Vizioncore, and VMware are offered together with hypervisor software from VMware and Microsoft as well as the Xen environment.

Dell augments these virtualization solutions with a rich set of service offerings designed to help enterprises capture the full value of virtualization. Dell Services provides broad expertise in six key areas: physical-to-virtual migration, high availability, backup and recovery, configuration management and monitoring, development and test environments, and virtualization upgrades. Modular options include validation in a test environment, ongoing configuration management and monitoring, and enhanced backup and recovery. Dell virtualization training can help enterprises increase their understanding of how to maximize their virtual IT infrastructure. Training is designed to help IT departments learn everything they need to know about load balancing, high availability, and more from the experts at Dell. In addition, Dell Services offers best practices, configuration, and implementation guides to help simplify the migration to a virtual infrastructure.*

* For more information about Dell Infrastructure Consulting Services and virtualization, see "Achieving Balance-Sheet Business Value with Virtualized Server Solutions," in *Dell Power Solutions*, August 2007, www.dell.com/downloads/global/power/ps3q07-50070497-DellSvcs.pdf.

- **Streamlining software testing and development:** Virtualization allows organizations to consolidate disparate test, development, and staging environments involving multiple operating systems and multitier applications on the same hardware. IT departments can also set up self-service developer portals to enhance developer productivity.
- **Simplifying infrastructure provisioning:** With sophisticated automation capabilities, organizations can provision new infrastructure components in minutes rather than the hours or days required for physical configurations.[4] Virtualization also allows IT organizations to centralize control and responsibility for hardware resources while giving business units and application owners control over how those resources are utilized.
- **Re-hosting legacy applications:** IT departments can migrate legacy operating systems and software applications to VMs running on upgraded hardware for enhanced reliability and resource management.

For many organizations, virtualization is expected to be the most significant factor shaping IT infrastructure and operations. Moving forward, virtualization will likely bring about fundamental changes in the way enterprises deploy and manage technology from the end user all the way to the data center—including, for example, how they plan, what they buy, how they deploy new systems, how they account for usage and charge-backs, and how licensing, pricing, and component management work. Storage has already been largely virtualized, but primarily within the scope of individual vendor architectures. Networking is already virtualized. As virtualization techniques and technologies continue to mature, the next major advancements will likely be automating the provisioning

[4] For example, see "Upgrading to VMware Infrastructure 3 on Dell PowerEdge Servers," by Todd Muirhead, in *Dell Power Solutions*, August 2007, www.dell.com/downloads/global/power/ps3q07-20070251-Muirhead.pdf.

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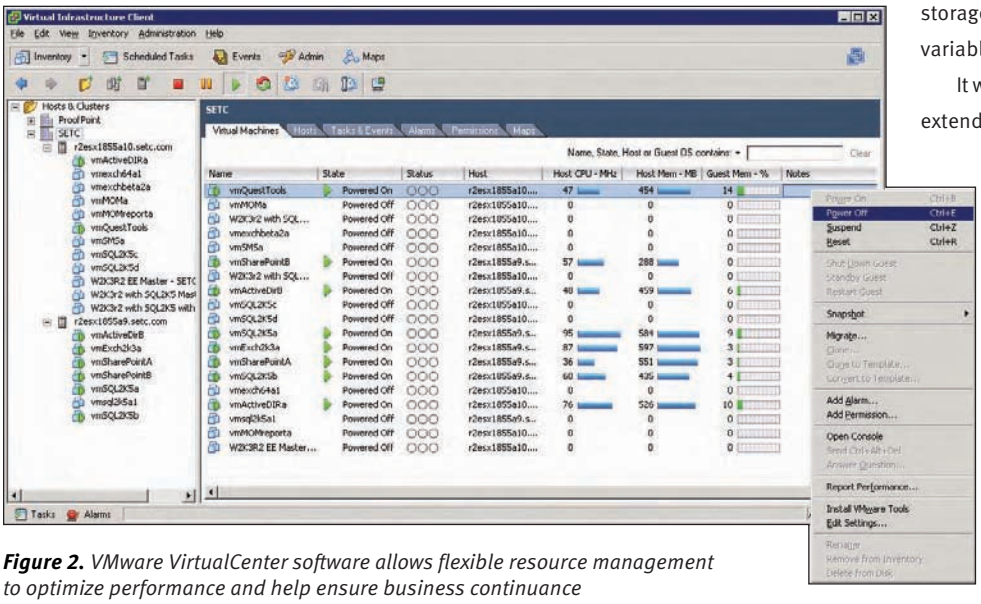

Figure 2. *VMware VirtualCenter software allows flexible resource management to optimize performance and help ensure business continuance*

and management of virtualized server, storage, and networking resources.

Unlocking the business value of virtualization

Virtualization is now an industry-standard approach to data consolidation, which makes virtualization key to a highly scalable, highly available enterprise IT infrastructure. A virtual infrastructure can help simplify IT operations in several important ways. For example, virtualization helps shield software from hardware variability, enables secure resource sharing, and facilitates rapid software deployment and relocation. Virtualization also helps increase business agility by dynamically deploying or re-provisioning resources as needed. Advanced management tools such as VMware VirtualCenter (see Figure 2) together with shared storage can further optimize performance to help meet rigorous service-level agreements, avoid unplanned downtime, enhance the efficiency of application testing and development, and facilitate fast, cost-effective disaster recovery.

Because virtualization enables multiple applications to share physical hardware, it allows organizations to lower requirements for data center real estate, power consumption, and the volume of server hardware to be purchased and managed compared with non-virtualized configurations. Virtualization can also help reduce capital and operating expenses by creating an abstraction layer between the hardware and software stack that encapsulates the software workload in a VM. This approach helps simplify the processes of moving workloads across hardware platforms, provisioning new servers, and supporting legacy applications on updated hardware. (For more information on how Dell hardware and services can help enterprises implement virtualization, see the "Virtualization strategy: Simplify migration, simplify management" and "Virtualization in action" sidebars in this article.)

Looking ahead

Server virtualization has entered the mainstream and is fast becoming an indispensable data center technology. Today, virtualization is cost-effective and easy to implement even for small and midsize enterprises, helping expedite software deployment, accelerate disaster recovery, and dampen the impact of skyrocketing energy costs through consolidation to powerful, energy-efficient servers. As virtualization techniques and technologies mature, the next major advancements are likely to be increasingly automated provisioning and management of virtualized server, storage, and networking resources—including variable usage accounting and charge-backs.

It will likely not be long before virtualization extends past servers to the desktop. With a virtual desktop—a server-hosted approach to client virtualization designed to deliver desktop images to end users through a remote protocol—even highly mobile users would be able to access their own desktop anywhere, from any device. Moving forward, virtualization is expected to be a significant factor shaping IT infrastructure and enterprise-wide business operations from the data center to the desktop and beyond. In many organizations, the bottom line is already profiting from reduced IT infrastructure costs, simplified management, and unprecedented business response.

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Upgrading to VMware Infrastructure 3 on Dell PowerEdge Servers

BY TODD MUIRHEAD

VMware® Infrastructure 3 on ninth-generation Dell™ PowerEdge™ servers offers several important features and can help provide significant performance increases over previous-generation systems. Administrators can take advantage of the portability of virtual machines to easily perform a rolling upgrade to VMware Infrastructure 3, helping minimize downtime for users and applications during the transition.

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Server virtualization is a key technology for scalable enterprise solutions. One of its primary advantages is the portability of virtual machines (VMs) from one physical server to another: as new generations of industry standards–based servers are released, administrators can easily migrate VMs running on the VMware ESX Server platform to the new hardware, provided the new hardware is also running ESX Server and shares storage with other ESX Server systems.

Administrators can take advantage of this portability when upgrading to VMware Infrastructure 3, which not only introduces several important features but can also help provide significant performance increases when deployed on ninth-generation Dell PowerEdge servers. This article describes the advantages of this type of environment and outlines best practices to help administrators carry out this upgrade while minimizing downtime for users and applications.

Running VMware Infrastructure 3 on ninth-generation Dell PowerEdge servers

The VMware Infrastructure 3 suite—which includes both the ESX Server 3 platform and the VirtualCenter 2 centralized management tool—introduces several features valuable in enterprise environments, including load balancing, high availability, and consolidated backup functionality. It also allows robust configurations for individual VMs, which can now have up to four virtual processors, 16 GB of RAM, and 64-bit capabilities, enabling enterprises to virtualize more-demanding applications than was possible with earlier versions of ESX Server.

Ninth-generation Dell PowerEdge servers incorporate advanced technologies designed to offer high levels of performance and scalability. Using dual-core Intel® Xeon® 5100 processors and quad-core Intel Xeon 5300 processors in two-socket PowerEdge servers can help increase performance over previous-generation PowerEdge servers, and ninth-generation PowerEdge servers include increased frontside bus speeds, fully buffered dual in-line memory modules (DIMMs), low-voltage processor options, TCP/IP Offload Engines (TOEs), network interface cards (NICs) on the motherboard, and advanced remote management capabilities through the Dell Remote Access Controller 5 (DRAC 5).

Upgrading to VMware Infrastructure 3 on ninth-generation PowerEdge servers can help increase performance over previous-generation systems. In tests performed by Dell engineers in September and October 2006, a PowerEdge 2950 server with two quad-core Intel Xeon X5355 processors at 2.66 GHz and ESX Server 3 provided performance increases of up to 272 percent over a PowerEdge 2850 server with two dual-core Intel Xeon processors DP at 2.8 GHz running ESX Server 2.5.2, and was also able to host more than twice as many VMs as

the PowerEdge 2850.[1] The dual-core Intel Xeon 5100 series processors and quad-core Intel Xeon 5300 series processors, fully buffered DIMMs, and increased frontside bus speeds of the PowerEdge 2950 all help contribute to such performance increases.

Upgrading to VMware Infrastructure 3 from an existing ESX Server installation requires upgrading all the virtualization software components, including both ESX Server and VirtualCenter. ESX Server 3 uses an updated VM format as well as updated versions of VMware Virtual Machine File System (VMFS) and VMware Tools. VM portability enables administrators to upgrade these components with limited impact on production systems. However, administrators should keep in mind that they cannot later downgrade these components to previous versions; they should maintain backups of all VMs and plan the upgrades in advance to help ensure a smooth upgrade.

The VMware *Installation and Upgrade Guide: ESX 3.0.1 and VirtualCenter 2.0.1*[2] provides detailed information about possible upgrade scenarios, particularly in-place upgrades of both ESX Server and VirtualCenter. When only an in-place upgrade of a single ESX Server system is necessary, administrators should follow the VMware documentation closely. In data centers with more than one ESX Server system connected to shared storage—typically a storage area network (SAN)—a staggered upgrade approach may be preferable, allowing upgrades to be carried out during normal business hours with minimal VM downtime.

Administrators should also upgrade Dell OpenManage™ Server Administrator to the latest supported version after completing the upgrade to ESX Server 3. For details about installing Dell OpenManage Server Administrator in ESX Server environments, see the March 2007 Dell white paper "Installing Dell OpenManage Software in a VMware ESX Server Software Environment."[3]

Following best practices when upgrading to VMware Infrastructure 3

Administrators should carry out the upgrade in three stages, by first installing VMware VirtualCenter 2, then performing a rolling upgrade to ESX Server 3, and finally upgrading the virtual hardware and VMware Tools for each VM. The primary goal is to limit the amount of VM downtime by performing the upgrade in stages, taking advantage of VM portability to make the process as seamless as possible to the users and applications that depend on the VMs. One key decision is whether to manage the upgrade internally or bring in outside help; understanding the best practices for carrying out the upgrade can help IT departments determine which path to take.

Installing VMware VirtualCenter 2

Although not always an option, simply installing a new VMware VirtualCenter 2 instance can be easier and much faster than performing an in-place upgrade of an existing earlier version of VirtualCenter. This approach does not allow historical events and performance information to be imported into the new instance, but it does help avoid the console downtime associated with in-place upgrades.

Because VirtualCenter 1.*x* does not support ESX Server 3, administrators should upgrade VirtualCenter before upgrading ESX Server. However, once the VirtualCenter 2 upgrade is complete, administrators can use the VirtualCenter 2 console to manage existing ESX Server 2.5 systems.

Performing a rolling upgrade to VMware ESX Server 3

Performing a rolling upgrade to ESX Server 3 helps avoid VM downtime. It requires enough spare capacity to move all VMs off each server to be upgraded; if necessary, administrators can add a server to provide this capacity. As shown in Figure 1, after moving VMs off one of the servers, administrators can install ESX Server 3 on that system, move VMs back onto the upgraded ESX Server 3 system and off one of the remaining ESX Server 2.5 systems, and upgrade the VMs on the ESX Server 3 system. They can then install ESX Server 3 on the newly empty ESX Server 2.5 system and repeat the process until they have upgraded all the servers. (Upgrading the VMs for ESX Server 3 systems is a separate step, and is discussed in the "Upgrading virtual machines" section in this article.)

A successful rolling upgrade also requires upgrading VMFS volumes on the storage side. To operate in normal read/write mode, ESX Server 3 VMs must be on VMFS 3 volumes, so the first upgraded server must have a VMFS 3 volume that can host the VMs. VMFS 2 volumes can be upgraded to VMFS 3, but VMs on those volumes must be powered down during this conversion process. To avoid VM downtime, administrators should perform VM migrations on storage similarly to how they do on the servers: they should create a new VMFS 3 volume, move VMs off one of the VMFS 2 volumes until it is empty, then upgrade the empty VMFS 2 volume to VMFS 3. They can then repeat this process until they have upgraded all the VMFS 2 volumes.

TALK BACK

Tell us how the Dell Enterprise Technology Center can help your organization better simplify, utilize, and scale enterprise solutions and platforms. Send your feedback and ideas to enterprise_techcenter@dell.com.

[1] See "Performance Scaling with Dell PowerEdge 2950 Servers and VMware Infrastructure 3," by Todd Muirhead, in *Dell Power Solutions*, February 2007, www.dell.com/downloads/global/power/ps1q07-20070201-Muirhead.pdf.

[2] Available at www.vmware.com/pdf/vi3_installation_guide.pdf.

[3] Available at www.dell.com/downloads/global/solutions/Installing_Dell_OpenManage_50_on_ESX_3.pdf.

Administrators can upgrade VMFS 2 volumes to VMFS 3 in VirtualCenter 2 by clicking the Configuration tab in the Storage section for an ESX Server system that has access to the volume. After selecting the VMFS 2 volume, they can click a button to upgrade the volume to VMFS 3. They should avoid connecting a VMFS 3 volume to an ESX Server 2.*x* system, which causes the volume to no longer appear as a VMFS 3 volume to ESX Server 3 systems; during the storage upgrade, therefore, they should be sure to assign VMFS 3 volumes only to ESX Server 3 systems.

Upgrading virtual machines

The only VM downtime required during a rolling upgrade to ESX Server 3 occurs when upgrading the VMs for ESX Server 3. If the ESX Server 2.5 and ESX Server 3 systems use the same processor type and generation, then administrators can often perform a live migration using VMware VMotion™ technology. In this case, the only additional step is to upgrade VMware Tools, which requires downtime to reboot the VMs.

If the two servers use different processor types or generations, however, then administrators must shut down the VMs when moving them from an ESX Server 2.5 system to an ESX Server 3 system, which they can do using VirtualCenter 2. The amount of time it takes to move the VMs depends on VM file size, server speed, available network bandwidth, and possibly the amount of disk subsystem activity. After moving the VMs to an ESX Server 3 system, administrators must upgrade their virtual hardware, which they can do using either VirtualCenter 2 or the vmware-vmupgrade command-line utility on the VirtualCenter 2 server. The command-line utility can upgrade a large number of VMs simultaneously, and is discussed in more detail in the "Upgrading virtual machines in the lab environment" section in this article.

Regardless of how administrators migrate VMs to the ESX Server 3 system, they should upgrade VMware Tools. They can do this using VirtualCenter 2 and the VM console or by using the vmware-vmupgrade command-line utility when upgrading the virtual hardware.

The primary factor determining VM downtime is the amount of time it takes to move the VMs onto the ESX Server 3 systems and VMFS 3 volumes. Upgrading the virtual hardware and VMware Tools typically takes a fraction of the time that VM migration requires, and performing a live migration using VMotion can reduce the downtime to a single VM reboot following the VMware Tools upgrade.

Testing the upgrade process in the Dell Enterprise Technology Center lab

To enable performance and feature testing, in December 2006 Dell engineers upgraded the VMware virtualization environment in the Dell Enterprise Technology Center lab to VMware Infrastructure 3 and documented the process to record example times for each phase of the process. This process also involved upgrading to servers with next-generation processors, requiring VMs to be shut down before migration.

Installing VMware VirtualCenter 2 in the lab environment

The Dell team chose to install a new instance of VirtualCenter 2 on a Dell PowerEdge 1855 blade server. They first used Altiris® Deployment Solution™ software to deploy the Microsoft® Windows Server® 2003 Enterprise Edition OS, then installed the Microsoft SQL Server™ database platform. (VirtualCenter 2 requires both the 32-bit version of Windows Server as well as SQL Server.) Finally, they installed VirtualCenter 2 along with the license server option.

The Dell team chose the license server option over server-based licensing to help simplify the management of ESX Server licenses in the lab environment: it is much easier to maintain a single license server than to supply a license during every installation or reinstallation of ESX

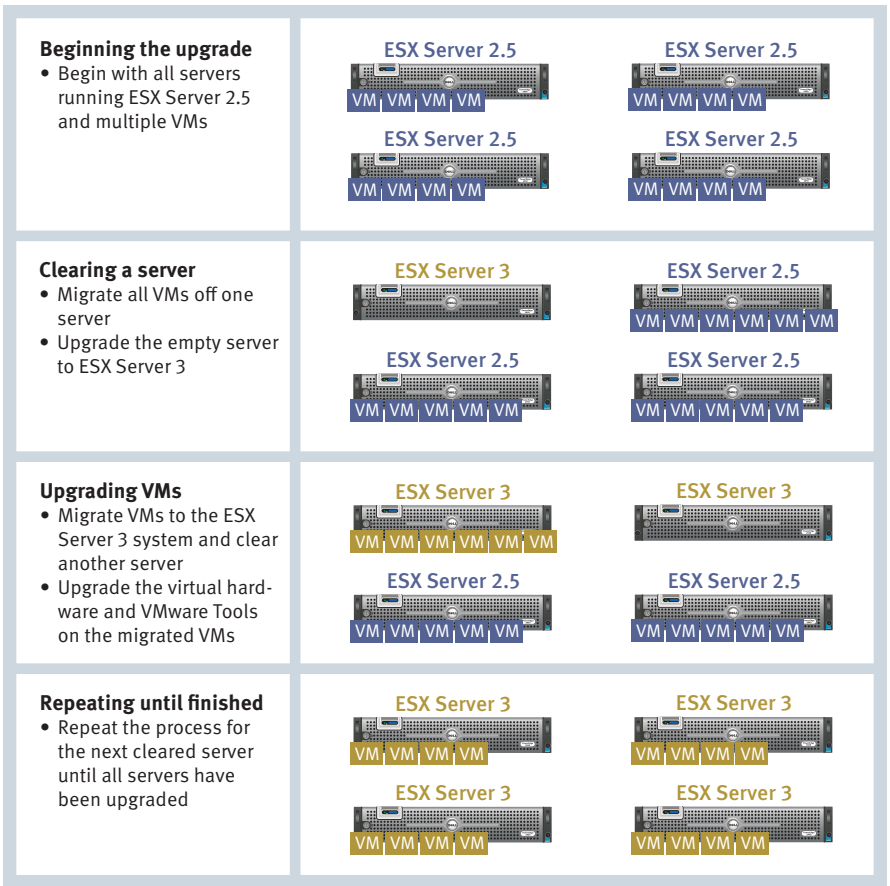

Figure 1. *Process for a rolling upgrade to VMware ESX Server 3*

Server. The team obtained the license file by redeeming a license activation code at the VMware Web site. Because administrators are prompted for the license file during installation, they should redeem their license code and obtain the license file before installing VirtualCenter 2.

Following VirtualCenter 2 installation, the Dell team added all existing ESX Server 2.5.2 systems to the VirtualCenter 2 console, which automatically removed them from the previous VirtualCenter 1.3 console. These actions had no effect on the VMs running on the servers.

Performing a rolling upgrade to VMware ESX Server 3 in the lab environment

The previous virtualization infrastructure comprised two PowerEdge 1855 blade servers, two PowerEdge 2850 servers, and a PowerEdge 6650 server, all running ESX Server 2.5.2. The new infrastructure comprises two PowerEdge 1855 blade servers, a PowerEdge 2850 server, two PowerEdge 2950 servers, and a PowerEdge 6850 server. Because the team was adding new servers to the infrastructure, they did not need to create space on an existing server to perform the rolling upgrade process. They first installed ESX Server 3 on the new PowerEdge 2950 servers and the PowerEdge 6850 server, then moved the VMs off the remaining servers by migrating the VMs as described in the "Upgrading virtual machines in the lab environment" section in this article.

The new ESX Server 3 systems were attached to a Dell/EMC CX3-80 array through a SAN. The Dell team used the EMC® Navisphere® Manager application to create four new logical units (LUNs) and assign them to a storage group. They then added the new ESX Server 3 systems to the same storage group to allow them access to the newly created LUNs, and formatted each LUN with a large VMFS 3 partition. As the VMs were migrated to this storage, they were evenly distributed on the four new LUNs.

Networking can be greatly simplified in ESX Server 3 because the service console no longer requires a dedicated NIC, as was the case with ESX Server 2.5, helping reduce the need for additional server NICs. The standard lab configuration for the PowerEdge 2850 servers running ESX Server 2.*x* was three NICs—one for the service console and two for the two virtual networks supporting VM network traffic. The low network traffic on the service console allows the lab to use only the two on-board NICs on the PowerEdge 2950 servers as the standard configuration with ESX Server 3.

After migrating all of the VMs off the PowerEdge 1855 and PowerEdge 2850 servers, the Dell team upgraded these servers to ESX Server 3. Once this upgrade was complete, they upgraded the VMFS 2 partitions to VMFS 3, then migrated some of the VMs back to these servers to help balance the load across the server farm.

Upgrading virtual machines in the lab environment

The Dell team needed to migrate and upgrade 52 VMs running the Microsoft Windows® OS and 26 VMs running the Linux® OS. Most of these VMs have a 10 GB virtual disk residing on one of four LUNs in the SAN. Each VM has a single network connection mapped to one of two virtual switches.

Upgrade step	Approximate time (hours: minutes:seconds)	VM status
Installing VirtualCenter 2	1:00:00	All VMs are online
Using VMotion to clear a server for upgrade	0:10:00	All VMs are online (with slight performance impact during VMotion migration)
Installing ESX Server 3	0:30:00	All VMs are online
Migrating 1 VM	0:06:07	Migrating VM is offline
Migrating 6 VMs	0:14:30	Migrating VMs are offline
Migrating 16 VMs	0:35:00	Migrating VMs are offline
Upgrading virtual hardware for 1 VM	0:00:03	Upgrading VM is offline
Upgrading VMware Tools for 1 VM	0:03:00	VM is rebooted following upgrade
Upgrading virtual hardware and VMware Tools for 6 VMs using the vmware-vmupgrade command-line tool	0:03:00	VMs are rebooted following upgrade

Figure 2. *Approximate recorded time and VM status for each stage when upgrading to VMware Infrastructure 3 in the Dell Enterprise Technology Center lab environment*

Migrating VMs from a PowerEdge 2850 running ESX Server 2.5.2 to a PowerEdge 2950 running ESX Server 3 required the Dell team to shut the VMs down and migrate them using VirtualCenter 2, the only point in the process that necessitated VM downtime. After shutting the VMs down, the Dell team migrated each VM to a new host and upgraded its virtual hardware and VMware Tools before bringing it back online. Figure 2 details the approximate time and VM status for each stage of this process, including example times when migrating different numbers of VMs simultaneously.

The Dell team shut down and migrated the VMs using VirtualCenter 2 by first right-clicking on each VM and selecting "Shutdown Guest," and then dragging and dropping the VM to a PowerEdge 2950. They next selected a VMFS 3 volume to store the VM virtual disk and waited while the virtual disk file was copied from the VMFS 2 partition to the VMFS 3 partition. (The amount of time that this copy process takes depends heavily on the virtual disk size.)

Once the copy process was completed, the Dell team upgraded the virtual hardware by right-clicking on the VM and selecting "Upgrade Virtual Hardware," a process that typically completed in 3–5 seconds. They then upgraded VMware Tools by booting up the VM, running the VMware Tools installation, and rebooting the VM, which took several minutes in total.

Administrators can use the vmware-vmupgrade command-line utility to streamline the upgrade process for the virtual hardware and VMware Tools. This utility can upgrade multiple VMs simultaneously; administrators can

choose either individual VMs or an entire host server. The Dell team used the following command to upgrade the six initial VMs they had migrated to one of the PowerEdge 2950 servers running ESX Server 3:

```
vmware-vmupgrade -u administrator -p password
-h SETC/r2esx2950a.setc.com
```

Because this utility reboots the VMs following the upgrade, if administrators have chosen to upgrade the VMs on an entire host server, a large number of VMs may reboot at the same time and slow down the server unnecessarily. To help avoid this situation, administrators can use an additional parameter, `-m`, to limit the number of upgrades that can occur at one time. In the lab environment, the Dell team found that six was an optimum number of VMs to upgrade at once using this utility, and therefore added `-m 6` to the command when upgrading the remaining VMs.[4]

Minimizing downtime when upgrading to VMware Infrastructure 3

Upgrading to VMware Infrastructure 3 on ninth-generation Dell PowerEdge servers can help provide significant performance increases over previous-generation systems and enable enterprises to take advantage of key features such as load balancing, high availability, and consolidated backup. By following the best practices outlined in this article, administrators can limit VM downtime during the upgrade process to just a few minutes, allowing them to carry out much of the work during normal business hours with minimal impact on the users and applications that depend on the virtualized data center.

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[4] For more information about the vmware-vmupgrade utility, see *Installation and Upgrade Guide: ESX 3.0.1 and VirtualCenter 2.0.1*, www.vmware.com/pdf/vi3_301_201_installation_guide.pdf.

Using VMware Cluster Features on Dell PowerEdge Servers

BY SCOTT HANSON

The VMware® High Availability and Distributed Resource Scheduler features are designed to mitigate the risk of host failure while optimizing resource utilization in virtualized cluster environments. This article examines these features and describes tests that demonstrate their functionality and performance on Dell™ PowerEdge™ servers in common enterprise data center scenarios.

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Combining virtualization with increasingly powerful servers has allowed many enterprises to run multiple applications on a single server inside isolated virtual machines (VMs). The downside of this type of environment, however, is that a single hardware failure can affect multiple critical systems simultaneously.

To help mitigate this risk, enterprises can take advantage of the VMware High Availability (VMware HA) and Distributed Resource Scheduler (DRS) features of the VMware Infrastructure 3 platform, which allow VMs to easily migrate to other hosts in a virtualized cluster during maintenance, server failure, and similar situations. Although VMware HA and DRS are separate features, they provide complementary functionality and are typically used together.

Implementing these features on industry standards–based Dell PowerEdge servers can provide cost-effective, enterprise-class high availability and load balancing in virtualized environments. For example, a previous *Dell Power Solutions* article[1] demonstrated that a farm of three two-socket Dell PowerEdge servers can provide higher performance, higher performance per watt, and lower price/performance than two four-socket HP ProLiant servers. By avoiding the centralization of critical VMs on just a few large servers, a data center built on several two-socket servers using VMware HA and DRS can easily recover from the loss of a single server by restarting VMs on other hosts. Administrators can also integrate the Dell OpenManage™ suite with VMware Infrastructure 3 and features such as DRS to create proactive responses to hardware faults and adaptive power management.[2]

This article discusses the basics of VMware HA and DRS and describes tests performed by the Dell Enterprise Technology Center team to help demonstrate their functionality and performance on Dell PowerEdge servers in three common enterprise data center scenarios: planned maintenance, unplanned outages, and workload spikes. For detailed information about VMware HA and DRS, see the VMware *Resource Management Guide: ESX Server 3.0.1 and VirtualCenter 2.0.1*.[3]

Understanding VMware High Availability

Traditional high-availability software such as Microsoft® Cluster Service focuses on keeping applications running during a failure, a level of availability that requires duplicating a significant amount of hardware in the form of dedicated

[1] "Comparing Virtualization Performance: Dell PowerEdge and HP ProLiant Servers," by Todd Muirhead; Dave Jaffe, Ph.D.; and Terry Schroeder, in *Dell Power Solutions*, May 2007, www.dell.com/downloads/global/power/ps2q07-20070339-Muirhead.pdf.

[2] For more information about this integration, including a framework of scripts and programs based on the VMware Infrastructure Software Development Kit that administrators can modify to fit their specific environment, see "Proactive Maintenance and Power Management with Dell OpenManage and VMware Virtualization," by Balasubramanian Chandrasekaran and Puneet Dhawan, in *Dell Power Solutions*, May 2007, www.dell.com/downloads/global/power/ps2q07-20070131-Chandrasekaran.pdf.

[3] Available at www.vmware.com/pdf/vi3_esx_resource_mgmt.pdf.

standby servers. These standby servers typically run workloads only when a primary server fails, and users would typically experience very minimal or no downtime during such a failure.

A VMware ESX Server–based cluster is simply a collection of physical hosts with shared resources and a shared management interface. VMware HA, a licensable feature that administrators can add to a cluster, handles host failure by automatically powering down the VMs on the failed host and restarting them on other cluster nodes. Although VMware HA does not require dedicated standby servers, users must wait for the server to go through the VM boot process before they can regain connectivity. If desired, administrators can combine VMware HA with traditional high-availability software to help increase availability levels beyond what each can provide alone.[4]

Administrators can enable and configure VMware HA in VMware VirtualCenter after configuring a cluster. VirtualCenter is only required during the initial VMware HA setup process, after which this feature can function without VirtualCenter running. During the setup process, an agent is installed on each host in the cluster. This agent sends heartbeat signals over the network to the other hosts; if an agent stops sending heartbeat signals for 15 seconds, its host is considered to have failed. The default response to this failure is to power down the VMs on that host, which allows them to be restarted on the remaining hosts in the cluster. If the VMs were allowed to continue running on that host, VMware Virtual Machine File System (VMFS) disk locking would prevent the VMs from starting on other hosts.

Because the failed-heartbeat threshold is only 15 seconds, robust network connections for these signals can be critical to avoid unnecessary VM failover. A best practice is to configure each host with redundant physical network interface cards (NICs). Administrators can then either use NIC teaming or set up two service console interfaces to enable a redundant heartbeat connection.

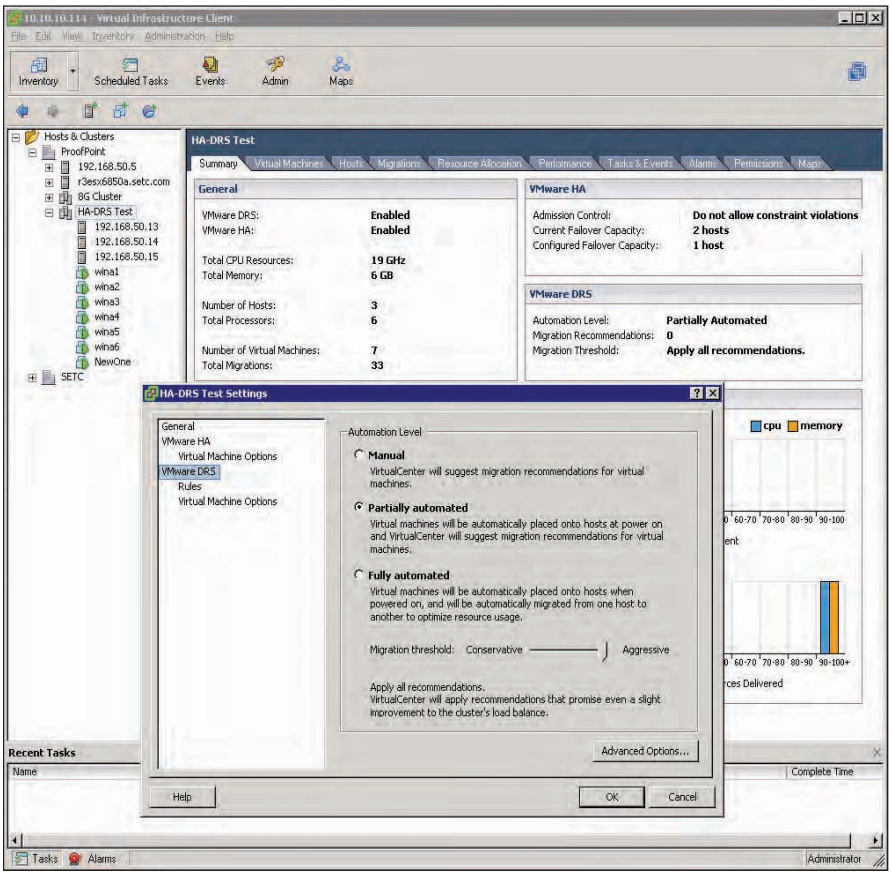

Figure 1. *Example cluster configuration showing Distributed Resource Scheduler automation level in VMware VirtualCenter*

Understanding VMware Distributed Resource Scheduler

Like VMware HA, DRS is a licensable feature that administrators can add to a cluster. Once DRS is enabled, VirtualCenter can use this feature's system algorithms and administrator-created rules to manage and optimize cluster resources, treating the processor and memory resources of each host as part of a global resource pool that all VMs in the cluster can use. DRS moves VMs between hosts using VMware VMotion™ technology.

When using DRS, administrators do not choose a specific host on which to create a new VM. Instead, DRS collects resource usage information for both hosts and VMs in the cluster and generates recommendations for VM placement. Administrators can configure different automation levels in the VirtualCenter console that determine whether these recommendations are applied manually or automatically:

- **Manual:** DRS recommends a host through the VirtualCenter console both when a VM is powered up and during normal operations rather than automatically moving VMs.
- **Partially automated:** DRS automatically chooses a host when a VM is powered up, but makes recommendations through the VirtualCenter console during normal operations rather than automatically moving VMs.
- **Fully automated:** DRS automatically chooses a host when a VM is powered up and automatically moves VMs during normal operations. Administrators can configure the migration threshold level using a slider bar.

Figure 1 shows the VMware VirtualCenter interface for setting the DRS automation level of an example cluster configuration. The General section of the Summary tab in Figure 1

[4] For more information about combining Microsoft Cluster Service with VMware HA, see the VMware guide *Setup for Microsoft Cluster Service: ESX Server 3.0.1 and VirtualCenter 2.0.1*, www.vmware.com/pdf/vi3_vm_and_mscs.pdf.

also displays the total processor and memory resources, which are the result of adding all the resources from the three hosts in the cluster.

DRS resource distribution

DRS tracks processor and memory utilization of the hosts in a cluster and the percentage of entitled resources delivered, then uses these statistics to help determine the optimal placement of VMs within the cluster. Administrators can view this information in the DRS Resource Distribution graph, located on the Summary tab of the VirtualCenter console for the cluster. Figure 2 shows an example of a balanced three-node cluster in this graph. The "number of hosts" vertical axis is dynamic and changes with host utilization. In this example, all three hosts have a processor utilization of 0–10 percent and a memory utilization of 40–50 percent, a case in which DRS does not need to move VMs. If these utilizations change, the bars split to show different ranges for different numbers of hosts.

Figure 3 shows the same cluster in an unbalanced state. In this example, two hosts have a memory utilization of 60–70 percent and one has a memory utilization of 20–30 percent, and the "number of hosts" axis has changed from 3 to 2. In general, DRS moves VMs to try to get the bars closer together, with a single bar representing a balanced state; in this example, DRS would typically move VMs from the two hosts with 60–70 percent memory utilization to the host with 20–30 percent utilization.

DRS affinity rules

Administrators can create affinity rules to determine whether specific VMs should run on the same host, typically for performance reasons, or be separated from other specific VMs, typically to help maintain high availability by keeping a single hardware failure from disrupting those VMs simultaneously. Figure 4 shows an example configuration in which DRS tries to keep the wina1, wina3, and wina5 VMs on the same host while keeping the wina1 and wina2 VMs on different hosts.

Testing VMware High Availability and Distributed Resource Scheduler

In May 2007, Dell Enterprise Technology Center engineers tested VMware HA and DRS functionality by simulating three common data center scenarios: planned maintenance, unplanned outages, and workload spikes. Video demonstrations of all three scenarios are available at www.delltechcenter.com/page/VMware+Demonstrations.

The test cluster comprised three blade servers within a Dell PowerEdge 1955 blade server system. A PowerEdge 1955 blade server supports up to two Intel® Xeon® 5000, 5100, or 5300 series processors. The test team configured each PowerEdge 1955 blade server in the test environment with two quad-core Intel Xeon X5355 processors at 2.66 GHz and 8 GB of memory using four 2 GB dual in-line memory modules (DIMMs). The servers were connected to a storage area network with dual-port QLogic QLE2462 PCI Express host bus adapters and utilized storage on a Dell/EMC CX3-80 array with twenty 146 GB, 15,000 rpm disks.

The VMs ran the Microsoft Windows Server® 2003 OS, with the servers using VMware Infrastructure 3 as the virtualization platform. VMware Infrastructure 3 includes ESX Server 3 and VirtualCenter 2 as well as VMware HA and DRS. ESX Server allows multiple VMs to run simultaneously on a single physical server, while VirtualCenter enables administrators to consolidate the management of ESX Server and VMs to help increase efficiency in large environments. The test team used a Dell PowerEdge 2950 server to manage the virtual infrastructure during the tests.

Planned maintenance

Servers can require several BIOS or firmware updates each year, and components such as

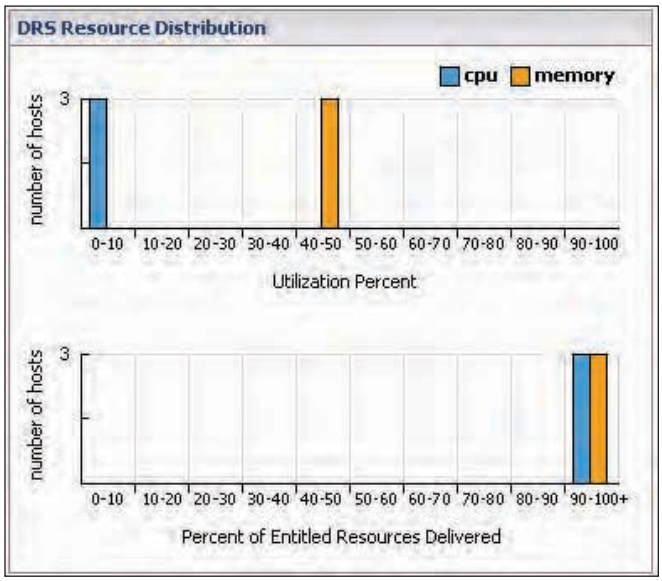

Figure 2. *Balanced cluster shown in the VMware VirtualCenter DRS Resource Distribution graph*

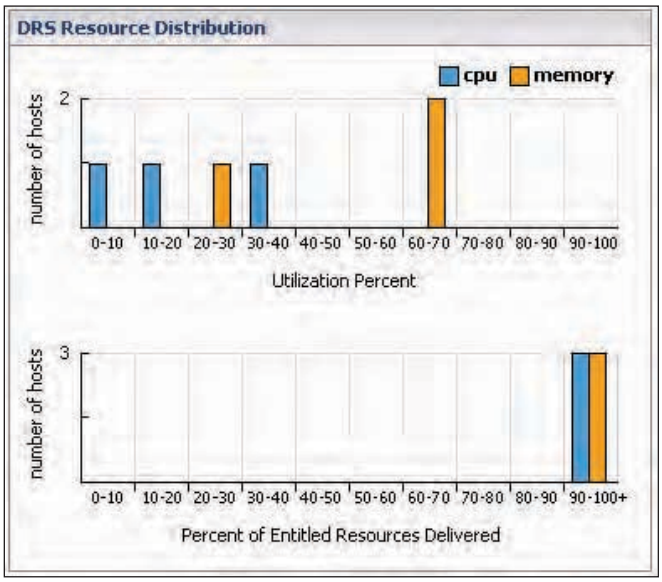

Figure 3. *Unbalanced cluster shown in the VMware VirtualCenter DRS Resource Distribution graph*

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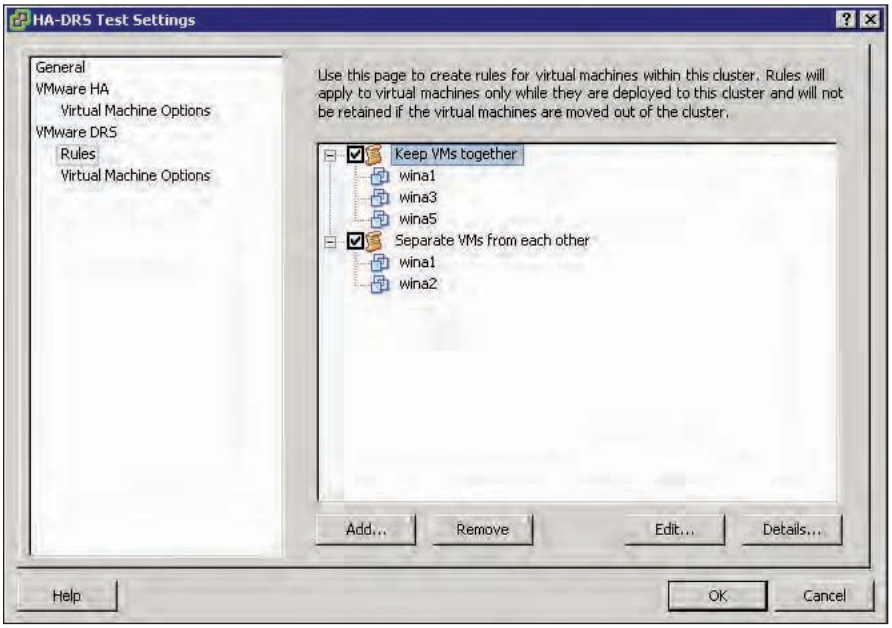

Figure 4. *Example Distributed Resource Scheduler affinity rules in VMware VirtualCenter*

I/O adapters can require regular updates as well. After applying these updates, administrators typically must reboot the server. With VMware HA and DRS enabled, administrators can easily avoid disrupting VMs during these updates by placing the host in maintenance mode, which triggers DRS to move VMs on that host to other hosts in the cluster based on the DRS rules. (*Note:* If administrators have set the automation level to "manual" or "partially automated," the host cannot enter maintenance mode until the VMs have been manually moved to other hosts. VirtualCenter displays a dialog box to remind administrators of this requirement.)

To simulate VM migration during planned maintenance, the Dell test team placed two VMs on each of the three PowerEdge 1955 blade servers in the cluster, for a total of six VMs. Placing one of the three servers into maintenance mode caused DRS to move the two VMs from that server to the other servers in the cluster, a process that took 1 minute and 10 seconds. During this time, users connected to the two migrated VMs experienced no loss of connectivity. Once the migration is complete, administrators can update and reboot the host in maintenance mode without disrupting either the VMs or the users. When they complete the maintenance and turn off maintenance mode, DRS can automatically migrate VMs back to the upgraded server to balance the workload.

To see how increasing the number of VMs affects VM migration time, the test team next placed 16 VMs on each host, for a total of 48 VMs in the cluster. They then put each host into maintenance mode separately and timed the results. On average, the VM migration process took 8 minutes and 15 seconds, approximately seven times longer than the time for two VMs. This increased time is primarily attributable to the VMware software only queuing up two VM migrations at a time, which administrators should take into account when designing a cluster.

Unplanned outages

One of the primary advantages of VMware HA is its ability to restart VMs on other hosts should their current host fail. To test how VMware HA and DRS function during such an unplanned outage, the Dell test team again placed two VMs on each of the three PowerEdge 1955 blade servers in the cluster. They then simulated an unplanned outage by physically removing one of the servers from the chassis. The VirtualCenter console detected the host loss after about 15 seconds—the amount of time it takes the heartbeat signals of the VMware HA agent to time out—and then automatically powered down and restarted the VMs on the other servers in the cluster, which took another 2 minutes and 30 seconds.

The total time that users experience an application outage varies depending on how long it takes to restart the VM and its associated applications and services. To see how long users might experience such an outage in the test environment, the test team performed a continuous ping test to a VM on the server experiencing the simulated outage and measured the time from when the ping stopped to when it started again. They performed this test once on each of the three servers in the cluster: the first took 5 minutes and 40 seconds, the second took 7 minutes and 28 seconds, and the third took 3 minutes and 10 seconds, for an average time of 5 minutes and 26 seconds.

If the hosted applications are not critical and downtime of a few minutes is acceptable, then using VMware HA alone may be sufficient. Because traditional high-availability solutions such as Microsoft Cluster Service can help minimize or eliminate application downtime in this type of situation, however, administrators may want to combine one of these tools with VMware HA to help increase availability for critical applications.

Workload spikes

A strength of DRS is its ability to move VMs to other hosts within a cluster in response to dynamic changes in workload, such as spikes during payroll processing at financial firms, when specific servers become much more heavily loaded than they are under normal conditions. When these systems are running as VMs in a DRS-enabled cluster, DRS can use VMotion to automatically rebalance the cluster and help optimize performance.

To test the dynamic movement of VMs in response to workload changes, the test team used version 2 of the Dell DVD Store application

and database[5] to simulate Web-based orders on three VMs in the cluster, named wina1, wina2, and wina3. The first server in the cluster hosted the wina1 and wina2 VMs, the second hosted the wina3 VM, and the third hosted no VMs.

The team first started a workload on wina1 and wina2 that increased the processor utilization of the first server to nearly 100 percent. They then started another workload on wina3 that increased the processor utilization of the second server to approximately 50 percent. The third server, which had no VMs and no workload, had very low processor utilization. Recognizing that the heavy workload on the first server should be balanced across the cluster, DRS used VMotion to migrate wina1 to the third server, after which each server had a comparable workload and approximately 50 percent processor utilization.

Creating efficient, highly available virtualized clusters

The VMware HA and DRS features are designed to provide flexible high-availability and load-balancing functionality for virtualized clusters, especially when combined with traditional high-availability software such as Microsoft Cluster Service. Using these features on Dell PowerEdge servers can help administrators create cost-effective, easy-to-manage enterprise-class clusters in virtualized environments.

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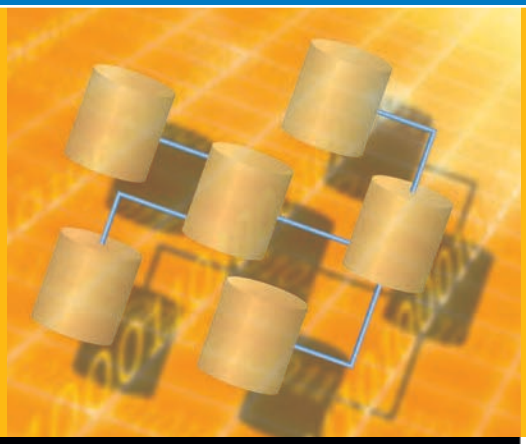
Resource Management Guide: ESX Server 3.0.1 and VirtualCenter 2.0.1:
www.vmware.com/pdf/vi3_esx_resource_mgmt.pdf

[5] The complete DVD Store application code is freely available for public use under the GNU General Public License (GPL) at linux.dell.com/dvdstore.



Deploying Dell iSCSI Storage with VMware Infrastructure 3

BY DAVE JAFFE, PH.D.

Dell™ Internet SCSI (iSCSI) storage arrays are designed to provide cost-effective, easy-to-deploy shared storage for software like the VMware® Infrastructure 3 server virtualization suite. This article discusses the key features of these arrays, outlines how administrators can configure them for use with VMware software, and provides test results comparing their performance in a virtualized environment.

Related Categories:

Dell PowerEdge servers

Dell PowerVault storage

Dell/EMC storage

Internet SCSI (iSCSI)

Virtualization

VMware

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Running server virtualization software such as VMware Infrastructure 3 on server farms connected to shared storage can provide several advantages. For example, by placing virtual machine (VM) virtual disks on storage area networks (SANs) accessible to all virtualized servers, VMs can easily migrate between servers as needed for load balancing or failover. VMware Infrastructure 3 provides this functionality through the VMware VMotion™ live migration technology in its Distributed Resource Scheduler feature. Shared storage is key to enabling VMotion, because when a VM migrates from one physical server to another, the virtual disk can remain where it is, with only its ownership changing. VMware Infrastructure 3 also provides a VMware High Availability (VMware HA) component that takes advantage of shared storage to quickly restart VMs on a different host should their original host fail.

Traditional networking technology employed in SANs uses the Fibre Channel interface. Products such as Dell/EMC Fibre Channel storage arrays can provide excellent performance, reliability, and functionality, but also typically require specialized hardware and skills to set up and maintain. A Fibre Channel fabric, for example, uses Fibre Channel host bus adapters (HBAs) in each server connected by fiber cables to one or more Fibre Channel switches, which in turn can connect multiple storage arrays supporting a scalable number of high-speed disk enclosures. Application I/O requests to storage originate as SCSI requests, then are encapsulated in a Fibre Channel packet by the HBA and sent to the appropriate storage array through a Fibre Channel switch, similar to the way that IP packets are sent over Ethernet.

For small IT organizations, those just beginning to implement virtualization, or those looking to create a second storage tier to complement an existing Fibre Channel infrastructure, another emerging shared storage model may be appropriate for their needs: Internet SCSI (iSCSI). In this model, communication between servers and storage uses standard Ethernet network interface cards (NICs), switches, and cables, allowing administrators to take advantage of their existing networking expertise and equipment to simplify SAN implementation. Application I/O requests originate as SCSI requests, then are encapsulated in standard IP packets and sent to the appropriate storage array through Ethernet switches and routers. Like Fibre Channel, iSCSI supports block-level data transmission for all applications, not just those from VMware. To help increase security, iSCSI can utilize Challenge Handshake Authentication Protocol (CHAP) authentication as well as IP security (IPsec) encryption.[1]

[1] For a more detailed introduction to iSCSI, see "iSCSI: Changing the Economics of Storage; Part 1—Understanding iSCSI in Enterprise Environments," by Travis Vigil, in *Dell Power Solutions*, May 2007, www.dell.com/downloads/global/power/ps2q07-20070335-Vigil.pdf.

Servers can communicate with iSCSI storage using two methods. The first uses an add-in card called an iSCSI hardware initiator or HBA (analogous to a Fibre Channel HBA) that connects directly to the Ethernet infrastructure. The second involves a software initiator that performs the iSCSI conversion at the software level and sends the Ethernet packets through the server's standard Ethernet NIC. Only software initiators are currently supported by VMware software, although VMware plans to support hardware iSCSI initiators in the future.

This articles discusses the key features of Dell iSCSI storage arrays, outlines how administrators can configure them for use with VMware software, and provides test results comparing their performance in a virtualized environment. The performance results represent an example of how these arrays can perform with a simple virtualization workload running on only five disks in each array. Typical enterprise use would employ larger arrays than those used in the test environment and support a variety of applications, which may result in varying performance.

Dell iSCSI storage arrays

Dell has introduced multiple iSCSI storage platforms in the last several years, including the Dell PowerVault™ NX1950, Dell/EMC CX3 Fibre Channel/iSCSI arrays, and the Dell/EMC AX150i. These three options are designed for use in different types and sizes of environments while being easy to configure when providing storage for VMware software–based hosts. Figure 1 summarizes key features of the four arrays tested by the Dell team for this article.

Dell PowerVault NX1950

The PowerVault NX1950 is an integrated storage solution that can provide both block-level data access using iSCSI as well as file-level data access over Ethernet using the standard Common Internet File System (CIFS) protocol for Microsoft® Windows® operating systems and the standard Network File System (NFS) protocol for Linux® operating systems. The high-availability PowerVault NX1950 consists of two clustered 1U, two-socket servers running Microsoft Windows Unified Data Storage Server 2003, connected using Serial Attached SCSI (SAS) to an integrated PowerVault MD3000 disk array with redundant embedded RAID controllers containing a total of 1 GB of cache. Windows Unified Data Storage Server 2003 provides an integrated console for storage systems management.

The PowerVault NX1950 is designed to offer a good entry point into storage virtualization while allowing small and midsize enterprises and remote offices to both consolidate file data and virtualize application data in one device. The integrated PowerVault MD3000 disk array can be expanded with up to two PowerVault MD1000 disk expansion enclosures (with up to 15 drives each) to accommodate future growth.

Dell/EMC CX3 Fibre Channel/iSCSI arrays

Dell/EMC CX3-10c, CX3-20c, and CX3-40c arrays provide both end-to-end 4 Gbps Fibre Channel and iSCSI SAN capabilities (see Figure 2). Each array includes two redundant storage processors and a standby power supply to enable the write cache on the storage processors. Administrators can manage these arrays using EMC® Navisphere® software. Although the CX3 Fibre Channel/iSCSI arrays can utilize their Fibre Channel and iSCSI ports simultaneously, a given server can only connect to them through one of these protocols at a time.

Dell/EMC AX150i

The entry-level Dell/EMC AX150i can house two storage processors and twelve 3.5-inch Serial ATA (SATA) II drives in a single 2U rack enclosure, and provides iSCSI connectivity through four Gigabit[2] Ethernet ports. It contains a 1 GB mirrored cache that uses an uninterruptible power supply to enable the write cache. Administrators can use EMC Navisphere Express software, a simplified version of EMC Navisphere, to manage this array.

	Disk type	Number of disks	Maximum number of disks	Disk size	Disk speed	Rack size (including standby power supply)	Cache size	List price (including storage software)*	"Starting at" price**
Dell PowerVault NX1950	SAS	15	45	146 GB	15,000 rpm	5U	1 GB	US$48,719	US$20,391
Dell/EMC CX3-20c	4 Gbps Fibre Channel	15	120	73 GB	15,000 rpm	5U	4 GB	US$77,052	US$52,862
Dell/EMC CX3-40c	4 Gbps Fibre Channel	15	240	73 GB	15,000 rpm	5U	8 GB	US$110,559	US$86,369
Dell/EMC AX150i	SATA II	12	12	250 GB	7,200 rpm	3U	1 GB	US$17,239	US$5,900

*All prices are given as of May 16, 2007. List prices include on-site SAN implementation services as well as Microsoft Windows Unified Data Storage Server 2003 Standard Edition for the PowerVault NX1950, EMC Navisphere Workgroup Edition for the CX3-20c and CX3-40c, and EMC Navisphere Express for the AX150i.

**"Starting at" price configurations are as follows: the PowerVault NX1950 includes Microsoft Windows Unified Data Storage Server 2003 Standard Edition, a single head, and two 36 GB, 15,000 rpm SAS drives; the CX3-20c and CX3-40c include EMC Navisphere Departmental edition and five 146 GB, 10,000 rpm drives; and the AX150i includes EMC Navisphere Express, one storage processor, and three 250 GB, 7,200 rpm SATA II drives.

Figure 1. *Features of Dell iSCSI storage tested by the Dell team*

[2] This term does not connote an actual operating speed of 1 Gbps. For high-speed transmission, connection to a Gigabit Ethernet server and network infrastructure is required.

iSCSI and VMware Infrastructure 3

Administrators can follow the steps described in this section to attach iSCSI storage to a VMware ESX Server host.[3] Once administrators have attached and formatted the storage, VMs can use the storage as virtual disks that appear as local storage.[4]

Configuring VMware ESX Server

A built-in software initiator provides connectivity from a host running ESX Server to the iSCSI storage. The physical NICs that connect to the Ethernet network in which the iSCSI storage is located must be included within a VMware virtual switch that also includes the VMware service console and the VMkernel (which supports VMotion traffic as well as iSCSI packets).

For a two-NIC system, administrators typically should team the NICs as shown in Figure 3, which helps provide NIC and cable failover and iSCSI traffic load balancing across the NICs to multiple iSCSI targets with different IP addresses. Because the VM and iSCSI traffic are mixed in this configuration, administrators should employ CHAP authentication and IPsec encryption in the iSCSI connection. (Alternatively, in a two-NIC configuration, they can provide total isolation by placing the VM and iSCSI traffic each on its own non-teamed NIC.) Administrators create network configurations in VMware VirtualCenter using the Virtual Infrastructure Client by highlighting the server to be connected, then selecting Configuration › Networking.

If a host server has more than two NICs available, administrators typically should create two virtual switches, one that hosts the service console and VMkernel (including iSCSI and VMotion traffic) and one that is dedicated to VM traffic. They should also cable the two NICs carrying iSCSI traffic to redundant Ethernet switches. Figure 4 shows an example four-NIC configuration using two groups of two-NIC teams.

Connecting VMware ESX Server hosts to the iSCSI array

Connecting ESX Server hosts to an iSCSI array requires three steps: configuring the iSCSI software initiator in ESX Server to point to the storage array, creating the host's disk logical units (LUNs) and configuring the storage array to enable host access, and formatting the storage with VMware Virtual Machine File System (VMFS).

Configuring the iSCSI software initiator. As a security measure, ESX Server disables iSCSI access by default. To enable it, from the ESX Server host in VirtualCenter, administrators can select ESX Server › Configuration › Security Profile › Properties › Enable Software iSCSI Client. Next, they can select Configuration › Storage Adapters and highlight "iSCSI Software Adapter," which should include SAN identifier information; in the Dell tests, for host r3esx1950c, the identifier was iqn.1998-01.com.vmware:r3esx1950c-7b658143. In the Details pane, administrators can then select Properties to bring up the iSCSI Initiator Properties page, select Configure, and select Status: Enabled if necessary. Finally, they can select the Dynamic Discovery tab and select "Add," and then, on the Add Send Targets Server page, enter the IP address of the iSCSI storage array and change the port from its default value of 3260 if necessary.

Creating the LUNs and configuring the storage array. First, administrators must create the LUNs that will be assigned to the VMware software on the storage array. For the PowerVault NX1950,

	CX3-10c	CX3-20c	CX3-40c
Rack size (including standby power supply and one disk array enclosure)	5U	5U	5U
Processors	Two at 1.8 GHz	Two at 2.8 GHz	Four at 2.8 GHz
Cache	2 GB	4 GB	8 GB
Front-end Fibre Channel ports	4	4	4
Front-end iSCSI ports	4	8	8
Back-end Fibre Channel loops	1	1	2
Maximum number of hard drives	60	120	240

Note: All figures are for two storage processors.

Figure 2. *Features of Dell/EMC CX3 Fibre Channel/iSCSI arrays*

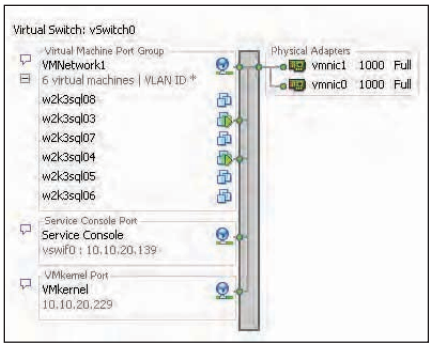

Figure 3. *Two-NIC iSCSI configuration in VMware VirtualCenter*

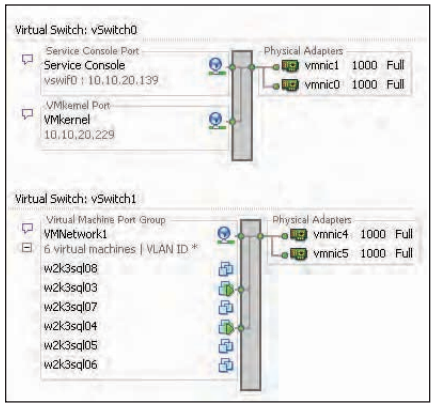

Figure 4. *Four-NIC iSCSI configuration in VMware VirtualCenter*

[3] For additional details about the process described in this section, including screenshots, visit the Dell Enterprise Technology Center wiki at www.delltechcenter.com/page/iSCSI+and+VMware.

[4] An alternative method, in which the VM is attached directly to iSCSI storage through a software iSCSI initiator supplied with the VM guest OS, can also be used. For more information, see "iSCSI: Changing the Economics of Storage; Part 2—Deploying iSCSI in Virtualized Data Centers," by Matt Baker and Travis Vigil, in *Dell Power Solutions*, August 2007, www.dell.com/downloads/global/power/ps3q07-20070401-Baker.pdf.

they can create these LUNs using the built-in Windows Unified Data Storage Server 2003 console; for the Dell/EMC CX3 Fibre Channel/iSCSI arrays and AX150i, they can use EMC Navisphere and Navisphere Express, respectively.

Administrators must then enter the ESX Server iSCSI identifier into the target array. To do so for the PowerVault NX1950, in the Windows Unified Data Storage Server 2003 console, they can select Microsoft iSCSI Software Target › iSCSI Target, right-click on the PowerVault NX1950 with the LUNs, and select Properties. Then, in the iSCSI Initiators tab, they can select Add › Identifier Type IQN, then enter the full SAN identifier in the Value field.

To enter the ESX Server iSCSI identifier into the Dell/EMC CX3 Fibre Channel/iSCSI arrays or AX150i, in Navisphere, administrators can right-click on the array, select "Connectivity Status," then select "New" to create a new initiator record. They can then specify the full SAN identifier as both initiator name and host name and specify the host IP address. Finally, they can select "Connect Hosts" to add this initiator to the storage group containing the appropriate disk LUN.

Formatting the storage with VMFS. Administrators can format the storage with VMFS in VirtualCenter by first selecting ESX Server › Configuration › Storage Adapters, then selecting Rescan › Scan for New Storage Devices, which should display the LUNs defined on the storage array. If no hosts have previously accessed a given LUN, administrators must format it with VMFS. From the Configuration tab, they can select "Storage (SCSI, SAN and NFS)" and click "Add Storage," then select "Disk/LUN" and select the LUN to be formatted. Next, they can enter a data store name (for example, "NX1950-1") and either accept the default Disk/LUN Formatting values for default maximum file size (256 GB), block size (1 MB), and capacity or edit them as needed. The data store should now appear in the list of storage devices. When the next ESX Server host is connected to the same iSCSI storage array, the data store should appear when administrators select Rescan › Scan for New Storage Devices.

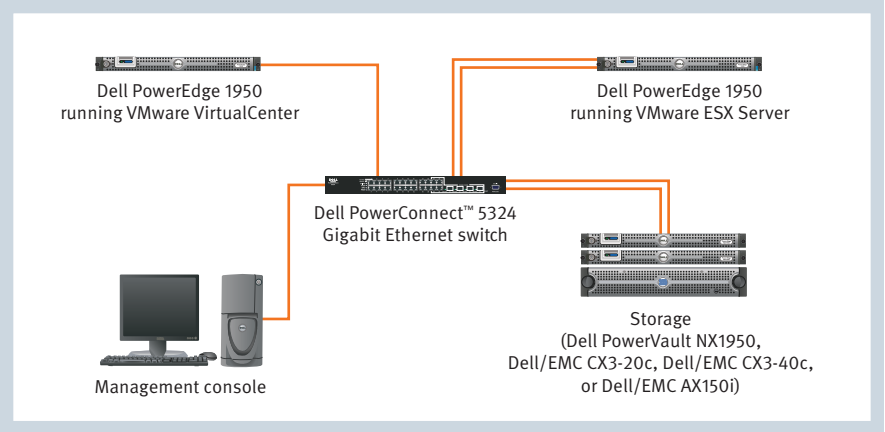

Figure 5. *Hardware configuration used in the test environment*

After adding the storage LUN to a host, administrators can create VMs on that host and configure the VM virtual disks to use the LUN storage. Because the LUN is shared across all ESX Server hosts connected to the storage array, VMs can easily move from one host to another using VMotion without disrupting their access to the virtual disks.

iSCSI storage test configuration and results

To provide a basic performance comparison of Dell iSCSI storage arrays, in April 2007 Dell Enterprise Technology Center engineers connected a Dell PowerEdge™ 1950 server with two quad-core Intel® Xeon® X5355 processors at 2.66 GHz and 8 GB of memory to five-disk RAID-5 LUNs on Dell PowerVault NX1950, Dell/EMC CX3-20c, Dell/EMC CX3-40c, and Dell/EMC AX150i storage as described in the preceding section. The tests used a two-NIC team for the VMware service console, VMkernel (including iSCSI traffic), and VM traffic as shown in Figure 3. The PowerVault NX1950 had fifteen 146 GB, 15,000 rpm SAS drives; the CX3-20c and CX3-40c each had one DAE4P disk array with fifteen 73 GB, 15,000 rpm drives; and the AX150i had two storage processors and twelve 250 GB, 7,200 rpm drives. Figure 5 illustrates the hardware configuration used in the test environment.

The test team created two ESX Server–based VMs running the Microsoft Windows Server® 2003 Release 2 (R2) OS, the Microsoft SQL Server™ 2005 database platform, and a medium-size (1 GB) version of the Dell DVD Store database online transaction processing (OLTP) application[5] with 10 GB virtual disks stored on a five-disk LUN on one array. They then cloned the VMs three times and placed the clones' virtual disks on similar LUNs on each of the other three arrays. Each VM had four virtual processors and 512 MB of memory, giving each virtual processor approximately the resources of a single processor core. Because the SQL Server database on each VM was created on its local disk and stored on the LUN, and the database size (1 GB) exceeded the VM memory (512 MB), SQL Server was forced to access the database from the LUN during the tests.

Test procedure and results

The team tested each VM pair using the DVD Store order entry simulator, which models users logging in to an online DVD store; browsing for DVDs by title, artist, or category; and finally making a DVD purchase. A complete cycle of logging in, browsing, and purchasing counts as one order. The simulator can control the number of users and the amount of time they spend thinking during an order; in these tests, the

[5] The complete DVD Store application code is freely available for public use under the GNU General Public License (GPL) at linux.dell.com/dvdstore.

team set the think time to 0 seconds, so that each driver thread can be thought of as a "super user" entering orders without stopping.

Starting with two such driver threads per VM, the test team applied a workload to each VM pair for four minutes and recorded the average number of orders per minute (OPM) and response time. They next restored the VM databases to their original state and ran the workload again with an increased number of driver threads, then continued increasing the number of driver threads until the OPM rate stopped increasing. At that point, the storage array could not handle any additional I/Os per second even as the workload increased. The team then repeated the tests on VMs utilizing each of the other three storage arrays.

Figures 6 and 7 summarize the test results. For this workload, the AX150i, PowerVault NX1950, CX3-20c, and CX3-40c handled a maximum of approximately 10,000, 15,500, 31,000, and 35,000 OPM, respectively. These were the maximum performance rates for five-disk LUNs on the four storage arrays in the test environment, and are intended to provide an example of their relative performance for a specific OLTP application using similarly configured disk sets. In a typical real-world implementation, each storage array would include many LUNs from a large number of VMs from varied sources across multiple disk cabinets, and performance would vary greatly depending on the particular application.

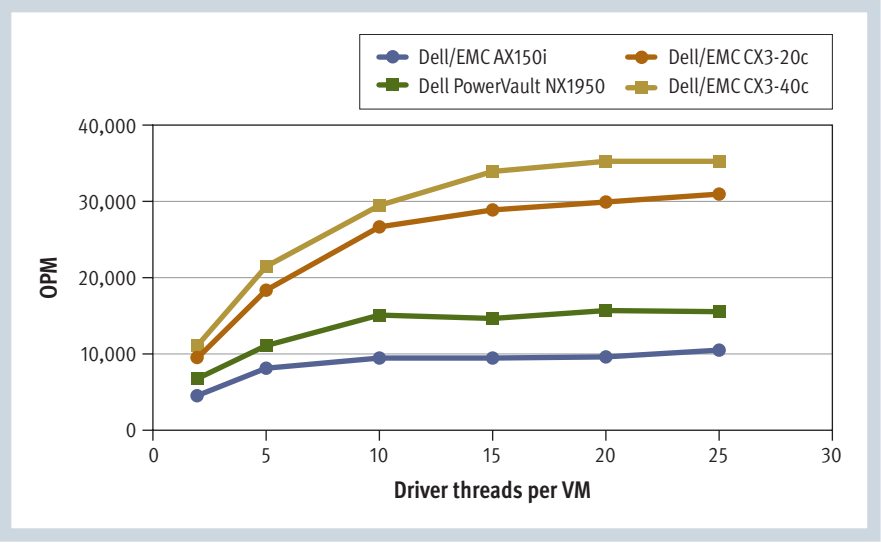

Figure 7. *Orders per minute by number of driver threads for each iSCSI storage array in the test environment*

Versatile, easy-to-manage storage for virtualized environments

Dell iSCSI storage arrays are designed to provide a range of performance and functionality for different types of applications and data center environments. The Dell PowerVault NX1950 is a flexible, cost-effective option for enterprises with file-intensive environments looking to deploy virtualization for a small amount of application data. For enterprises requiring robust, high-speed storage, especially those that have already invested in Dell/EMC hardware and expertise, Dell/EMC CX3 Fibre Channel/iSCSI arrays can allow them to deploy large iSCSI-based SANs either as stand-alone systems or in conjunction with existing Fibre Channel–based SANs, while the Dell/EMC AX150i may be appropriate for enterprises looking to create an entry-level iSCSI-based SAN. Combining these arrays with VMware virtualization software can provide versatile, easy-to-manage virtualized environments for enterprises of all sizes.

Dave Jaffe, Ph.D., *is a senior consultant on the Dell Enterprise Technology Center team who specializes in cross-platform solutions. He has a B.S. in Chemistry from Yale University and a Ph.D. in Chemistry from the University of California, San Diego.*

	Dell/EMC AX150i		Dell PowerVault NX1950		Dell/EMC CX3-20c		Dell/EMC CX3-40c	
Driver threads per VM	OPM	Response time	OPM	Response time	OPM	Response time	OPM	Response time
2	4,486	51 ms	6,719	33 ms	9,282	23 ms	10,543	21 ms
5	7,930	73 ms	11,174	51 ms	18,349	30 ms	21,426	25 ms
10	9,494	124 ms	14,980	75 ms	26,655	41 ms	29,570	37 ms
15	9,486	188 ms	14,682	119 ms	28,891	58 ms	33,803	49 ms
20	9,641	245 ms	15,566	149 ms	29,937	75 ms	35,074	63 ms
25	10,231	291 ms	15,437	190 ms	30,894	92 ms	35,173	80 ms

Figure 6. *Orders per minute and response times for each iSCSI storage array in the test environment*

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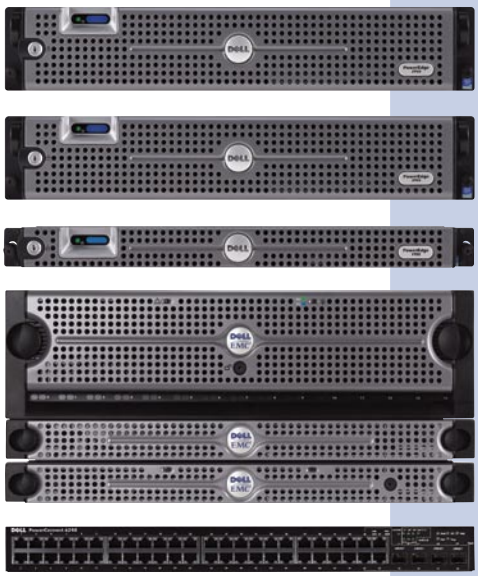

Host Servers

- VMware Infrastructure 3 Enterprise Edition
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Management Server

- VMware VirtualCenter Management Server
- Qty. 1: Dell PowerEdge 1950 server

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Using XenSource XenEnterprise with Dell Servers and Dell OpenManage

BY VICTOR MASHAYEKHI, PH.D.
PUNEET DHAWAN
SIMON CROSBY
ROGER B. A. KLORESE

Combining XenSource XenEnterprise software with Dell™ PowerEdge™ servers can provide a scalable, efficient virtualized environment in enterprise data centers. This article describes key features of XenEnterprise 3.2 and outlines how administrators can install and configure Dell OpenManage™ software to simplify management of XenEnterprise hosts.

Related Categories:

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Virtualization can offer multiple advantages in enterprise environments, including increased resource utilization, efficient server consolidation, scalable test and development environments, and high availability through dynamic provisioning. The Xen hypervisor at the core of the XenSource XenServer software family can provide these same benefits along with additional features, including a powerful virtualization architecture called paravirtualization. Combining XenSource software with standards-based Dell PowerEdge servers and the Dell OpenManage systems management suite can provide an excellent platform for virtualized data centers.

Comparing emulation virtualization and paravirtualization

First-generation emulation hypervisors present each virtual machine (VM) with an emulated hardware layer that offers the guest OS the illusion of a standard server with standard hardware devices. When a running guest OS attempts to control the hardware using privileged instructions, the hypervisor stops execution and emulates the legacy hardware device, hiding the real hardware. It then patches the OS code of the running guest in real time to help ensure that its future hardware access functions correctly. Of course, this complexity can reduce performance, much as emulated floating-point computation did prior to the implementation of hardware floating-point support.

Paravirtualization, pioneered by the XenSource founders, can deliver near-native performance for VMs while helping ensure that physical resources are shared between them in a balanced way. Xen guest operating systems interface with the hypervisor through the hypercall application programming interface (API) rather than through hardware emulation. This approach allows the hypervisor and OS to cooperate to optimally virtualize the underlying hardware and schedule guest OS virtual processors and I/O, helping increase performance, security, and portability compared with emulation virtualization.

Another key advantage of Xen paravirtualization is that it can reuse the hardware qualification and driver certification of existing operating systems. The driver stack is simply a standard OS, certified on the hardware by the system vendor, with specific privileges to perform I/O to real hardware on behalf of other guest operating systems. This use of an off-the-shelf OS helps eliminate the need to import drivers into a separate hypervisor.

Both Intel® Virtualization Technology and AMD Virtualization™ technology provide a processor-level hardware-accelerated vector that automatically enters the hypervisor (akin to a hardware hypercall) when a running guest OS executes a privileged operation. Intel and AMD also offer instructions allowing Xen guests to benefit from paravirtualized I/O. Many servers—including ninth-generation Dell

"Paravirtualization can deliver near-native performance for VMs while helping ensure that physical resources are shared between them in a balanced way."

PowerEdge servers—now support this hardware assistance for virtualization, likely signaling the end of first-generation emulation. Figure 1 illustrates some of the key differences between these two approaches.

Exploring XenSource XenEnterprise

The XenSource XenServer 3.2 family—comprising XenEnterprise, XenServer, and XenExpress software—is designed to offer the advantages of Xen paravirtualization as part of a comprehensive, easy-to-use enterprise virtualization solution. XenEnterprise, built on the open source Xen hypervisor, enables multiple levels of consolidation for mainstream servers and is designed to support both Microsoft® Windows® and enterprise Linux® operating systems, including the same set of server hardware, storage, and I/O devices as standard enterprise Linux distributions. It incorporates the Xen hypervisor, easy-to-use installers for Xen and guest operating systems, physical-to-virtual (P2V) conversion tools to help administrators virtualize existing server OS installations, and a multi-server management console in a single package.

XenServer and XenExpress include different functionality subsets of XenEnterprise at a lower cost: XenServer offers high-performance virtualization for Windows-based VMs while providing the same multi-server management capabilities as XenEnterprise, and XenExpress offers free entry-level server virtualization for Windows- and Linux-based VMs with single-server management. Administrators can easily upgrade servers from XenServer or XenExpress to XenEnterprise without reinstalling the software or losing VM configurations, in many cases simply by entering a new license key.

XenSource XenEnterprise architecture

XenEnterprise is a virtualization platform for Windows and Linux guest operating systems that is designed to support both paravirtualized and fully virtualized VMs and to deliver fast paravirtualized I/O for all guest operating systems. It utilizes Intel Virtualization Technology and AMD Virtualization—both of which are available on ninth-generation Dell PowerEdge servers—to run Windows and other unmodified guest operating systems. In addition, Microsoft Services Premier Support customers can utilize Microsoft support for the Windows guest operating systems running on XenEnterprise.

Deploying XenEnterprise in enterprise data centers can help administrators enhance the performance of legacy Windows and Linux systems while still taking advantage of the paravirtualization support in later Windows and Linux OS releases. In XenSource tests, for example, the combination of paravirtualization and hardware-assisted virtualization, coupled with the enhanced disk and network drivers for Windows supplied in XenEnterprise, delivered performance comparable to that of other leading virtualization platforms across a broad range of Windows benchmarks. XenEnterprise also delivered significant performance increases over traditional binary translation virtualization for Linux benchmarks.[1]

Figure 2 illustrates the virtualization architecture of XenEnterprise 3.2. XenEnterprise is based on the Xen hypervisor, which is loaded directly on the server hardware when the server is booted. The hypervisor boots a privileged VM known as Domain 0 (Dom0), which is based on the Community Enterprise Operating System (CentOS) 4 distribution and provides management services for other VMs. Within Dom0, the back-end

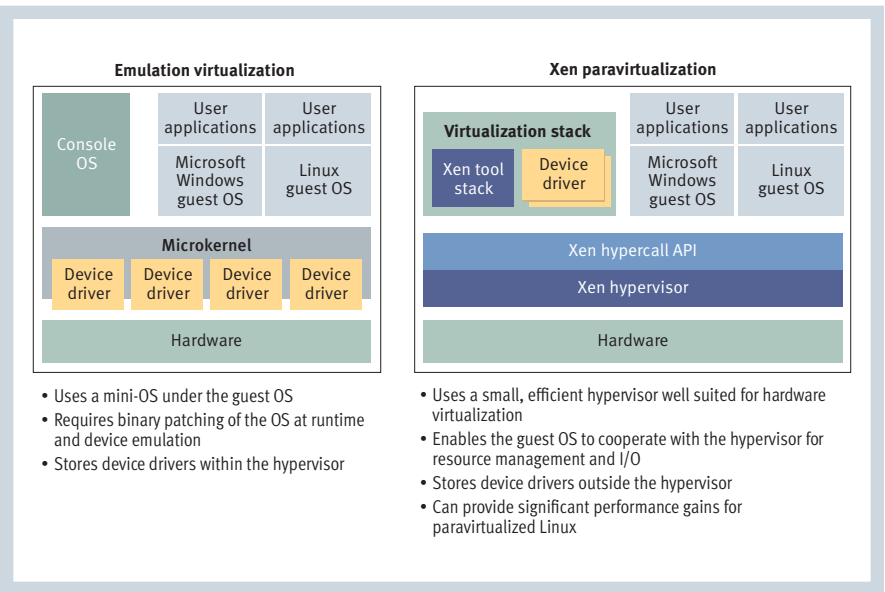

Figure 1. *Emulation virtualization compared with Xen paravirtualization*

[1] For a detailed performance analysis, see "A Performance Comparison of Commercial Hypervisors," by XenSource, www.xensource.com/performancepaper200703.

I/O drivers that provide access to devices perform I/O on behalf of the front-end drivers in other VMs; these I/O operations are passed through a high-performance memory-mapped communications channel within the Xen hypervisor known as XenBus.

Dom0 also runs the agent infrastructure used to provide and coordinate VM management services and life cycle control; administrators can access Dom0 through a graphical user interface (GUI) or command-line interface (CLI). Interactions with the hypervisor are then performed through the control API, for which processes running in Dom0 serve as the client for the server provided by the hypervisor. For VMs using hardware-assisted virtualization (primarily Windows guest operating systems, but also Linux guest operating systems that take advantage of installation processes using in-place P2V technology), the open source QEMU emulator provides basic I/O services for installation and boot until the optimized paravirtualized drivers are loaded, as well as support services for low-speed devices such as CD drives.

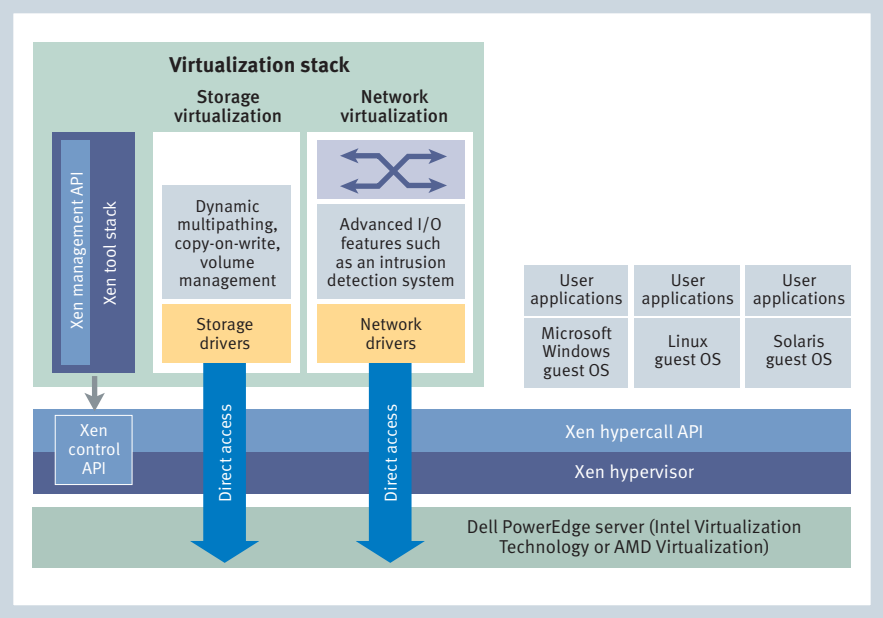

Figure 2. *XenSource XenEnterprise architecture*

XenSource XenEnterprise features

XenEnterprise is designed to enable administrators to consolidate server deployment and management easily and cost-effectively, supporting targeted workloads such as file, print, Web, directory, and infrastructure services; multiple development and testing environments and multitiered applications; and branch office and departmental consolidation. In addition to the efficient, high-performance virtualization provided by the Xen hypervisor, XenEnterprise provides the components of a comprehensive virtualization platform, including the following features:

- A simplified bare-metal installer that helps administrators quickly prepare Dell PowerEdge servers for Xen virtualization, either by booting from a CD—or a virtual CD provided by the Dell Remote Access Controller (DRAC) management interface—and answering a few simple questions, or by preparing an answer file and installing the software using Preboot Execution Environment (PXE) boot
- Optimized disk and network drivers for Windows guest operating systems, helping increase I/O performance for critical services
- A one-to-many administrator GUI available from Windows- and Linux-based management stations that administrators can use to create, manage, and monitor multiple VMs and interact with their consoles or, alternatively, launch other desktop interfaces such as Windows Remote Desktop (see Figure 3)
- A powerful CLI for managing the VM life cycle from creation through start, stop, suspend, and resume iterations, helping manage VM configuration, allocation, and associated storage
- The ability to clone VMs through the GUI or CLI and export them to a desktop system or another server, preparing them for import to the same or another XenEnterprise system
- Guest OS installers and P2V conversion tools for common Linux distributions, providing rapid Linux-based VM implementation and deployment

XenSource also plans for XenEnterprise to soon provide an increased range of data center–class features, including the following:

- A 64-bit hypervisor, offering support for both 64- and 32-bit guest operating systems as well as increased physical and guest OS memory
- Support for shared storage as well as enhanced Fibre Channel and iSCSI integration
- Live and static migration of VMs between servers
- An XML-RPC API offering control over VM life cycles and server and storage configuration as well as enhanced scripting and management software integration

Using Dell OpenManage software with XenSource XenEnterprise hosts

Ninth-generation Dell PowerEdge servers are designed to scale efficiently and optimize virtualized workloads, supporting Intel Virtualization Technology or AMD Virtualization, quad-core processors, large amounts

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of memory, PCI Express I/O, Serial Attached SCSI (SAS), 4 Gbps Fibre Channel storage, and efficient power consumption. Administrators can manage Dell systems running XenEnterprise using Dell OpenManage Server Administrator (OMSA) and Dell OpenManage IT Assistant.

Installing Dell OpenManage Server Administrator on XenEnterprise 3.2 hosts

OSMA is a comprehensive systems management tool for Dell PowerEdge servers designed to simplify administration of local and remote systems through a set of integrated services. It resides solely on managed systems and is accessible both locally and remotely; on XenEnterprise virtualized systems, the OMSA agent resides in Dom0. Although OMSA is not supported by Dell inside CentOS distributions, administrators can use it to manage XenEnterprise hosts by performing the following steps, which apply to OMSA 5.2 on a server running Red Hat® Enterprise Linux 4:

1. Download the Dell OpenManage Server Administrator Managed Node software package for Red Hat Enterprise Linux 4 from support.dell.com.
2. Copy the tar.gz file to the XenEnterprise host.
3. Extract the tar.gz file with the command `tar -zxvf filename.tar.gz`.
4. Edit the setup script to enable installation on a XenEnterprise host. To do this, first change the permissions of the setup.sh script by using the command `chmod +w setup.sh`. Next, edit the file with the `vi setup.sh` command and locate the following at line 2,976:

```
# Set default values for return variables.
GBL_OS_TYPE=${GBL_OS_TYPE_UKNOWN}
GBL_OS_TYPE_STRING="UKNOWN"
```

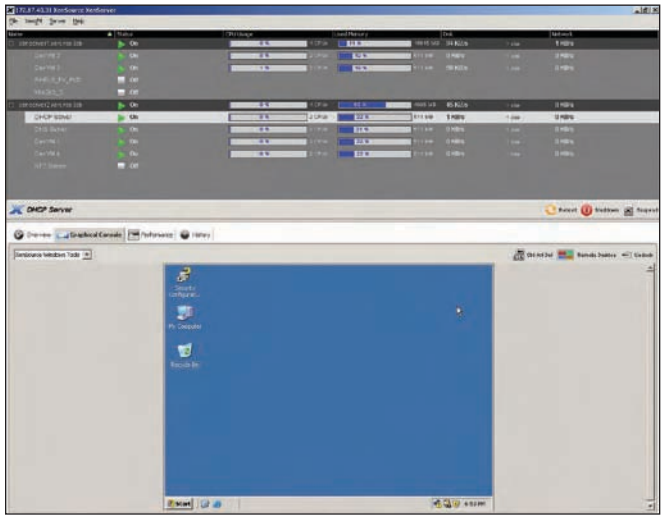

Figure 3. *One-to-many administrator GUI for the XenSource XenServer family*

Change these lines to the following, then save the changes and close the file:

```
# Set default values for return variables.
GBL_OS_TYPE=${GBL_OS_TYPE_RHEL4}
GBL_OS_TYPE_STRING="RHEL4"
```

5. Install the compat-libstdc++-33-3.2.3-47.3.i386.rpm package on the XenEnterprise host by using the following command from the linux/RPMS/supportRPMS directory:

```
rpm -ivh compat-libstdc++-33-3.2.3-47.3.i386.rpm
```

6. Download the procmail-3.22-14.i386.rpm package from mirror.centos.org/centos/4/os/i386/CentOS/RPMS, then install it with the following command:

```
rpm -ivh procmail-3.22-14.i386.rpm
```

7. Start the OMSA installation using the command `./setup.sh`, then follow the on-screen instructions to complete the installation.
8. After completing the installation, change the firewall settings to allow communication through the ports that OMSA uses. First, edit the firewall rules with the `vi /etc/sysconfig/iptables` command. Next, add the following rules to the `INPUT` section below the `:INPUT ACCEPT [0:0]` line to open the OMSA and Simple Network Management Protocol (SNMP) ports, then save and close the file:

```
-A INPUT -p tcp -m tcp --sport 1024:65535
  --dport  1311 -m state --state NEW -j ACCEPT
-A INPUT -p tcp -m tcp --sport 1024:65535
  --dport  1311 -j ACCEPT
-A INPUT -p udp --dport 161 -j ACCEPT
```

Finally, restart the iptables service with the command `service iptables restart`.

9. Open the server's OMSA Web interface at https://*server*:1311 and log in with the root username and password.

Note: Because OMSA is not supported by Dell inside CentOS distributions, the preceding steps are provided without implied support or warranty.

Configuring Dell OpenManage IT Assistant to manage XenEnterprise hosts

Dell OpenManage IT Assistant is a comprehensive, standards-based console for managing Dell servers, storage, tape libraries, network switches,

"XenEnterprise can play a key role in building a scalable, efficient enterprise data center."

printers, and client systems. It allows administrators to use a central Web browser–based console to monitor the health and status of Dell systems, capture events and alerts generated by Dell servers running OMSA, configure actions based on these events and alerts, and monitor server performance statistics such as processor and memory utilization, I/O, and so on.

Dell OpenManage IT Assistant uses SNMP to manage Dell servers running Linux distributions. If administrators have installed the IT Assistant management application on their network, they can use IT Assistant to manage XenEnterprise hosts. To do so, they should edit the /etc/snmp/snmpd.conf file on the XenServer hosts as follows:

1. Locate the line that reads `com2sec notConfigUser default public`, then replace `public` with the new SNMP community name.
2. Add the following line at the end of the file (where *`ipaddress`* is the IP address of the IT Assistant server and *`community`* is the SNMP community name):

   `trapsink` *`ipaddress community`*

3. Save the snmpd.conf file and restart the snmpd service with the command `service snmpd restart`.

For more information on IT Assistant, see the *Dell OpenManage IT Assistant User's Guide*.

Supporting XenSource environments

XenSource provides freely available support resources at www.xensource.com/support, including software documentation, a searchable knowledge base, and discussion forums. XenSource also offers paid support services that allow administrators to enter support cases and upload related information such as logs and screenshots through a Web-based interface. Additional details on these paid support services are available in the XenSource Technical Support Guide at www.xensource.com/support/guide/tech_support_guide.html.

Implementing scalable, efficient virtualization

The XenSource XenEnterprise paravirtualization architecture can provide several advantages over emulation virtualization, including near-native VM performance and the efficient allocation of physical resources. As a virtualization platform running on Dell PowerEdge servers and managed by Dell OpenManage software, XenEnterprise can play a key role in building a scalable, efficient enterprise data center.

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Simon Crosby *is the chief technology officer at XenSource. Previously, he was a principal engineer at Intel; founder and chief technology officer of CPlane Inc., a network optimization software vendor; and tenured faculty member at the University of Cambridge, where he led research on network performance and multimedia operating systems. He is the author of over 35 research papers and patents.*

Roger B. A. Klorese *is the senior director of product and solutions marketing at XenSource. He previously served as vice president of marketing at Trigence and Sychron, and in a variety of marketing, product management, and product support roles at VMware, Veritas, Hewlett-Packard, Consera, Sendmail, MIPS Computer Systems, Celerity Computing, and Prime Computer. He studied Critical Studies (English and Film) and Computer Science at Dartmouth College.*

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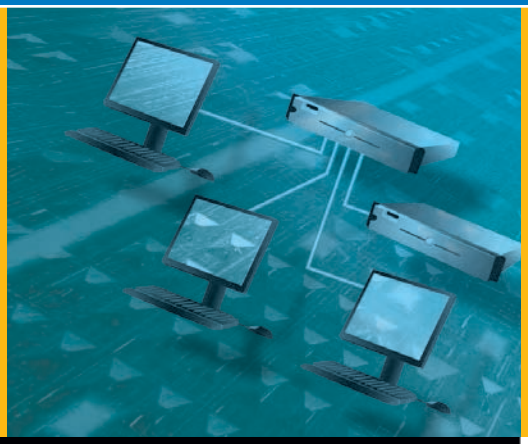

Virtualization Management Using Microsoft System Center and Dell OpenManage

BY BALASUBRAMANIAN CHANDRASEKARAN
RANJITH PURUSH
BRENT DOUGLAS
DAVID SCHMIDT

Managing large virtualized environments can be challenging and time-consuming. This article outlines how enterprises can use Microsoft® System Center Virtual Machine Manager 2007, Microsoft System Center Operations Manager 2007, and the Dell OpenManage™ suite to help simplify administrative tasks and enhance operational efficiency in virtualized data centers.

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Virtualization is a powerful technology that enables enterprises to consolidate servers and storage, isolate systems from one another, and rapidly deploy new systems. However, virtualization can also lead to increased management requirements, from performing critical life cycle and systems management tasks to deploying features designed to take advantage of virtualization's advanced capabilities.

Microsoft offers several tools that administrators can integrate with the Dell OpenManage suite to help simplify the management of virtualized environments on Dell™ PowerEdge™ servers. Microsoft System Center Virtual Machine Manager (VMM), which will be released later in 2007, delivers centralized management of Microsoft Virtual Server–based systems, and includes features such as physical-to-virtual (P2V) conversion, virtual machine (VM) provisioning tools, and intelligent VM deployment. Integrating VMM with Microsoft System Center Operations Manager 2007 and the Dell Management Pack (MP) allows VMM to monitor the environment and allocate VMs effectively across the entire data center.

Microsoft System Center Virtual Machine Manager

VMM, one of the key components of the Microsoft System Center suite, is a one-to-many manager for Microsoft Windows® OS–based VMs. VMM facilitates the deployment of Microsoft Virtual Server software, rapid and intelligent provisioning of VMs on physical servers, and management of VMs across multiple servers.

Key components

Figure 1 illustrates the key components of a VMM infrastructure, which include the following:

- **VMM server:** The VMM server runs the core application that communicates with VM hosts through VMM agents and maintains system information in the VMM database. Administrators can access it through the VMM Administrator Console, VMM provisioning Web portal, and scripting client.
- **VMM Administrator Console:** Administrators can use the VMM Administrator Console to add and manage hosts, create and manage VMs, monitor tasks, and administer the Web portal. This console is a stand-alone application built on Microsoft Windows PowerShell technology, and can be installed on a variety of systems to help administrators remotely manage VMs.
- **VMM delegated management and provisioning Web portal:** The VMM Web portal is a Web page through which authorized users can create and manage VMs that are delegated to them. Administrators determine who can create VMs, which hosts their VMs can run on, which templates they can use, and which actions they can take on their own VMs. Administrators can also monitor resource utilization and use this information to bill VM users accordingly.
- **VMM database:** The VMM database stores configuration and performance information for hosts and VMs.

Key features

Key features of VMM include centralized management, Virtual Server software deployment, optimized VM placement, P2V conversion, a central library, and scripting and automation.

Centralized management. VMM provides centralized management of VMs as well as the physical servers hosting them. Administrators can use VMM to perform basic VM operations such as creating VMs, powering them up and down, cloning, performing offline migrations, creating checkpoints, and configuring virtual hardware. They can also easily add, group, and manage hosts running Virtual Server, including setting host server properties such as host reserves and configuring virtual networks.

Microsoft Virtual Server software deployment. Administrators can easily add new physical servers to VMM. When they do so, VMM can use the existing Microsoft Active Directory® directory service infrastructure to automatically install Virtual Server along with VMM agents on these new servers, allowing the servers to host VMs and communicate with VMM for monitoring and management.

Optimized VM placement. VMM can intelligently place VMs to optimize resource utilization, recommending a physical server based on VM resource requirements supplied by administrators. VMM bases its recommendations on the physical servers' processor, memory, disk, and network characteristics, then ranks them using a weighted sum of available resources. Once administrators have chosen from the ranked list, VMM creates and deploys the new VM on the selected server.

P2V conversion. The P2V wizard in VMM helps simplify the migration of physical systems to VMs, including recommending a physical host for the new VM. VMM uses Microsoft Volume Shadow Copy Service (VSS) in the Microsoft Windows Server® 2003 OS to create VMs quickly and without requiring downtime for the source physical server. VMM currently supports P2V conversion of servers running Microsoft Windows 2000 Server or Windows Server 2003. VMM can also integrate with Operations Manager 2007 to identify potential candidates for P2V conversions (see the "Integrated virtual machine provisioning and management" section in this article).

Central library. VMM provides administrators with a centralized library containing the building blocks for a virtual infrastructure. Objects that the library can contain include VM templates, virtual disk files, virtual CD ISO files, virtual floppy image files, hardware profiles that can be assigned to new VMs, and post-deployment customization scripts. The library is maintained by one or more library servers, each with its own owners and access control.

Scripting and automation. The VMM Administrator Console and provisioning Web portal are built on Microsoft Windows PowerShell, as shown in Figure 1. PowerShell provides a powerful scripting and automation interface directly to the VMM core engine, enabling administrators to perform VMM graphical user interface (GUI) functions using PowerShell. VMM also allows administrators to view the equivalent PowerShell scripts for tasks when using the GUI.

Microsoft System Center Operations Manager 2007

Operations Manager 2007 is a comprehensive, end-to-end service management tool designed to work seamlessly with other Microsoft software, helping administrators efficiently monitor their entire data center from a single console. Operations Manager 2007 and VMM both belong to the System Center product family, and their tight integration allows enhanced management capabilities.

Key features of Operations Manager 2007 include the following:

- **Health monitoring:** Administrators can monitor thousands of events and performance counters across hundreds of servers, operating systems, and applications to provide a single view of data center health.
- **Alert monitoring:** Operations Manager 2007 can combine alerts for critical events requiring action, helping administrators respond quickly to events that may affect normal operations.
- **Tasks:** Administrators can investigate and resolve problems from the Operations Manager 2007 Operations Console by using built-in as well as custom tasks, and take advantage of the detailed troubleshooting and best-practices information provided by Operations Manager 2007 to guide them through problem resolution.
- **Diagram views:** Administrators can access graphical and hierarchical views of the

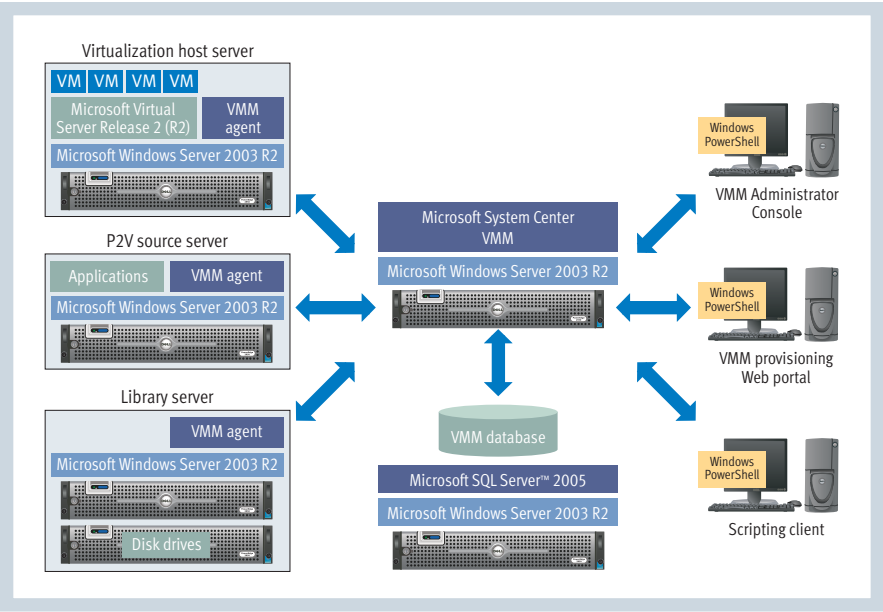

Figure 1. *Key components of a Microsoft System Center Virtual Machine Manager infrastructure*

different hardware and software components of their data center.

- **Reporting:** Operations Manager 2007 can generate a variety of reports based on events, alerts, and performance data stored in its data warehouse.
- **Audit collection:** Operations Manager 2007 can automate the collection and consolidation of auditable events from Windows security logs, enabling enterprises to meet regulatory compliance requirements.

Figure 2 illustrates the key components of a basic Operations Manager 2007 infrastructure.

Management packs

A key feature of Operations Manager 2007 is the ability to expand its capabilities through MPs, which allow it to discover, monitor, troubleshoot, report on, and resolve problems for specific components. MPs are available for products from Microsoft as well as numerous third-party vendors, including Dell. Two MPs in particular add important functionality that allows administrators to integrate VMM and Operations Manager 2007 to effectively manage a virtualized environment on Dell PowerEdge servers: the Microsoft Server Virtualization MP and the Dell MP.

Microsoft Server Virtualization MP. The Microsoft Server Virtualization MP is actually a collection of MPs, and is central to integrating VMM with Operations Manager 2007. It enables administrators to centrally monitor and manage both virtual and physical environments and their workloads.

Key functionality added to Operations Manager 2007 by this MP includes the following:

- Graphical mapping of VMs to physical hosts at any given point in time
- Real-time monitoring of VMs and alert generation for VM resource utilization, heartbeats, and other resources
- Reporting capabilities to help identify candidates for P2V conversion based on historical processor, memory, disk, and network utilization; show historic resource utilization and trends for both hosts and VMs; and allow tracking of resource allocations across cost centers, which enterprises can then use to bill based on usage
- Operations Manager 2007 VM utilization reports accessible in the VMM console
- Ability to launch the Virtual Server Web browser–based administration GUI from Operations Manager 2007

Dell MP. The Dell MP reports Dell-specific server and application alerts through the Operations Manager 2007 Operations Console, helping simplify management of these systems. Features introduced in this MP for Operations Manager 2007 provide reports and pre-failure alerts, and enable administrators to view information on specific hardware components to help ensure the continuous availability of Dell servers. In addition to installing the Dell MP, administrators should install Dell OpenManage Server Administrator (OMSA) on managed servers to enable Operations Manager 2007 to capture Dell-specific alerts.

Key functionality added to Operations Manager 2007 by the Dell MP includes the following:

- Generation of Dell-specific alerts for server hardware events, such as chassis intrusion and abnormal temperature or voltage
- In-band management allowing administrators to launch the OMSA console from Operations Manager 2007 alerts and clear Embedded Server Management (ESM) logs
- Out-of-band management allowing administrators to launch the Dell Remote Access Controller (DRAC) console from Operations Manager 2007 alerts (only available on servers supporting the DRAC III or later)
- Extensive knowledge base providing typical resolutions for Dell-specific alerts
- Server-specific information such as service tag, asset tag, IP address, and model

The latest Dell MP for Operations Manager 2007 is available for download from support.dell.com. Dell MP versions earlier than 3.0 are not compatible with Operations Manager 2007.

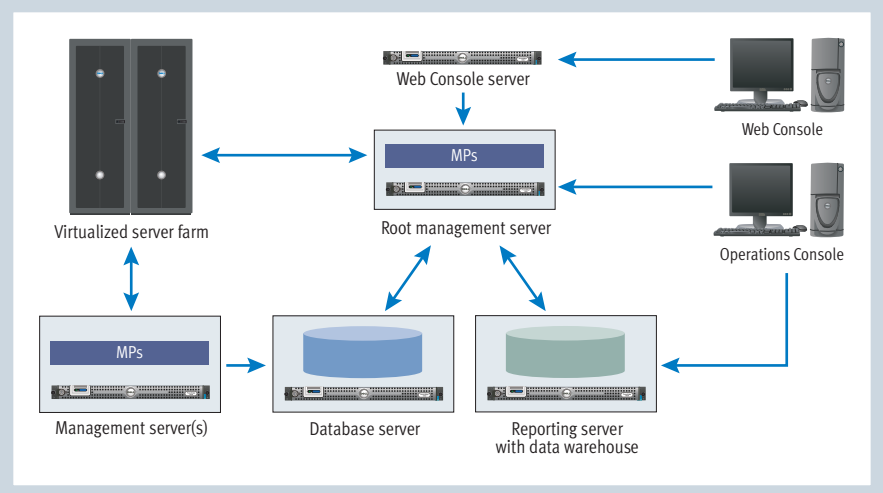

Figure 2. *Key components of a Microsoft System Center Operations Manager 2007 infrastructure*

Dell OpenManage systems management suite

The Dell OpenManage suite, which includes OMSA and Dell OpenManage IT Assistant, is designed to simplify the monitoring and management of Dell systems. OMSA is a comprehensive one-to-one systems management application that allows administrators to manage both local and remote systems. It provides an integrated Web browser–based GUI and an OS-based command-line interface (CLI).

Dell OpenManage IT Assistant provides a central console to monitor and manage systems

on a local or wide area network. Similar to the way Operations Manager 2007 aggregates system data, IT Assistant presents administrators with a comprehensive view of their network, helping automate repetitive tasks, increase system uptime, and prevent interruption of critical operations. Administrators can use IT Assistant to create tasks that apply to a single system or each system in a group, create dynamic groups of systems to facilitate management, and inventory systems. In addition, IT Assistant provides a consolidated launch point for OMSA, Dell OpenManage Array Manager, and Dell OpenManage Switch Administrator; DRAC consoles; and printer, tape, storage, IPMI, and digital keyboard, video, mouse (KVM) devices.

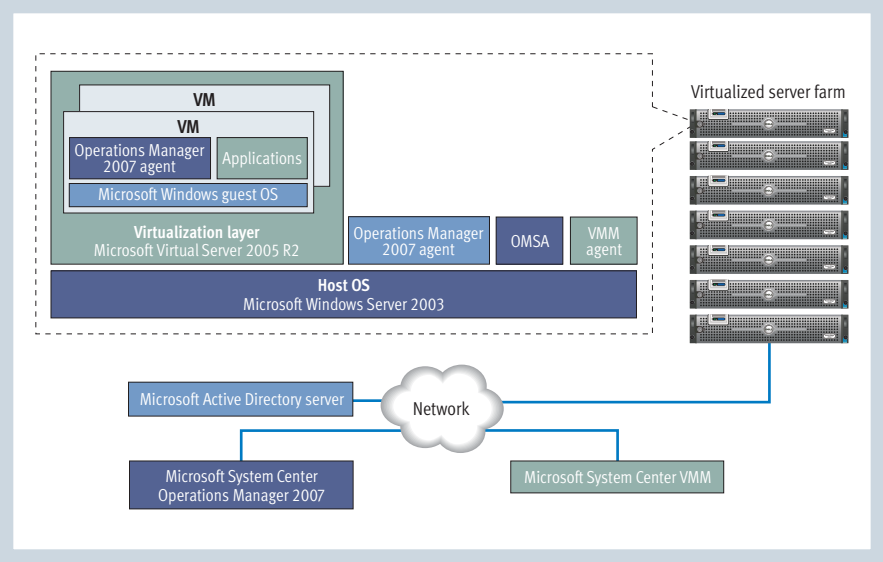

Figure 3. *Example environment using Microsoft System Center Virtual Machine Manager and Microsoft System Center Operations Manager 2007*

Integrated virtual machine provisioning and management

Integrating VMM and Operations Manager 2007 can help administrators increase VM availability and perform seamless P2V migrations on Dell PowerEdge servers. For example, the Operations Manager 2007 reporting component tracks the resource utilization of physical servers, and VMM can use this information to make recommendations about VM placement and identify potential P2V conversion candidates. Administrators can then use the P2V capability in VMM to migrate the OS and hosted applications from physical servers into an intelligently configured virtualized environment.

In addition, to help increase VM availability, VMs can be moved across physical servers based on host health. Operations Manager 2007 can trigger custom tasks, based on alerts and administrator-configured policies, that launch scripts in VMM to migrate VMs across hosts.

Figure 3 illustrates an example environment using both VMM and Operations Manager 2007. Figure 4 summarizes the management functionality available across VMM, Operations Manager 2007, and Dell OpenManage to show how administrators can use these tools together to help provide end-to-end management of virtual and physical server environments. The "Best practices for managing virtualized Microsoft Windows environments on Dell servers" sidebar in this article summarizes some of the ways administrators can use Operations Manager 2007 to efficiently manage virtualized Windows environments on Dell PowerEdge servers.

BEST PRACTICES FOR MANAGING VIRTUALIZED MICROSOFT WINDOWS ENVIRONMENTS ON DELL SERVERS

The following best practices can help administrators use Microsoft System Center Virtual Machine Manager and Operations Manager 2007 to efficiently manage virtualized Windows environments on Dell PowerEdge servers:

- To have both in-band and out-of-band management capabilities on Dell servers, administrators should install the Dell MP for Operations Manager 2007. They should also install OMSA on all Dell servers.
- Although Operations Manager 2007 supports agentless server management, in which no Operations Manager 2007 agents are installed on the managed servers, the additional functionality provided by the various MPs is not available in agentless managed servers. To allow comprehensive management functionality, administrators should use agent-managed servers.
- The Operations Manager 2007 agent can be pushed to VMs through the Operations Manager console, or it can be manually installed on the VMs. However, a better implementation would be to add the agent to the base VM image. When such an image is deployed, the Operations Manager 2007 agent queries Microsoft Active Directory and automatically communicates with the appropriate management server.
- To help optimize VM monitoring and provide virtualization-specific reporting features, administrators should add Windows guest operating systems running in a Windows virtualized environment as agent-managed servers in Operations Manager 2007.
- To allow Operations Manager 2007 to monitor VM heartbeats and report VM states, Windows guest operating systems should also be running Microsoft Virtual Server Virtual Machine Additions.

Category	Management task	VMM	Operations Manager 2007 with the Microsoft Server Virtualization MP and Dell MP	Dell OpenManage
Installation	Installing Microsoft Virtual Server	✔		
	Installing Operations Manager 2007 MPs		✔	
	Installing VMs	✔		
	Installing OMSA			✔
P2V conversion	Identifying candidates for P2V conversion	✔*	✔	
	Performing P2V conversion with intelligent VM placement	✔		
VM management	Creating VMs	✔		
	Intelligently placing VMs	✔		
	Cold migrating VMs	✔		
	Managing VM states (start/stop)	✔	✔	
	Starting and stopping Virtual Server service		✔	
	Delegating rights to provision and manage VMs	✔		
VM monitoring	Monitoring Virtual Server status	✔	✔	
	Monitoring VM status and performance	✔	✔	
	Monitoring guest OS–specific alerts from VMs		✔	
	Mapping VMs to hosts	✔	✔	
	Generating reports on host and VM resource utilization and historic trends	✔	✔	
Physical server monitoring	Monitoring server-specific alerts		✔	✔
	Monitoring OS-specific alerts		✔	✔
	Retrieving server configuration information	✔	✔	✔
Physical server remote management	Updating BIOS and firmware			✔
	Configuring virtualization software settings (such as host reserves and virtual networking)	✔		
	Performing out-of-band server management		✔	✔

* Enabled with Operations Manager 2007.

Figure 4. *Key management functionality of Microsoft System Center Virtual Machine Manager, Microsoft System Center Operations Manager 2007, and Dell OpenManage software*

Efficient management of virtualized environments

Effective management tools can be essential to managing virtualized environments in enterprise data centers. Combining management tools like Microsoft System Center Virtual Machine Manager, Microsoft System Center Operations Manager 2007, and Dell OpenManage software with the Microsoft Virtual Server and Dell management packs can provide a flexible, efficient way of monitoring virtualized environments and carrying out key administrative tasks.

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Microsoft System Center:
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Microsoft System Center Virtual Machine Manager:
www.microsoft.com/systemcenter/scvmm

Microsoft System Center Operations Manager 2007 documentation:
www.microsoft.com/technet/opsmgr/2007/library/proddocs.mspx

Management packs for Microsoft Operations Manager:
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Enhancing Resiliency of VMware Virtual Infrastructures with EMC Layered Applications

BY ERIC PAN
JOSH DONELSON
MARK CLIFTON

Combining VMware® Infrastructure 3 and EMC® layered applications provides powerful high-availability, business continuity, and disaster recovery capabilities that can help organizations create highly resilient IT infrastructures and meet stringent service-level agreements, recovery point objectives, and recovery time objectives for critical systems.

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Business continuity

Dell PowerEdge servers

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IT environments that demand continuous system uptime and require robust capabilities for rapid recovery are typically very expensive, complex to build, and difficult to manage, maintain, and test. These factors create challenges for designing architectures that can deliver resilient IT services and survive disasters such as hurricanes, earthquakes, and fires; handle mishaps from human error; and address governance and regulatory considerations such as those of the Sarbanes-Oxley Act and the Health Insurance Portability and Accountability Act (HIPAA).

VMware Infrastructure 3 Enterprise Edition incorporates features that address many requirements for service-level agreements (SLAs), recovery point objectives (RPOs), and recovery time objectives (RTOs),[1] including VMware VMotion™ technology and the VMware High Availability (VMware HA) and Distributed Resource Scheduler (DRS) features.

VMware Infrastructure 3 requires high-performance shared storage for the implementation of mainframe-class, highly available, capacity-on-demand, policy-based IT infrastructures that deliver comprehensive management and resource optimization for IT environments. A key feature of VMware Infrastructure 3 is its built-in multipath storage access to enable a highly available shared storage architecture, which increases the number of operating environments that can take advantage of shared storage and helps create a resilient IT infrastructure.

Network resiliency is another key element of building highly available IT environments. The network interface card (NIC) teaming feature of VMware Infrastructure 3 enables host servers to provide each virtual machine (VM) with built-in NIC failover and load-balancing capabilities—helping increase hardware availability and fault tolerance. NIC teaming policies allow administrators to configure multiple active and standby NICs.

To further enhance infrastructure resiliency, combining a VMware virtual infrastructure with EMC SnapView™, MirrorView™, and SAN Copy™ layered applications helps address the challenges of protecting critical applications and data by replicating storage area networks (SANs) without using host-based processors or I/O.

This integration of interoperable technologies can significantly reduce risks and typical costs of redundant clustered systems while helping increase system uptime as well as application and workload availability. Architectures based on integrated solutions that Dell, EMC, and VMware jointly test and certify are available from Dell as baseline platforms that can provide increasing degrees of resiliency based on

[1] An RPO is a point in time to which data must be restored to be acceptable to the owner(s) of the processes supported by that data, often the time between the last available backup and the time a disruption could potentially occur. It is based on tolerance for data loss or reentry. An RTO is the boundary of time and service level within which a process must be accomplished to avoid unacceptable consequences associated with a break in continuity.

organizational needs. Administrators can modify these solutions and templates to help meet enterprise RPOs and RTOs as required.

Understanding business continuity

Business continuity hinges on minimizing downtime and depends on preparation for both *planned* and *unplanned* downtime. Administrators use planned downtime to patch, update, or upgrade operating systems, applications, security signature files, and hardware. Performing these operations typically requires a well-planned sequence of administrative tasks carried out after normal operating hours, during which applications are unavailable to users. Taking a system offline for any period of time introduces risks to the organization, users, and IT systems alike. VMware VMotion and DRS directly address these risks by helping to eliminate application and workload downtime during these periods.

Technologies that address unplanned downtime include clustering, host and SAN replication, and advanced off-site mirrored facilities. These systems and processes, typically referred to as disaster recovery or redundant failover systems, can be very expensive and require extensive IT staff training in traditional physical environments. A VMware virtual infrastructure, combined with EMC layered applications, is designed to provide a cost-effective, highly resilient infrastructure and minimize unplanned downtime.

Using key business continuity features of VMware Infrastructure 3

Today, VMware Infrastructure 3 is a widely deployed virtualization software suite that incorporates intrinsic business continuity functionality. VMware Infrastructure 3 Enterprise Edition and VMware VirtualCenter Management Server offer high levels of flexibility and manageability to help administrators design and build resilient systems that can meet enterprise SLAs, RPOs, and RTOs.

VMware Infrastructure 3 goes beyond basic server virtualization by aggregating industry-standard x86 or x86-64 processor–based servers, shared storage, and networks into a unified resource pool, or *virtual infrastructure* (see Figure 1). In a virtual infrastructure, the resource pools of computing power and storage capacity are dynamically provisioned and allocated to match IT resources to specific requirements and organizational needs.

Shared storage is a fundamental component of a virtual infrastructure, enabling VMotion, VMware HA, and VMware DRS features as well as high-performance backup and restore and snapshot functionality through VMware Consolidated Backup. In a VMware virtual infrastructure, shared storage enables secure, robust, and redundant local data stores as well as accessible, duplicative, off-site storage capabilities. VMware virtual infrastructures allow IT organizations to efficiently manage data replication, disaster recovery processes, and dynamic secondary-site expansion based on their needs. VMware Infrastructure 3 also eases the manageability of IT environments and helps protect critical application workloads and their data through built-in self-healing capabilities from I/O multipathing through network devices and SAN fabrics within a virtual infrastructure.

Key features of VMware Infrastructure 3 include the following:

- **VMware VMotion:** This technology allows the live migration of VMs to help ensure that users and their applications are not disrupted during systems maintenance and planned downtime. VMotion is critically important to providing systems availability during planned downtime in a virtual infrastructure.
- **VMware HA:** This technology delivers high availability across a virtual infrastructure without the cost or complexity of clustering solutions. VMware HA can provide cost-effective high availability for any application running in a VM, regardless of its OS or underlying hardware configuration. It also helps eliminate the need for dedicated standby hardware and additional software.
- **VMware DRS:** VMware DRS is designed to continuously monitor utilization across resource pools and intelligently allocate available resources among VMs based on

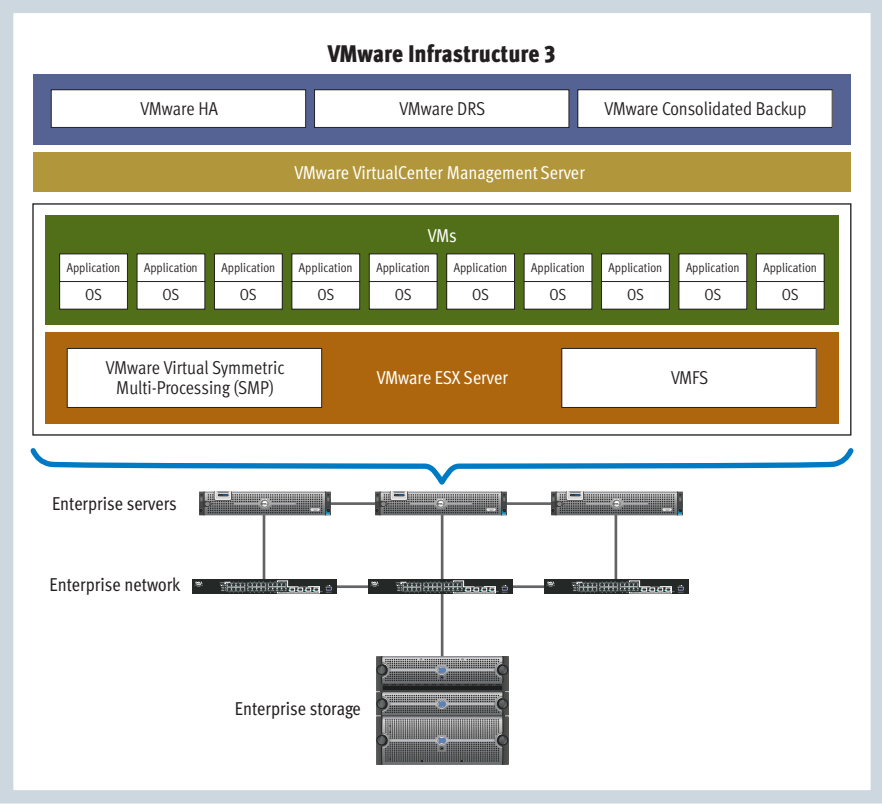

Figure 1. *Virtual infrastructure built on VMware Infrastructure 3*

	VMware Virtual Machine File System	Raw device mapping
Typical applications	• Microsoft® Active Directory® directory service • Application, file and print, and utility servers	• Microsoft Exchange databases and log volumes • Microsoft SQL Server™ databases and log volumes
Advantages	• Simplifies implementation and management by using a small number of large VMFS logical units (LUNs) • Can provide comprehensive protection when administrators back up entire VMFS LUNs, because all VM files reside on these LUNs	• Supports setting application priorities by recovery plan • Allows flexible replication and disaster recovery plans when following the backup best practice of separating data and system images • Does not require the replication of large amounts of static data, such as system drives or images • Enables low RTOs when using backup VMs at a disaster recovery site that have been preinstalled or that can pull system images from archives • Reduces bandwidth demands by allowing the number of VMs to scale without the replication of large amounts of data
Disadvantages	• Does not support application priorities (for example, SQL Server would have the same priority as a file and print server) • Does not discriminate system state—requires restarting service • Requires a transactional database to keep changes consistent, which can be bandwidth intensive, especially as the infrastructure scales (large databases and files require large backup targets)	• Increases the complexity of implementation and management by using a greater number of LUNs than are required for VMFS • Requires additional disks to host the increased number of LUNs, potentially increasing cost

Figure 2. *Comparison of VMware VMFS and raw device mapping*

predefined policies set by IT administrators. When VM resources are constrained, additional capacity can automatically be made available by migrating live VMs to a different physical server using VMotion.

- **VMware VirtualCenter:** This tool enables rapid provisioning of VMs and monitors performance of physical servers and VMs. VirtualCenter can intelligently optimize resources, helping ensure high availability for all VM-based applications. VirtualCenter also helps make IT environments highly responsive with virtualization-based distributed services such as VMotion, VMware HA, and VMware DRS.

Enhancing resiliency of VMware virtual infrastructures with EMC layered applications

Administrators can use two methods to allow VMware ESX Server to access shared storage: VMware Virtual Machine File System (VMFS) and raw device mapping (RDM).[2] VMFS is typically useful when crash consistency (as opposed to application consistency) is acceptable. RDM, which provides tunable I/O to help optimize performance, is typically useful when application consistency is required. A best practice is to use RDM in conjunction with VMFS by using VMFS for the OS and applications and RDM for databases and logs. EMC layered applications can perform optimally with either of these two methods. Figure 2 summarizes the typical applications, advantages, and disadvantages of these two storage access methods, and Figure 3 illustrates their respective architectures.

In a shared storage environment, the ESX Server systems and their respective VM workloads launch at boot time from the Dell/EMC CX or CX3 storage array. Files representing the encapsulated VMs—the guest OS and its data—launch directly from the SAN, an approach that provides portability and server hardware independence for the VM, OS, workload, and data.

EMC layered applications: SnapView, MirrorView, and SAN Copy

VMware VMs encapsulate an OS and its application or workload files into a set of four specific files. These files are easily replicated, and, more importantly, a VM service can be quickly restarted from a targeted remote SAN or replicated volume on a local SAN without

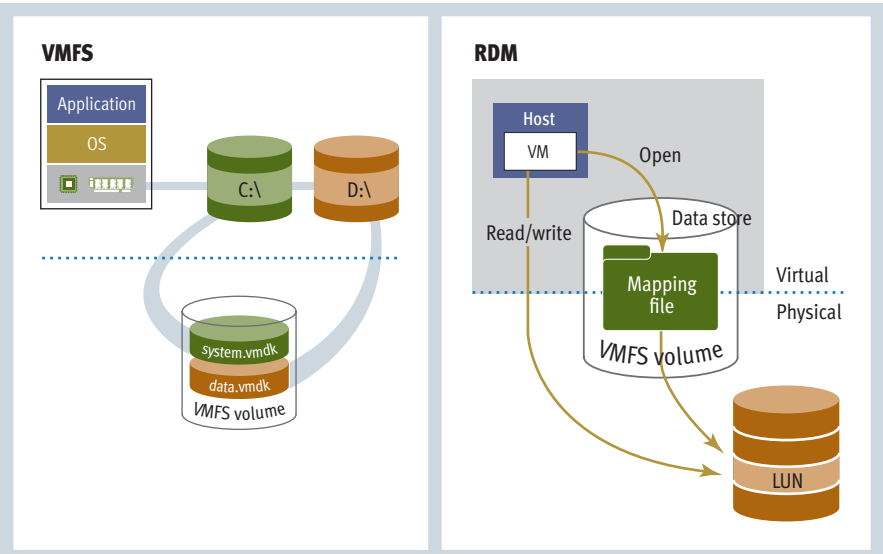

Figure 3. *Architecture of VMware VMFS and raw device mapping*

[2] A thorough discussion of presenting storage systems to ESX Server is available in the VMware *SAN Configuration Guide: ESX Server 3.0.1 and VirtualCenter 2.0.1*, www.vmware.com/pdf/vi3_301_201_san_cfg.pdf. Managing Dell/EMC CX and CX3 series storage arrays requires EMC Navisphere® Manager software.

dependence on the source hardware platform that originally hosted the files.

EMC SnapView, MirrorView, and SAN Copy are SAN-based replication applications that can help protect VMware ESX Server guest OS images and their associated application and workload files. They offer comprehensive, incremental, and full-site replicas of all files associated with a virtual infrastructure without using host processor or I/O resources, as well as varying degrees of enhanced resiliency for virtual infrastructures that utilize Dell/EMC CX and CX3 storage. Figure 4 summarizes the key features and typical uses of these applications.

Integrated disaster recovery

Disaster recovery in an environment not based on a VMware virtual infrastructure can be difficult and complex, and support only long recovery times. Potential problems with this type of disaster recovery include the following:

- **Cost:** Creating a secondary site with a 1:1 server environment identical to the primary production site can be both complex and expensive to implement. And although the disaster recovery systems are often sitting idle, their servers, storage, and networking hardware are still consuming power and cooling resources as well as floor and rack space.
- **Hardware dependencies:** Secondary site requirements are restrictive, and ensuring a viable and rapid recovery at a secondary site depends on maintaining server models, firmware and OS revisions, and hardware and storage configurations identical to those operating in the primary production site.
- **Extensive training:** Properly training IT staff to use the technologies at both the primary production and secondary sites is often impractical.
- **Testing and risks:** Proper testing requires a full shutdown and failover of the primary production site—which can be difficult, because many IT organizations provide critical services to their customers and constituents. And because successful system restarts typically require several attempts and adjustments along the way, this process introduces risks of downtime and lost productivity for enterprises depending on those resources.

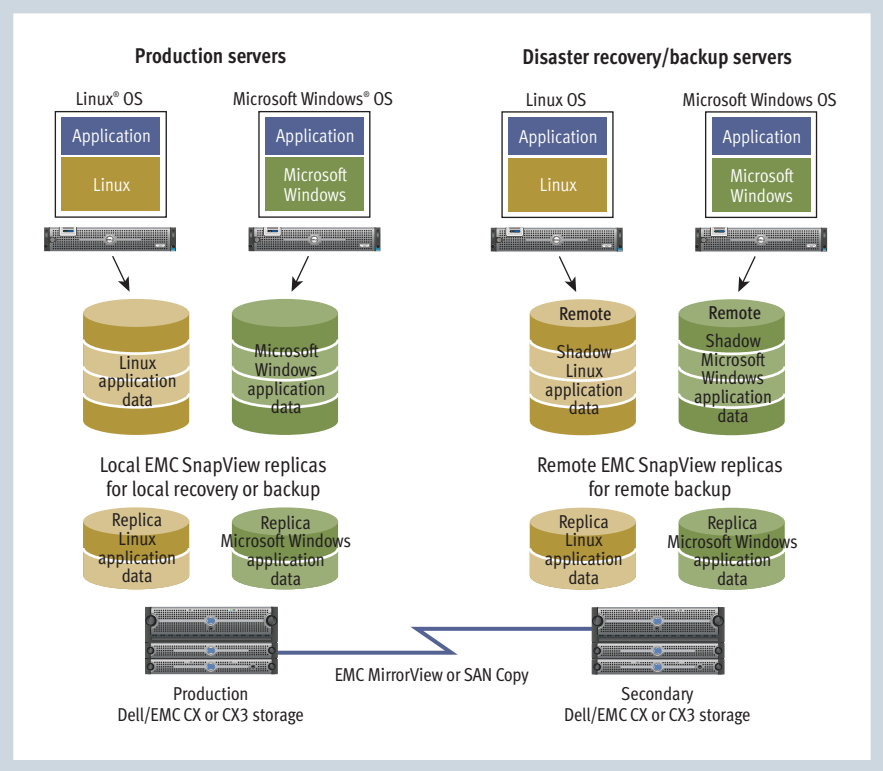

Figure 5. *Example physical-to-physical disaster recovery environment incorporating the EMC SnapView, MirrorView, and SAN Copy applications*

	Key features	Typical uses
EMC SnapView	• Enables LUN-based replication within a single Dell/EMC CX or CX3 array • Uses two methodologies: full-snapshot clones or business continuance volumes, and tabled copies of pointers to the original data changed from the source LUN (not a full copy)	• Creating clones—full copies of source LUNs to target LUNs on the same SAN • Offloading and preparing full volumes for full backup to separate media or low-cost drives installed in the same SAN for backup or staging
EMC MirrorView	• Maintains a mirror image of data at the storage block level in a separate or remote Dell/EMC CX or CX3 array • Replicates data at the transaction, record, and byte level as each application workload disk write is applied to each SAN • Provides highly available data storage mirroring for disaster recovery, including a configurable mirroring schedule that can vary from minutes to hours	• *MirrorView/Synchronous*: Keeping writes in sync between a primary SAN and a remote SAN, helping ensure near-real-time data availability and access from the remote SAN • *MirrorView/Asynchronous*: Performing data writes to a primary SAN and periodic data writes to a remote SAN, including a configurable update schedule for the remote SAN that can vary from minutes to hours
EMC SAN Copy	• Replicates data across multiple storage devices and/or within a single Dell/EMC CX or CX3 array • Includes both full and incremental modes	• Migrating existing data from one SAN to a new or separate SAN

Figure 4. *Comparison of EMC SnapView, MirrorView, and SAN Copy applications*

Figure 5 illustrates an example physical-to-physical disaster recovery environment incorporating EMC layered applications as part of a comprehensive remote replication solution. Figure 6 illustrates a similar solution built on a VMware virtual infrastructure. Disaster recovery

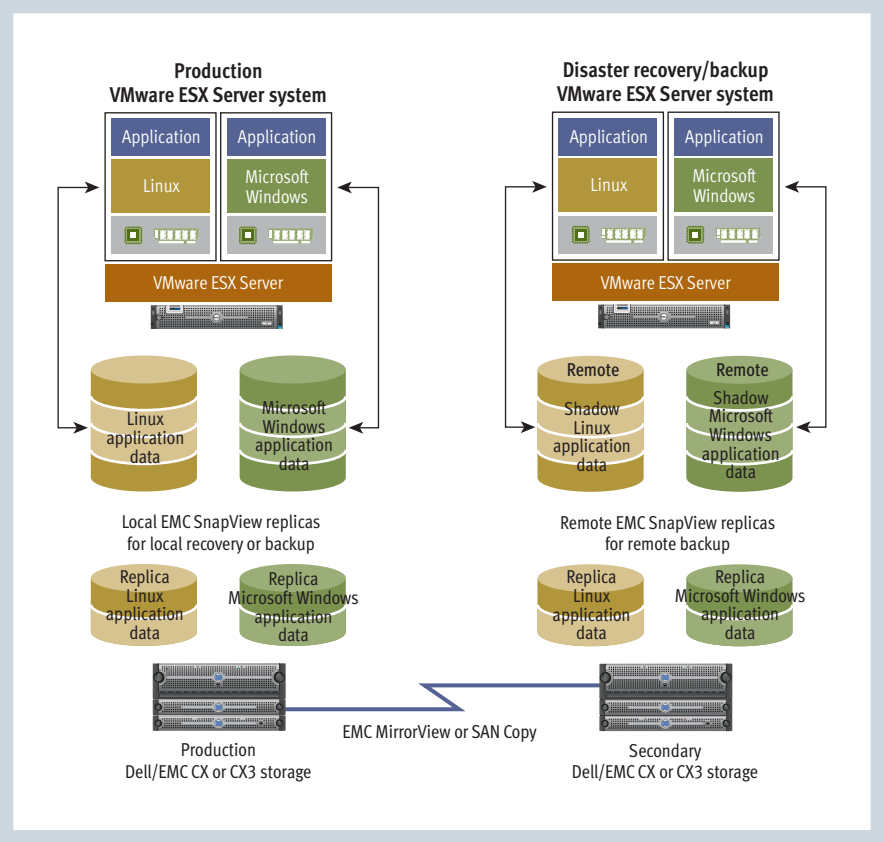

Figure 6. *Example virtual-to-virtual disaster recovery environment based on VMware Infrastructure 3 and incorporating the EMC SnapView, MirrorView, and SAN Copy applications*

environments based on a VMware virtual infrastructure in conjunction with EMC layered applications can help administrators meet SLAs, RPOs, and RTOs efficiently and avoid the physical infrastructure components that introduce complexity. The advantages of this type of environment include the following:

- **Cost-effectiveness:** A secondary site based on a virtual infrastructure often requires fewer network and storage components than a traditional physical infrastructure. More importantly, unlike a traditional physical infrastructure, a virtual infrastructure does not require that the disaster recovery site have a 1:1 server environment identical to the primary production site.
- **Predictable restart times:** Once administrators have replicated VM files to the secondary site using EMC MirrorView or SAN Copy, those systems should provide predictable system restart times (based on the amount of time required to restart VM workloads) and help reduce RTOs.
- **Efficient utilization:** In some cases, enterprises may be able to utilize the virtual infrastructure at a secondary site. Because a virtual infrastructure is built on a pool of shared computing and storage resources, it can provide the operational flexibility to run non-production or noncritical applications, or simply provide additional IT resources. Administrators can also take advantage of the advanced management capabilities and flexibility of SAN storage at both the primary production site and the secondary site to help meet organizational needs.
- **Reduced risk:** A secondary site based on a virtual infrastructure helps minimize the risks of lengthy system outages, reduced productivity, and failures to meet stringent SLAs.

Creating robust, cost-effective business continuity systems

VMware Infrastructure 3 provides built-in business continuity features and functionality, and EMC layered applications deliver SAN replication technologies for Dell/EMC CX and CX3 series shared storage systems that provide different levels of performance and functionality. When combined, VMware Infrastructure 3 and EMC layered applications offer powerful capabilities that can enhance the resiliency of IT infrastructures to help minimize risk and enable predictable SLAs, RPOs, and RTOs for organizations of all sizes.

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SAN Configuration Guide: ESX Server 3.0.1 and VirtualCenter 2.0.1:
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How Vizioncore Deploys Its Own esxRanger *Professional* Software for Disaster Recovery

When Vizioncore, a leading developer of software for the virtualization industry, needed to implement an efficient, cost-effective disaster recovery strategy, it turned to its own esxRanger *Professional*™ software. In conjunction with VMware® Infrastructure 3, esxRanger *Professional* helped Vizioncore create a reliable, easy-to-maintain disaster recovery system running on Dell™ and Dell/EMC hardware.

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Virtualization

Vizioncore

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In 2004, Vizioncore created its flagship esxRanger™ software for a client that needed a cost-effective backup and disaster recovery solution. Today, Vizioncore is using this software in its own data center as well. Designed to meet the needs of enterprises of all sizes, esxRanger *Professional* can provide fast, reliable VM backup and recovery and includes key enterprise functionality such as differential image backups and file-level restores for virtual machines (VMs) running in a VMware virtualization environment.

Vizioncore disaster recovery design

The Vizioncore data center comprises 41 Dell PowerEdge™ servers. Of these servers, 34 are devoted to testing and development, with a majority running VMware virtualization software. The production environment runs 25 VMs, supporting Microsoft® SQL Server™, Exchange Server, Internet Information Services, Active Directory®, and other software. The non-virtualized physical servers run Citrix® software.

The storage back end is provided by a Dell/EMC CX300 array with 2 TB of storage, with backup storage provided by a Dell/EMC AX100 array, also with 2 TB of storage. The main network runs on Dell PowerConnect™ 6024 switches; the main wide area network (WAN) link is a T1 line for e-mail and Web traffic, while another dedicated T1 line supports voice over IP (VoIP) for inbound and outbound calls.

Vizioncore maintains a backup site for disaster recovery, which is located 23 miles away from its production data center. This off-site location includes a Dell/EMC AX150i array with 3 TB of storage and uses a dedicated 4 MB/sec wireless connection for data replication. Figure 1 illustrates the Vizioncore disaster recovery configuration.

Vizioncore performs nightly and weekly image backups of all servers using esxRanger *Professional* and VMware Consolidated Backup (VCB). The esxRanger *Professional* and VCB proxy server has one host bus adapter (HBA) connected to the Dell/EMC CX300 for VM backups, and one HBA connected to the Dell/EMC AX100 for storing backups before they are replicated. Once the backups are created, they are replicated to the disaster recovery site. Because Vizioncore can replicate its entire environment weekly and its critical servers hourly or daily, it can quickly restore its entire environment following a major failure. In addition, VMware Converter allows Vizioncore to store copies of its servers running Citrix software in case administrators need to virtualize them at the disaster recovery site.

The esxRanger *Professional* software can create image-level hot backups simply and easily while the VMs are

> "Because Vizioncore can replicate its entire environment weekly and its critical servers hourly or daily, it can quickly restore its entire environment following a major failure."

running. Unlike file-level backup agent software, esxRanger *Professional* backs up the entire VM, including configuration settings, OS patches, the application itself, and data and other OS-level changes. The software supports the VMware platform in a number of key ways, including integration with VCB, VMware VirtualCenter, and VMware VMotion™ technology, which allows esxRanger *Professional* to follow VMs even after they have been moved to another host by VMware Distributed Resource Scheduler (DRS).

Tiered service levels and software redundancy

Vizioncore has assigned three service levels to its servers based on the data's importance and the required time for recovery:

- **Service level 1:** This level requires high availability, fast image recovery, database-consistent file backups, and off-site protection. Vizioncore supports this level by performing hourly off-site replication with Vizioncore esxReplicator™ software, nightly file-level backups with Veritas data protection software from Symantec, and weekly image backups using esxRanger *Professional* as well as weekly off-site image replication using the Distributed File System (DFS) in the Microsoft Windows Server® 2003 Release 2 (R2) OS.
- **Service level 2:** This level requires fast recovery at both the image and file levels, as well as off-site protection. Vizioncore uses esxRanger *Professional* for nightly and weekly image-level backups while utilizing the esxRanger *Professional* file-level restore functionality to retrieve user files, and replicates the nightly images off-site using Windows Server 2003 R2 DFS.
- **Service level 3:** This level requires simple image recovery and off-site protection. Vizioncore uses esxRanger *Professional* for weekly image-level backups, and replicates those images off-site using Windows Server 2003 R2 DFS.

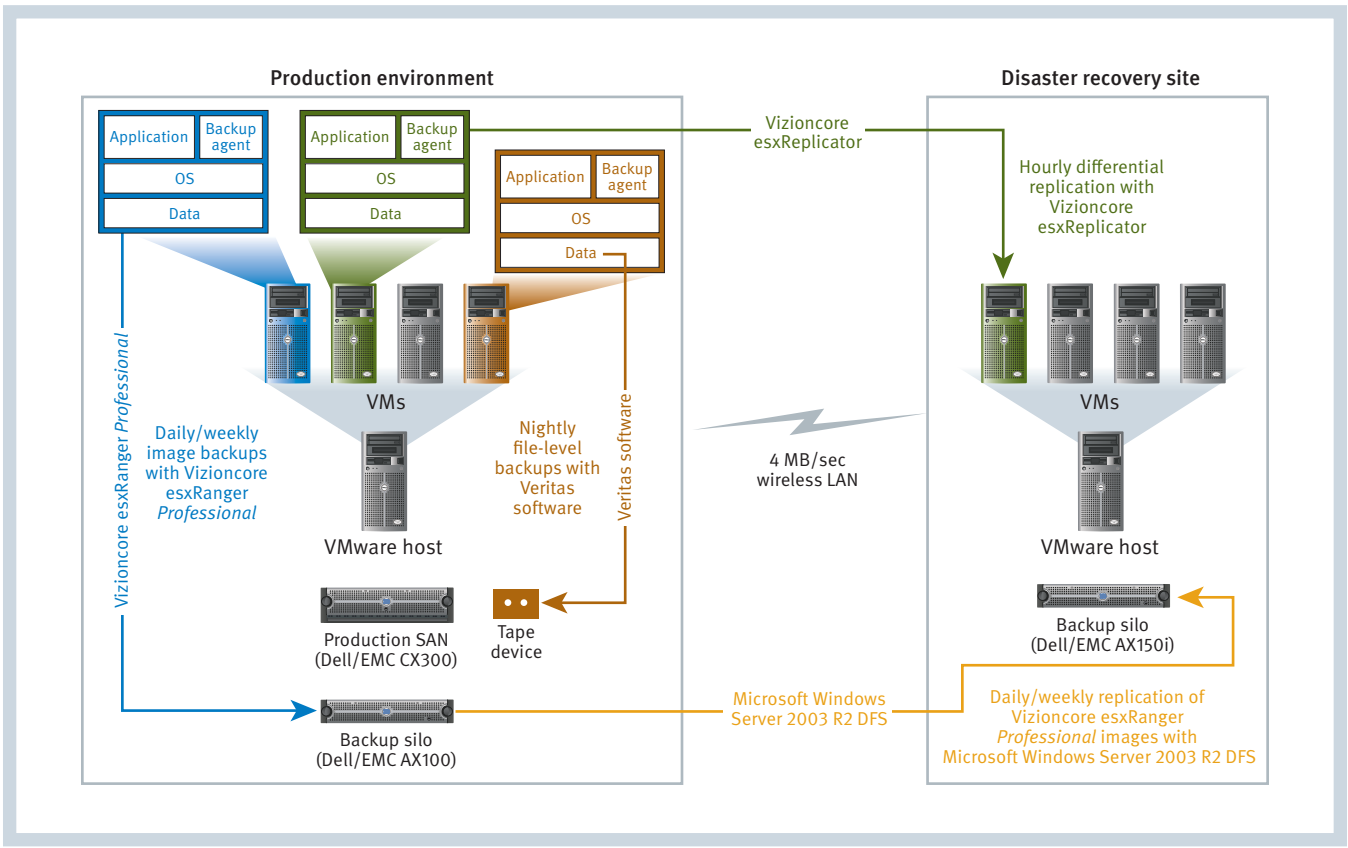

Figure 1. *Vizioncore disaster recovery configuration*

Like many enterprises, Vizioncore has rapidly changing data servers that need traditional file-level backups for databases, such as SQL Server and Exchange, in addition to image-level backups of entire VMs. Because storage utilization for backups is critical, Vizioncore analyzed its data and service levels to structure and utilize the esxRanger *Professional* retention policy, which helped maximize use of high-end storage for critical data. Only 10 of its VMs have frequently changing data that warrants nightly file-level backups. To help reduce downtime and simplify recovery of these VMs, Vizioncore performs weekly image backups and nightly differential image backups, utilizing the esxRanger *Professional* file-level recovery functionality to provide a comprehensive backup solution. The remaining VMs are relatively static and are backed up weekly as a full image, then overwritten after two weeks. Finally, the most current two weeks of full and differential image backups are replicated to the disaster recovery site.

"The Vizioncore data center's disaster recovery design allows administrators to quickly recover critical VMs following an outage, and the tiered backup approach helps reduce costs without compromising critical systems."

Also essential to the Vizioncore disaster recovery strategy is software redundancy. Veritas data protection software from Symantec is used primarily for frequently changing file-level data, and esxRanger *Professional* with VCB is employed for full and differential image backups to help ensure critical data is protected and can be recovered quickly. If the Veritas software fails on the database servers, then esxRanger *Professional* file-level recovery enables administrators to quickly restore single files from a full or differential image. And if esxRanger *Professional* experiences problems, administrators can manually rebuild a VM and run a Veritas file-level restore to recover the most current critical data (although this process can be much more involved and take much longer than restoring the image with esxRanger *Professional*).

For the process that Vizioncore recommends when creating a backup and disaster recovery solution, see the "Best practices for robust disaster recovery" sidebar in this article.

Efficient, cost-effective disaster recovery

The Vizioncore data center's disaster recovery design allows administrators to quickly recover critical VMs following an outage, and the tiered backup approach helps reduce costs without compromising critical systems. By relying on its own software in conjunction with VMware virtualization, Veritas software from Symantec, and Dell and Dell/EMC hardware, Vizioncore has created an efficient, cost-effective solution for maintaining the availability of its data and applications.

BEST PRACTICES FOR ROBUST DISASTER RECOVERY

When enterprises set out to create their own backup and disaster recovery systems, Vizioncore recommends they do the following:

- Investigate the use of virtualization—many applications can successfully run on VMs, and tools like VMware Converter can easily perform a physical-to-virtual conversion, so that even if the application remains on a physical platform, administrators can still back it up as a VM.
- Maintain one or more redundant physical infrastructures located far from the primary production site, with robust WAN connectivity between the sites.
- Analyze data and applications running on VMs, with the goal of prioritizing VMs for recovery following a major failure.
- Determine the ideal backup method (file, differential, or full image) or a combination of methods that is appropriate for specific environments.
- Determine the appropriate frequency of backups—daily, weekly, or, in the case of powered-down VMs, offline storage.
- Perform periodic tests to help ensure that the system performs as expected.

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Business Continuity and Disaster Recovery with **Virtualization and Double-Take**

BY KRISTINE LINDELY

BOB ROUDEBUSH

Virtualization has become a key enterprise technology, one that can help IT organizations not only consolidate servers and increase efficiency, but also create robust business continuity and disaster recovery strategies. Combining a virtualized environment with Double-Take® data protection software can help dramatically increase the manageability and flexibility of data recovery for critical systems.

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A growing number of enterprises have standardized on virtualization technologies because of the potential benefits provided by server consolidation and server rationalization, which can include reduced costs for hardware, maintenance, and power and cooling. Although server consolidation and rationalization continue to be major drivers, the ability to use virtualization as part of an efficient business continuity and disaster recovery (BC/DR) strategy is also becoming a compelling factor for implementing virtualization in enterprise environments.

IDC has predicted that the next phase of virtualization will focus on BC/DR.[1] The efficiency, flexibility, portability, hardware independence, and provisioning speed provided by virtual machines (VMs) running on standard x86 or x86-64 hardware help make virtualization an effective tool for BC/DR strategies. Combining virtualization software like the VMware® Infrastructure suite with the real-time replication and application failover capabilities of Double-Take data protection software on Dell™ PowerEdge™ servers can help enterprises implement a recovery strategy that is both reliable and cost-effective.

Data protection criteria and objectives

Enterprises should rank each of their critical applications and assign values to these applications' data and the systems on which they run, which can range from zero impact to mission-critical. They should then align data value with recovery goals by assessing their recovery point objective (RPO) and recovery time objective (RTO)—asking how much data they can afford to lose and how long they can afford to be down. They should also apply service-level agreements (SLAs) appropriately—successful BC/DR strategies base data recovery and operation resumption on these SLAs.[2]

Designing for maximum availability during many types of outages presents a challenge that can be met by using a variety of software and hardware, ranging from synchronous storage-based replication to crash-consistent application mirroring or storage-agnostic host-based replication.

Virtualization and data replication for disaster recovery

Deploying VMware or other virtualization software on Dell PowerEdge servers along with Dell high-availability storage systems and Double-Take data protection software enables enterprises to create cost-effective configurations while helping meet their RPO and RTO goals. Because the data protection software does not need to distinguish between physical and virtual hosts, the integration of host-based data availability can be seamless in virtual environments.

[1] "Worldwide System Infrastructure Software 2007 Top 10 Predictions," by IDC, Doc #204567, December 2006.

[2] For more information about data classification and best practices when constructing a BC/DR strategy, see "Architecting a Blueprint for Disaster Recovery," by Rich Armour, Paul Eno, Michael Kimble, and Jesse Freund, in *Dell Power Solutions*, February 2006, www.dell.com/downloads/global/power/ps1q06-20060124-CoverStory.pdf.

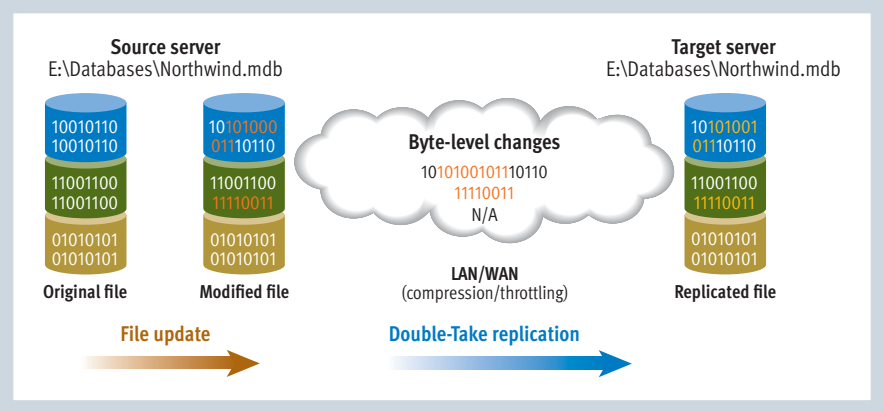

Figure 1. *Byte-level replication using Double-Take software*

The VMware ESX Server platform also provides enhanced resource allocation for VMs sharing a single server and tight integration with replication software at both the hardware and OS levels, providing additional advantages when using this platform as part of a BC/DR strategy. Double-Take software can integrate seamlessly into both physical and virtualized server environments to help provide effective data protection for each.

Double-Take data protection in virtualized environments

Three key components of Double-Take data protection for virtualized environments are Double-Take software, the Double-Take Server Recovery Option, and Double-Take for VMware Infrastructure. Double-Take real-time data replication and failover software is designed to augment existing data protection strategies and traditional backup technologies by helping reduce downtime and data loss with minimal impact on existing network resources. It allows administrators to select data sets that must be protected and then replicates that data in real time from a primary system to a secondary system. Replicating only byte-level changes rather than copying blocks or entire files allows Double-Take software to efficiently use available network resources (see Figure 1).

To help eliminate downtime during an outage, administrators can use the real-time data copies at the secondary site to resume processing of protected applications, such as e-mail or database services, on the secondary server. The Double-Take service running on the secondary server can monitor the production server and, in the event of an outage, automatically start the appropriate application services on the secondary server and seamlessly redirect end-user requests. This combination of real-time replication and application availability enables enterprises to implement flexible and resilient data protection solutions.

When combined with the Double-Take Server Recovery Option, Double-Take data protection software provides a single solution to help protect and recover entire servers. The Double-Take Server Recovery Option can use advanced system state protection and recovery technology to recover the replicated server image to a new system with the same or an entirely different hardware configuration.

Double-Take for VMware Infrastructure is a VM replication solution built specifically for VMware ESX Server. Working at the host level, it takes advantage of VMware snapshot capabilities to regularly replicate changes to protected VMs. For production VMs running on VMware ESX Server systems, Double-Take for VMware Infrastructure enables administrators to recover those VMs on another ESX Server system locally or at a disaster recovery site.

Protecting physical servers using physical-to-virtual real-time replication and failover

Virtualization allows enterprises to protect multiple physical servers using multiple VMs on a single shared physical server using a physical-to-virtual process. Double-Take software deploys easily on both physical servers and VMs, allowing administrators to configure and customize real-time replication and failover between a physical server and its virtual counterpart (see Figure 2).

During an outage, Double-Take software can automatically start the appropriate application services within the VMs and seamlessly redirect end-user requests through automatic updates to the Domain Name System (DNS) or the Microsoft® Active Directory® directory service. In addition, implementing high-availability Dell

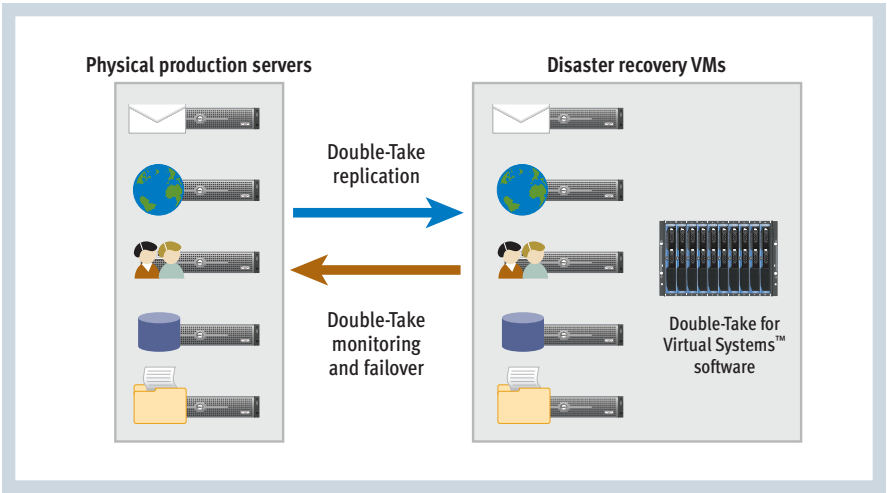

Figure 2. *Virtualized disaster recovery using Double-Take software*

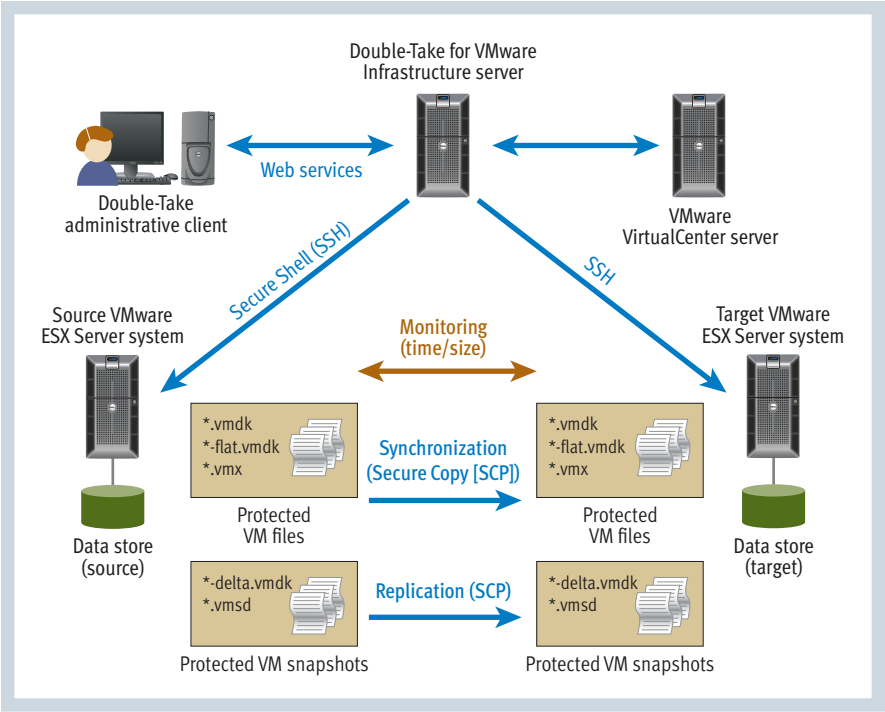

Figure 3. *Example environment utilizing Double-Take for VMware Infrastructure VM replication*

PowerVault or Dell/EMC CX3 storage arrays at a secondary site helps provide a stable repository for replicated data, which administrators can also use for backups, reporting, testing, and other purposes.

Performing whole-server recovery using virtualized systems

Combining Double-Take data protection software with the Double-Take Server Recovery Option creates a single solution to help continuously protect and recover an entire server. The Double-Take Recovery Manager, part of the Double-Take Server Recovery Option, presents server recovery tasks as a series of easy-to-understand steps. Because Double-Take replication can protect the production server OS, applications, and data, server recovery can take fewer steps and significantly less time than solutions such as tape backup.

The Double-Take Server Recovery Option also integrates with Microsoft Volume Shadow Copy Service (VSS) to allow scheduling and recovery from up to 512 point-in-time copies of protected data. And with the exception of the OS, the recovery server does not have to be an exact match for the server being recovered.

Protecting production VMware ESX Server virtual machines

The proliferation of VMs in production environments means that IT organizations must protect VMs as well. In cases where the workloads are not suited for the real-time replication and failover provided by Double-Take for Windows, enterprises can use Double-Take for VMware Infrastructure to protect ESX Server VMs. Double-Take for VMware Infrastructure provides administrators with centralized management of snapshots, replication sessions, and protected servers to help simplify management and reduce total cost of ownership. It integrates directly with VMware VirtualCenter to provide a comprehensive view of ESX Server systems and VMs and serves as a complement to features like VMware VMotion™ technology, enabling administrators to replicate and recover VMs across local area networks (LANs) and wide area networks (WANs).

Utilizing VMware application programming interfaces (APIs) for VM snapshot functionality, Double-Take for VMware Infrastructure captures changes regularly, keeping secondary virtual disks up-to-date and ready for recovery. During an outage, Double-Take software can start the replicated VM on a second ESX Server system with the most recent replicated data. Using VMware APIs allows Double-Take software to make protected data crash consistent and time coherent across all virtual disks on a protected VM. In addition, by replicating entire VMs, Double-Take software can protect any guest OS supported by VMware software (including Microsoft Windows®, Linux®, UNIX®, and other operating systems) on a secondary ESX Server system without requiring reconfiguration at recovery time. Figure 3 shows an example environment utilizing Double-Take for VMware Infrastructure VM replication to help protect enterprise data.

Efficient data protection in virtualized environments

Double-Take solutions implemented in conjunction with VMware virtualization software, Dell PowerEdge servers, and Dell/EMC high-availability storage can help enterprises create an efficient recovery strategy for production servers and other critical data. Dell can offer additional guidance on the appropriate consolidation ratios of physical servers to VMs for data recovery by performing a Virtualization Readiness Assessment, which suggests potential configurations for server and storage consolidation. Using Double-Take data protection software in combination with the Double-Take Server Recovery Option and Double-Take for VMware Infrastructure enables enterprises to protect physical servers using physical-to-virtual real-time replication and failover, perform whole-server recovery using virtualized systems, and protect production ESX Server VMs as part of a comprehensive BC/DR strategy. For more information, visit www.doubletake.com.

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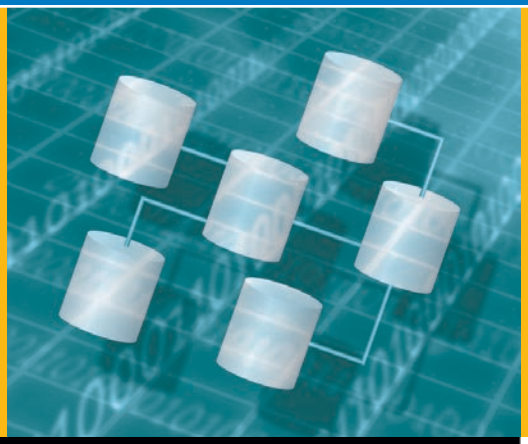
Bob Roudebush *is the director of solutions engineering at Double-Take Software.*



Using Dell/EMC Storage Software in a VMware Virtual Environment

BY ANDREW GILMAN

When deploying VMware® virtualization software, choosing storage with complementary software can be critical. The advanced software functionality available with Dell/EMC CX3 UltraScale™ series storage arrays is designed to provide the data mobility and resource flexibility necessary to create an integrated, highly available virtualized information infrastructure.

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Server virtualization can provide multiple benefits in enterprise environments, allowing enterprises to consolidate servers to help increase resource utilization, use power efficiently, and reduce operating costs. Enterprises can gain similar advantages in the storage environment by consolidating those resources, helping them simplify management, increase flexibility and allow nondisruptive virtual machine (VM) migrations, and meet service-level agreements (SLAs).

Choosing appropriate storage software functionality is a key part of combining a VMware software–based virtualized environment with consolidated storage. Important factors to consider include data mobility, flexible quality-of-service (QoS) functionality, high-availability features, and simplified management.[1]

Simplifying management with the EMC Navisphere Task Bar

Implementing storage software in a virtualized environment can seem like a daunting task, and the relative ease of deploying new VMs along with the variable I/O patterns that result can make efficient storage management a challenge. Ease of use, then, becomes a key factor when choosing storage management software in such an environment.

The EMC® FLARE® operating environment includes the Navisphere® Task Bar, which is designed to increase ease of use for storage administrators and complement the advantages of VMware and EMC software. Administrators can use this task bar (freely available to those with EMC service maintenance contracts) to perform many common storage management tasks in significantly fewer steps than they would otherwise require, including rapidly provisioning as much as 1 TB of storage, using the mirror wizard to help protect data, and creating a clone backup.

Enhancing data mobility through advanced LUN technology

The FLARE operating environment for Dell/EMC CX3 UltraScale series storage can provide high levels of data mobility and resource flexibility, allowing administrators to deploy new servers quickly and nondisruptively. Dell/EMC metaLUN and Virtual LUN technologies are designed to complement these capabilities, enabling real-time online expansion of logical units (LUNs) and transparent volume movement, respectively, typically without I/O interruption in hosts running the VMware ESX Server virtualization platform.

MetaLUNs are created by expanding a single LUN through concatenation, striping, or both. When VMs require additional

[1] The features described in this article apply to the Dell/EMC CX3 UltraScale series, and may not be available with other Dell/EMC storage arrays.

"Choosing appropriate storage software functionality is a key part of combining a VMware software–based virtualized environment with consolidated storage."

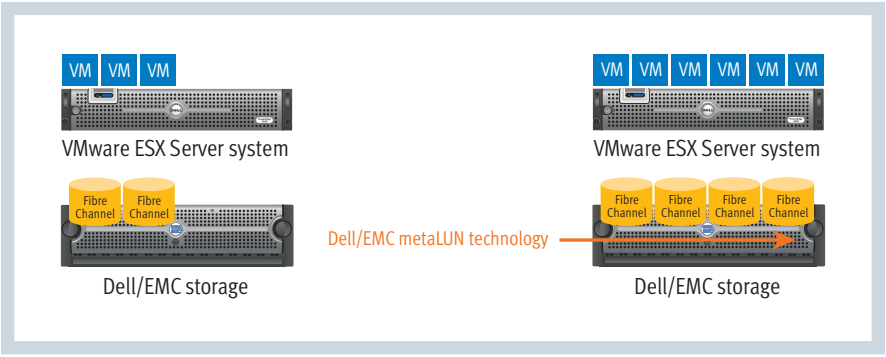

Figure 1. *Performing real-time LUN expansion to accommodate additional virtual machines with Dell/EMC metaLUN technology*

capacity, administrators can easily extend the VMware Virtual Machine File System (VMFS) using VMware VirtualCenter and its corresponding LUN through the intuitive Web browser–based interface of the EMC Navisphere Management Suite. This real-time LUN expansion also supports the creation of new VMs (see Figure 1). And because the added capacity is immediately available and the functionality is invisible to the host application, no reboot is necessary.

MetaLUNs are supported with both VMFS and raw device mapping (RDM), and can help administrators make efficient use of their storage resources in VMware software–based environments. Using the Logical Volume Manager available within ESX Server enables VMFS volumes to see the additional storage presented by the Dell/EMC CX3 UltraScale series storage after a re-scan at the ESX Server level. For RDM volumes, ESX Server hosts can immediately see the additional capacity presented by the storage after a re-scan. Administrators can also use striped metaLUNs to help balance loads across multiple disks for applications requiring additional disk space and increased performance. Because the ESX Server Logical Volume Manager only supports LUN concatenation, administrators can stripe the LUNs at the array level to help distribute the I/O load across multiple disks.

Virtual LUN technology is designed to let enterprises easily manage and alter their system configuration as their virtualized environment grows and changes. The Dell/EMC CX3 UltraScale series allows administrators to mix a wide variety of drive types—including Serial ATA (SATA) and both 2 Gbps and 4 Gbps Fibre Channel—within a single storage system, complementing virtualization's inherent flexibility. Virtual LUN technology, available without additional licensing fees, enables administrators to create tiers of VMs using these different drive types, migrate VMs between tiers, and alter the VM file system's performance characteristics at the LUN level, all without taking the system offline or disrupting the VMs. If specific VMs become more critical than they were previously, administrators can use Virtual LUNs to easily migrate their data from SATA to Fibre Channel storage to help increase performance (see Figure 2).

Meeting SLAs with EMC Navisphere Quality of Service Manager

The relative ease of deploying VMs brings its own challenges, such as VM performance prioritization. Because different VMs require different service levels, in complex virtualized environments it can be paramount to choose storage that provides complementary QoS functionality, allowing administrators to choose which VMs can access additional storage resources during periods of system contention. Moreover, this storage must be able to meet specific performance thresholds during these periods.

The Dell/EMC Navisphere Quality of Service Manager (NQM) application, accessible through the Navisphere Web browser–based interface, provides granular management to help meet LUN SLAs in VMware software–based environments. NQM uses a data feedback loop to

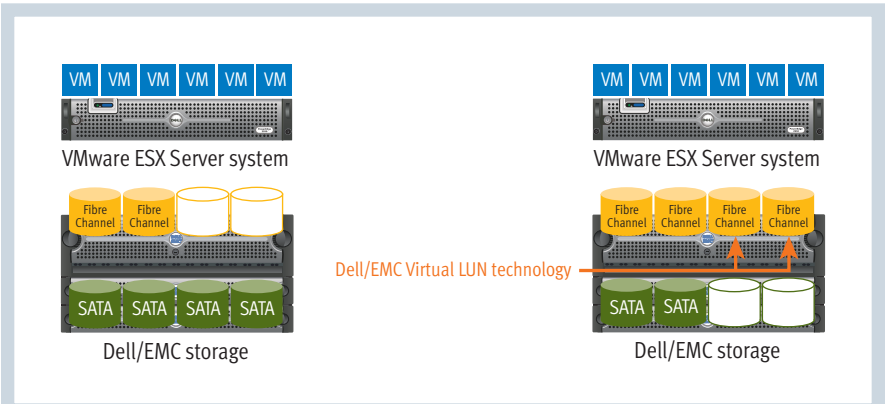

Figure 2. *Migrating LUNs to a high-performance tier with Dell/EMC Virtual LUN technology*

"By deploying VMware software in conjunction with Dell/EMC CX3 UltraScale series arrays, enterprises can create flexible, resilient, easy-to-manage virtualized infrastructures."

measure VM performance based on predefined performance objectives. Depending on the application performance profile, administrators can use three metrics within NQM to determine the service level of a specified VM: throughput, bandwidth, and response time. After identifying the appropriate service-level metric(s), they can then choose one of two control methods: goals or limits.

NQM also includes a scheduling capability allowing different policies to be used at different times. For example, administrators could configure NQM to provide their e-mail application with full system resources during normal operating hours, then limit the resources available to that application during the evening when a backup application is running. Administrators can easily use the metrics and scheduling capabilities of NQM to dynamically manage service levels based on enterprise requirements and help ensure that, for example, I/O processor–intensive operations such as VM creation do not affect production VM performance.

For VMs running applications that require specific service levels, administrators typically should configure a dedicated LUN as a VMFS or RDM volume that is presented only to that VM, which helps ensure that the VM receives the appropriate throughput, bandwidth, and response time. Alternatively, they can place VMs requiring specific service levels on a single LUN and use NQM to set a service-level goal for all of the VMs on that LUN.

Combining NQM with the VMware Distributed Resource Scheduler (DRS) feature, which provides service-level management for VM virtual processors and memory, can enhance QoS management capabilities. DRS monitors utilization across resource pools and dynamically allocates resources among VMs based on predefined policies, and can make additional resources available by migrating live VMs to different physical hosts using VMware VMotion™ technology. When combined, NQM and DRS can provide comprehensive policy-based service-level management for applications throughout a data center.

Deploying highly available storage with Dell/EMC UltraPoint architecture

Even in virtualized environments, an application's availability is only as good as the storage its data resides on. Dell/EMC CX3 UltraScale series arrays are designed to provide cost-effective mid-range storage with industry-leading high-availability capabilities. Architecture, process, and software enhancements over previous-generation Dell/EMC storage enable these arrays to provide enterprise-class reliability to VMware software–based environments.

The Dell/EMC CX3 UltraPoint DAE3P enclosure offers a back end designed to increase fault isolation by using a point-to-point architecture rather than an arbitrated loop between the link controller card and the disk drives. Isolating the disk drives when a fault is detected or when the drives are being installed mitigates risks to system-wide availability.

Complementing the increased resiliency of the UltraPoint hardware architecture are recent enhancements to the FLARE operating environment. These enhancements help reduce the risk of a double drive failure through the use of proactive hot spares, which allow copy operations to a hot spare from a failing drive to help eliminate the rebuild window and reduce exposure to a second drive failure. High availability is one of the primary advantages of virtualization, and Dell/EMC CX3 UltraScale series arrays can help ensure this availability for enterprises running VMware software.

Integrating VMware virtualization with flexible, resilient Dell/EMC storage

Choosing appropriate storage and storage software for a VMware software–based environment can be critical to maximizing the advantages of virtualization. By deploying VMware software in conjunction with Dell/EMC CX3 UltraScale series arrays, taking advantage of metaLUN and Virtual LUN technology, and using EMC Navisphere and Navisphere Quality of Service Manager software, enterprises can create flexible, resilient, easy-to-manage virtualized infrastructures.

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How Streaming the OS and Applications Changes the Rules for Server Provisioning

BY PETE DOWNING

Ardence Data Center Edition provisions Citrix Presentation Server™ software–based Dell™ PowerEdge™ servers on demand by streaming both the OS and applications from network storage. This approach enables organizations to lower system administration and operating costs, ensure server-build consistency, and increase data center flexibility—all while enhancing business agility.

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In traditional data center environments, servers are provisioned with an OS and applications on their local hard drives. Typically, each group of servers performing the same function—for example, running database, office, or accounting applications—has one or more live dedicated backups provisioned with the same OS and applications to help satisfy service-level agreements (SLAs) for IT organizations and their customers.

The challenge is that a traditional data center architecture can be expensive to maintain and complicated to manage, and typically forces overbuilding. Server provisioning—adding new servers, repurposing production servers, or installing updates, patches, and upgrades to production servers—is a time-consuming, resource-intensive process. Often, underutilized standby servers consume power and space that could be conserved if an on-demand or utility computing architecture were in place. The bottom line: in a traditional data center architecture, costs escalate while business flexibility suffers.

Ardence, a Citrix Company, has developed OS- and application-streaming functionality designed to revolutionize the relationship between server hardware and software—leading to a fundamental change in data center dynamics and economics. Ardence Data Center Edition enables organizations to provision bare-metal servers over the network by virtualizing server OS and application images and then streaming them to the target server on demand, using a management console for point-and-click administration.

Ardence Data Center Edition enables IT administrators to create virtual server images called vDisks by making a copy of the production image (the OS and applications) of each server group and storing the copied images as files on the network. Administrators can then update, patch, or upgrade the vDisk images without affecting the original production images on the server hard disks. Also, because each server can retain the original production image on its hard disk drive, image rollout and rollback processes are significantly simplified. In an Ardence-enabled Citrix Presentation Server environment, administrators can configure servers to boot from either the network vDisk or the local hard disk drive. If a problem occurs during vDisk deployment, administrators can revert to the previous production image simply by directing the server to reboot from the local hard disk instead of the network.

As illustrated in Figure 1, Ardence Data Center Edition simplifies the process of deploying new servers, repurposing existing servers, and updating, patching, or upgrading server images compared with the traditional approach of physically reconfiguring hardware and installing the OS and applications on multiple servers. Streaming the OS and application image on demand to bare-metal servers with Ardence can accelerate server provisioning, help ensure server-build consistency, and increase agility. (For an overview of Ardence Data Center Edition functionality, see the "How it works: Streaming the OS and application image" sidebar in this article).

Enhancing Citrix application delivery environments

Ardence Data Center Edition allows Citrix Presentation Server administrators to dynamically allocate servers hosting applications. For example, in a traditional Citrix Presentation Server environment, administrators could provision a new Citrix Presentation Server system to deliver Microsoft® Office Outlook® software using one of two methods:

- Purchase new server hardware, install and license the Microsoft Windows Server® OS and Terminal Server, install Citrix Presentation Server, test the server, add the new server to the server farm, and deploy Outlook.
- Reprovision an existing server, which requires taking the server out of production and repeating the time-consuming manual provisioning steps of the preceding method.

After deploying Ardence Data Center Edition, administrators can make a simple point-and-click change in the Ardence administration console to enable Citrix Presentation Server to boot from a newly created "Outlook vDisk" (OS, Citrix Presentation Server, and Outlook software). After a reboot, the Outlook vDisk is streamed to the server, reprovisioning the server to service Outlook sessions.

In addition, by using Ardence Data Center Edition, administrators no longer need to provide a dedicated backup for each Citrix Presentation Server group. Instead, a single server (or a small group of servers) can back up an entire Citrix Presentation Server farm. If a server fails, administrators can boot a backup server from the appropriate vDisk. This approach also enables dynamic allocation of application delivery servers. Citrix Presentation Server systems can be added and removed dynamically based on user loads and other factors, or repurposed to support other server functions as required—on demand.

Creating an on-demand data center infrastructure

Ardence Data Center Edition enables true on-demand computing in the data center. This approach to data center architecture allows IT organizations to dramatically reduce the server footprint necessary to maintain existing SLAs. Because servers can run diskless, administrators can stream the OS and server applications on demand from network storage to these stateless devices. As a result, servers can be provisioned from bare metal in the time it takes to reboot, allowing enterprises to meet changing needs by quickly scaling in or scaling out. As illustrated in Figure 1, Ardence Data Center Edition enables

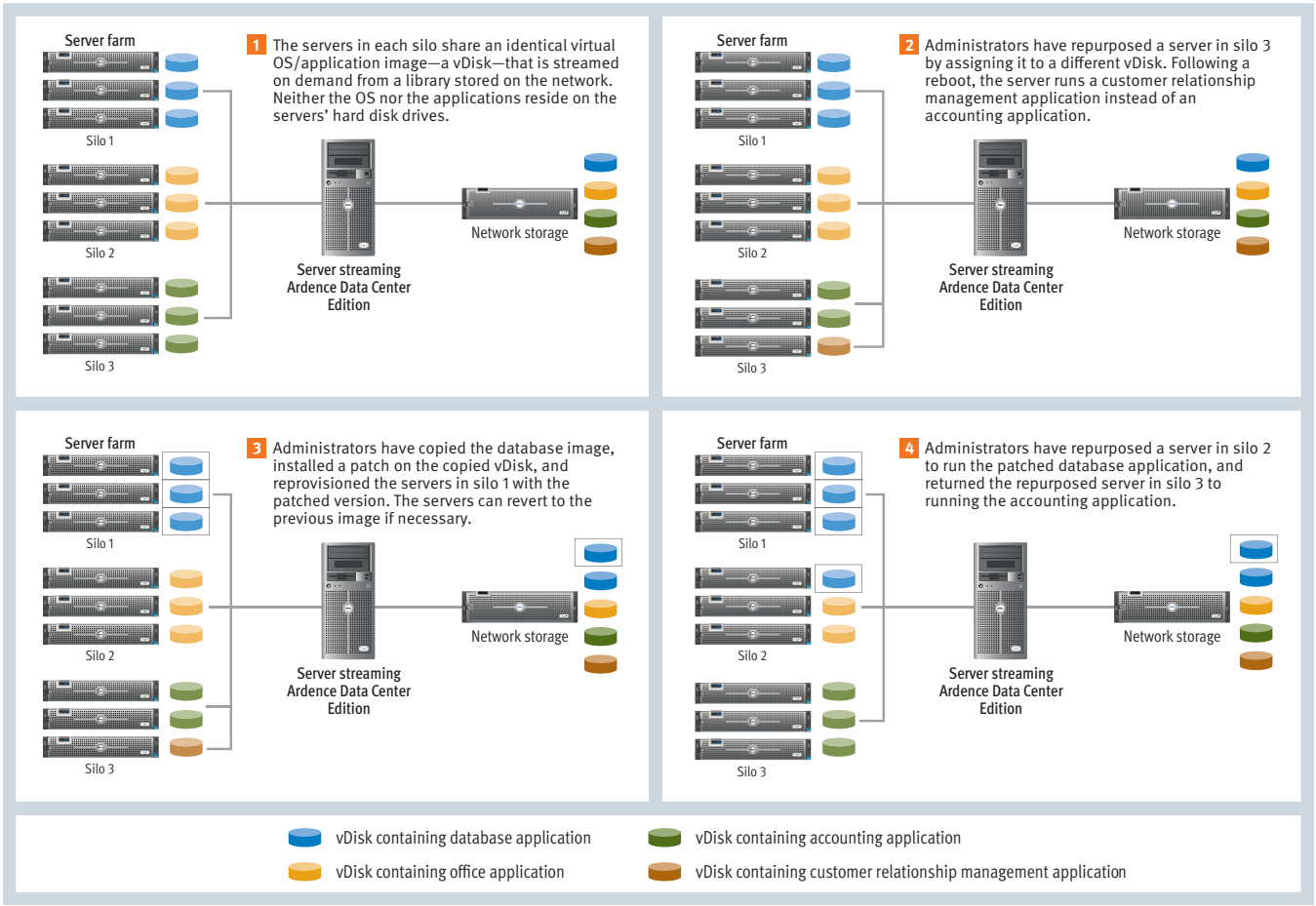


Figure 1. *Step by step: how Ardence OS and application virtualization capabilities help increase flexibility and agility*

HOW IT WORKS: STREAMING THE OS AND APPLICATION IMAGE

Ardence Data Center Edition delivers operating systems and server applications on demand over a network. To achieve this, Ardence creates a vDisk—a virtual version of a server's OS, configuration, and applications—by taking a snapshot of the OS and application stack and storing that image as a file on the network. Ardence vDisks contain the configurations required to support the various functions a server might perform, such as Web server, application server, or Citrix Presentation Server system. When powering up, instead of booting from the local hard disk, the server boots from the vDisk. The vDisk streams the assigned image to the server, and the server can start running the assigned configuration immediately—without waiting to download the entire OS.

Ardence Data Center Edition provides two deployment modes:

- **Standard image:** An identical image is streamed to groups of servers. Because Ardence accommodates the unique identifiers—host name, Media Access Control (MAC) addresses, and other differences—that are required to have the OS run on each server, each system appears to be unique even though it is delivered from a single OS image. This mode is particularly useful when groups of servers share the same OS and application stack, because it allows administrators to maintain a single software stack that can be delivered to hundreds of computers.
- **Private image:** Each server is assigned its own unique vDisk containing its OS and application image. All the vDisks reside on network storage, where the Ardence Streaming Service can access them. This mode is particularly useful in environments with many servers performing completely different functions, such as a telco hotel or outsourced data center. More specifically, some managed services may offer similar products, such as integrated voice response, while allowing individual customers to use their own software stack and dedicated server. Putting all the private vDisk images on a central disk enables the managed service to back up customer data on a single storage volume rather than backing up every single computer individually.

The Ardence approach enhances enterprise flexibility by enabling administrators to implement a server configuration contained in an Ardence vDisk, and then, when needed, implement a different server configuration contained in another Ardence vDisk from a centralized management console simply by pointing the server to a different vDisk and rebooting. No software—OS or applications—is preinstalled on the server, and no software is permanently loaded on the server. For more information, visit www.ardence.com and www.citrix.com.

administrators to increase data center flexibility and business agility.

Help ensure server-build consistency. Because all similarly configured Citrix Presentation Server–based systems share an OS and application image contained in a single vDisk on network storage, servers remain in sync. If administrators must reboot a server, the shared image is streamed on reboot—providing a consistent user experience together with simple, streamlined management.

Accelerate migrations and reduce risk. Administrators can quickly provision and scale out servers to balance workloads, because the servers do not rely on local hard disks for their OS and application image. The Ardence Data Center Edition administration console gives administrators point-and-click control to boot different operating systems and server configurations, or to bring another server into a cluster at peak traffic times. Maintenance is easy: administrators simply patch the virtual image and then stream this image to all servers. Likewise, flawed images can be rolled back instantly, helping ensure uninterrupted application delivery and business continuity.

Streamline operations, minimize server footprint, and lower operational costs. Optimizing the existing server infrastructure and breaking the 1:1 server-to-backup requirement enables organizations to reduce requirements for power, space, and heating, ventilation, and air conditioning (HVAC). Ardence Data Center Edition streamlines server image management (patching and upgrading) by supporting a fully redundant high-availability configuration, allowing servers to pick up sessions from any other server in the environment if a server should fail. Immediate rollout and rollback capabilities help create a flexible and dynamic server infrastructure.

Transform the data center into a business enabler. The data center moves from a cost center to a business enabler with the ability to meet SLAs quickly and flexibly. Scalability becomes dynamic and optimizes existing resources. Change on demand is enabled because server provisioning is a point-and-click exercise using Ardence Data Center Edition—whether adding server capacity or repurposing servers.

Ardence Data Center Edition helps IT management optimize business processes by provisioning server infrastructure quickly and cost-effectively, delivering outstanding flexibility and responsiveness. By streaming the OS and server applications from network storage, enterprises can enhance bottom-line results by reducing the number of servers required to service applications and keeping system administration and operating costs low.

Pete Downing *is a senior product manager and solutions architect at Ardence, a Citrix Company. His many credentials include Microsoft Certified Professional (MCP), Microsoft Certified Systems Administrator (MCSA), and Microsoft Certified Systems Engineer (MCSE).*

Achieving Balance-Sheet Business Value with Virtualized Server Solutions

Transforming administration-intensive physical data centers into optimized, cost-effective virtualized infrastructures is not something most organizations do every day. By drawing on best practices culled from successful customer engagements around the world, Dell Infrastructure Consulting Services can help organizations maximize IT resources, simplify server management, and sustain value across the overall IT infrastructure.

IT infrastructures have become central to enterprise operations in virtually every industry—which is why data center flexibility, simplicity, and costs have surfaced as top executive concerns. To help enterprises remain competitive and support these priorities, IT organizations must address a variety of challenges. Executives are demanding improved control of infrastructure management costs, including power and cooling. Therefore, IT organizations are under pressure to reduce the volume of hardware required to support their organizations and drive cost savings. In addition, IT infrastructures must meet regulatory requirements for high availability and business continuity and comply with strict service-level agreements (SLAs) with their constituents.

Under pressure to reduce costs by transforming their operations, IT organizations must also increase infrastructure flexibility to respond quickly to enterprise demands. System administration efforts, and therefore costs, must be reduced despite accelerating requirements for change management. IT organizations must drive efficient use of system resources to avoid buying new equipment when current assets are underutilized. At the same time, these organizations must design systems that can protect uptime and availability in the face of isolated component failure or broad disaster.

In the past few years, virtualization has become a preferred approach to consolidating data centers and increasing operating efficiency. Virtualized infrastructures are designed to increase reliability and minimize downtime for end users by reducing physical points of failure and enabling immediate failover during a system outage. Reducing the number of physical systems also reduces trouble tickets and alerts, helping lower system administration expenses. In addition, enterprises can benefit from increased resiliency, which helps reduce preparation and recovery time when faced with a major disaster such as a hurricane or tornado.

Virtualization can help reduce costs in several important ways. The consolidation of physical servers helps enterprises save on data center space as well as power and cooling (see Figure 1). Virtualization can also help simplify operations—allowing administrators to spend fewer hours on maintenance than would be required for physical systems.

Understanding virtualization services

Once an organization decides to proceed with a virtualization project, administrators face a pivotal decision: Should the organization implement virtualization on its own, or bring in experts to help?

The issue is not that enterprises lack the resources or knowledge to implement virtualization technologies. Instead, working with a consulting organization experienced in designing and deploying virtualized environments enables enterprises to benefit from expert guidance when designing an infrastructure that best meets their particular needs. Consultants with deep knowledge and broad expertise can help enterprises complete projects quickly and cost-effectively while transferring knowledge and sharing best practices.

Dell Services—whose virtualization consultants are VMware® Certified Professionals—takes a solutions-oriented approach to help organizations achieve tangible results quickly and cost-effectively. After an in-depth assessment of an organization's goals and current environment, Dell Services experts can design and implement a comprehensive, high-availability virtualization solution, including integration of the storage environment and tuning of the backup and recovery systems. As part of the virtualization process, the Dell Services team also optimizes x86 server architecture and enables the systems management capabilities required for a robust IT infrastructure.

Enhancing the work of the Dell Services virtualization team, the Dell Virtualization Global Practice Group leverages best practices the world over—including virtualization expertise honed from hundreds of customer engagements around the globe. Dell Services also uses and continuously enhances its intellectual property documentation and methodologies to apply relevant, state-of-the-art best practices to specific organizational needs (see sidebar in this article).

Delivering broad expertise

Dell Services offers six key areas of virtualization expertise.

Physical-to-virtual migration. Converting a set of physical servers to virtual machines (VMs) that run on a reduced number of physical servers can help simplify administrative efforts. Consolidation also helps lower acquisition costs, enabling organizations to buy fewer physical servers during the next system refresh than they would otherwise. Furthermore, consolidation through virtualization can help reduce transition risks and optimize use of systems resources.

High availability. Addressing fault tolerance and resiliency in the server infrastructure can help ensure that SLAs are met. High availability is commonly achieved by avoiding single points of failure—for example, using multiple network interface cards or host bus adapters, or implementing clusters running the Microsoft® Windows® or Linux® operating systems. VMs also enable fast recovery from hardware failure, which helps avoid unplanned downtime and enhances service levels.

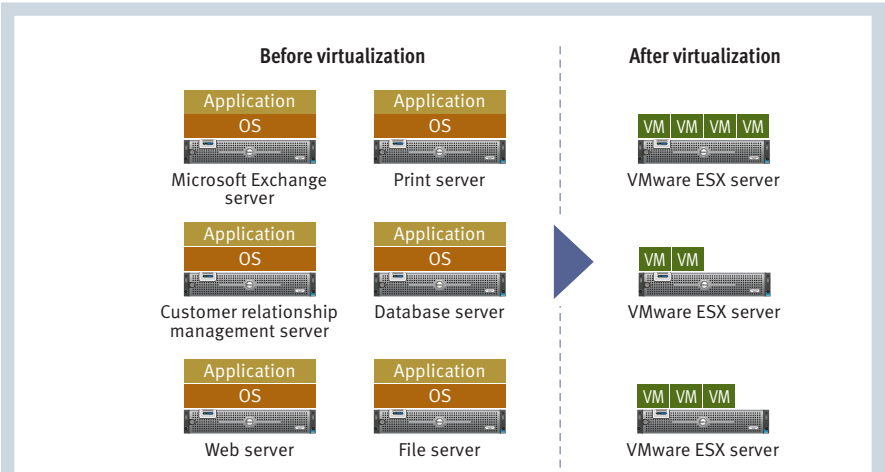
Backup and recovery. Optimizing backup and recovery processes in a virtualized server environment can significantly reduce the number of backup agents in the IT infrastructure. This approach also eases the risk of end-user disruption or system administration problems and helps reduce network traffic by backing up data directly from the storage area network (SAN). The Dell Services team offers knowledge transfer to help optimize backup and recovery processes in a virtualized server environment.

Configuration management and monitoring. Dell Services provides IT departments with the tools they need to track which VMs run on which physical servers. By monitoring resource utilization, IT administrators can decide whether to balance workloads by moving VMs from one server to another. Dell

Dell Services intellectual property for virtualization

The intellectual property used by Dell Services virtualization consultants is continuously updated to help meet specific organizational needs. This compendious resource includes:

- More than 600 pages of in-depth documentation
- Best practices gathered from around the world
- Dell Virtualization Reference Architecture and collaboration with Dell Solutions Engineering



Servers	800	50
Storage	Direct attach storage	Tiered SAN and network attached storage
Network	2,500 cables and ports	250 cables and ports
Facilities	180 racks and 300 power whips	10 racks and 20 power whips

Figure 1. *Virtualization enables server consolidation, flexibility, and availability*

Dell Services experts can help enterprises deploy virtualization solutions quickly and cost-effectively.

Services also can help organizations establish processes and tools to monitor system health and dynamically reconfigure physical and virtual server assets. This approach helps speed system resource provisioning for new or increased workloads.

Development and test environments. VMs allow organizations to quickly establish a production-like environment for testing configuration changes and software patches—sometimes in minutes, compared with the hours or days it can take to reconfigure an all-physical test and development environment. By leveraging virtualization, Dell Services helps reduce the risk of disrupting software development and test processes.

Virtualization upgrades. Making the transition from VMware Virtual Infrastructure 2 to Virtual Infrastructure 3 enables organizations to realize enhanced benefits. In the process, Dell Services can identify additional workloads to be virtualized. By drawing on its in-depth experience in diverse customer engagements around the world, Dell Services can help organizations reduce the risks inherent in this transition.

Taking virtualization from concept to reality

Within each of its six areas of virtualization expertise, Dell Services offers four types of virtualization consulting services: workshops, assessments, designs, and implementations. Reaching beyond the workshop and assessment services offered by many consulting organizations, Dell Services provides design and implementation services that enable enterprises to take virtualization all the way from concept to reality.

Workshops. Half-day virtualization workshops help organizations understand the potential of virtualization technology and how virtualization can apply to their specific problems and needs. Consulting whiteboard sessions include a broad discussion of enterprise requirements and technology capabilities, as well as a discussion of how virtualization technologies can address specific organizational needs and priorities. At the end of these sessions, Dell Services provides a high-level architecture and plan to help organizations get started.

Technology workshops complement consulting whiteboard sessions by providing an interactive, hands-on exploration of virtualization technology as driven by enterprise needs and priorities. In these workshops, Dell Services experts help organizations understand how they can use VMware technology to run their workloads with VMs and consolidate their physical servers. Organizations can also increase their understanding through the hands-on use of VMware VirtualCenter, VMotion™, VMware High Availability (VMware HA), and Distributed Resource Scheduler software.

Assessments. In a virtualization assessment, Dell Services helps organizations make informed decisions about whether and how to proceed with virtualization using VMware technology. Dell Services helps identify which workloads and physical servers are most suitable for virtualization based on resource utilization as well as total cost of ownership (TCO).

At the conclusion of an assessment project, Dell Services creates a report that covers not only infrastructure evaluation, but also organizational recommendations and TCO. This report provides a rough cost estimation for implementing the recommended architecture, including the costs of hardware, software, outside services, and internal IT staff effort. If an organization is considering a server refresh—with or without virtualization—Dell Services provides a comparison with a TCO estimate.

Designs. During design projects, Dell Services helps organizations lay the path to success by specifying detailed hardware and software configurations for the future virtualized server infrastructure, as well as providing a detailed implementation plan. This plan can enhance the efficiency of the implementation phase while helping lower TCO by reducing the number of physical servers and software licenses required during a server refresh. Design projects also help organizations specify how to establish configuration management and monitoring to enable flexible ongoing management of virtualized servers.

Implementations. In implementation engagements, Dell Services helps organizations capture the value of virtualization. Typical tasks include hardware and software installation, configuration, quality assurance, migration of VMs on physical servers, migration of data, promotion of data to production environments (making it available to end users), and transfer of knowledge to the organization's IT staff.

Typical deliverables for implementation projects include diagrams and build documents that describe how the systems were configured so that the organization and Dell support teams can refer back to the initial production state. Dell also provides a knowledge transfer checklist, which includes best-practices tips tailored to the organization's specific environment.

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"Imagine your SUV going through gallon after gallon of gas while sitting in the garage. Servers use about 30 percent of their peak electricity consumption while sitting idle, which is often more than 80 percent of the time."

—**Bogomil Balkansky**, Director of Product Marketing, VMware

Once upon a time, CIOs could solve IT problems simply by adding new servers to handle additional workloads. Today, the legacy left by this strategy haunts enterprises everywhere. Server proliferation has become a serious challenge. However, virtualization is more than just a concept—it is a concrete business strategy that can provide tangible value for companies in virtually any industry.

The high cost of inefficient data centers

In today's environment, the top concerns of managing IT systems have turned from the simple mathematics of hardware procurement, systems administration, and programmers to the modern day data center concerns of energy efficiencies—power and cooling requirements and costs, rising real-estate costs, business continuance policies to meet regulatory governance, and increasing server hardware sprawl. IDC's recent Directions presentation, "Enterprise Class Virtualization 2.0,"[1] provides facts around operational costs that vex organizations tasked to manage and fund IT infrastructures:

- $8 is spent maintaining legacy IT for every $1 invested in new IT infrastructure; this severely limits business innovation
- 50¢ is spent to power and cool servers for every $1 in server spending today; this may increase to 70¢ by 2010
- Constructing a new data center costs approximately $1,000 per square foot; this is $40,000 per rack or $2,400 for a typical server

As operational costs for IT infrastructure and data centers continue to increase, enterprises, agencies, and institutions around the world are turning to virtual infrastructures as an answer to mitigating costs, driving optimization, and gaining efficiencies from their IT environments. IDC reports that "virtualization impacts more than servers—storage, networks, clients, management, security, etc." and "server virtualization is now considered a mainstream technology among IT buyers."[2]

Virtualization: A smarter way to allocate resources

Adding even more servers to already overbuilt, underutilized networks is not the answer for companies trying to focus on strategic IT projects. Instead, businesses need consolidated IT environments that require less maintenance and fewer power and cooling resources.

By making resources available when and where they are needed, virtualization eliminates unused headroom, allowing companies to handle their workloads using fewer servers. And fewer servers mean less maintenance, power, and cooling, which translates into significant reductions in

[1] IDC, "Enterprise Class Virtualization 2.0—Application Mobility, Recovery, and Management," Document #DR2007_5MEW, February 2007

[2] IDC, "Enterprise Class Virtualization 2.0—Application Mobility, Recovery, and Management," Document #DR2007_5MEW, February 2007

Virtualization in the Real World

Virtualization is more than just a concept—it is a concrete business strategy that can provide tangible value. For example, when Data Guard Systems—a hosted point-of-sale provider for cell phone retailers—found itself facing a million-dollar price tag to add power capacity to its data center, the company chose instead to facilitate growth by finding ways to reduce its per-server power consumption.

By consolidating 45 backup database servers onto four Dell™ PowerEdge™ servers with dual-core Intel® Xeon® processors running VMware® Infrastructure 3 data center optimization and management software, Data Guard was able to reduce its power costs by as much as $10,000 per month and pay back the cost of the new infrastructure within one year. The virtual infrastructure, created with the assistance of Dell assessment, design, and implementation services, also made disaster recovery more cost-effective and reliable with built-in business continuity features provided by VMware technology.

operations costs—and more money for strategic initiatives.

Dell has developed adaptive power management and worked with VMware to develop ways to autonomically and proactively power-down underutilized systems during off-peak times. Ultimately this drives down costs of power and cooling for unused systems during nights and weekends.

What's at stake for your budget—and the environment

New initiatives chartered to solve problems around energy and conservation have emerged. Dell Earth and the Green Grid initiative are examples where Dell, Intel, and VMware are collaborating to refine information technology that conserves energy and resources. Here are some of the glaring facts that are advancing these new efforts toward energy efficiency and conservation: according to Gartner Research, energy costs may increase from 10 percent of the typical IT budget today to more than 50 percent in the next few years.[3] Current IT infrastructures are very inefficient due to underutilization, especially with x86/x64 servers. Gartner states that during a 24-hour period, less than 10 percent of the available computing power of these servers is being used. The picture is slightly better for RSC/UNIX machines (at 20 percent during a 24-hour period), whereas a typical mainframe environment can achieve between 70 percent and 80 percent. Because most of the power and cooling problem is caused by high-density x86 servers, this low level of use is a major contributor to the overall energy problem.[4] IDC found that the cost of power for servers may exceed the cost of the servers themselves by 2008. What's more, IDC calculates that the total power and cooling bill for servers worldwide is almost $30 billion for 2006—and if current trends persist, that number will rise to $45 billion by the end of the decade.[5]

Virtual infrastructures offset these mounting operational costs by matching IT infrastructure to business requirements and needs. Virtualization enables multiple applications and workloads to operate on individual servers, thus driving higher utilization and computing power for every unit of energy expended to run each server. For example, in a company running 1,000 mainstream servers in a 12:1 consolidation ratio over a period of three years, virtualization can facilitate major cost savings. VMware studies[6] indicate that this company could save approximately $759,000 on power costs alone over three years—in addition to $949,000 on cooling and $416,000 on space costs. The company could save $5.8 million on hardware, as well as $586,000 on networking and storage equipment.

Consolidated, virtualized data centers extend another important benefit: environmental stewardship. For every workload moved from physical to virtual, an organization can save $250 per year in electricity costs and $310 in cooling costs. That means for every one million workloads running on VMware virtual machines, companies realize $560 million in total savings.

This scenario also represents 8 billion kilowatts saved—which exceeds the total energy needed for heating, ventilation, and cooling in New England in a year. By cutting power and cooling requirements, virtualization helps industry leaders do their part to promote "green" policies and prevent climate change.

Dell, Intel, and VMware: The power of virtualization

VMware® Infrastructure 3 Data Center Management and Optimization Suite running on Dell™ PowerEdge™ servers featuring quad-core Intel® Xeon® 5300 series processors

[3] Gartner, "A Message From Data Center Managers to CIOs: Wake Up to Our Energy Crisis," Page 4, August 2006

[4] Gartner, "Data Center Power and Cooling Scenario: Options for the Road Ahead," Pages 2–3, April 2007

[5] IDC, "Worldwide Server Power and Cooling Expense 2006–2010 Forecast," Document #203598, September 2006

[6] VMware Market Opportunity Study, Server and Infrastructure Virtualization, January 2007. Data in example enterprise scenario based on usage reported by VMware customers.

provides an outstanding platform to deliver the value of virtualization. Together, Dell, Intel, and VMware provide production-proven, mainframe-class infrastructure that is always on, offers capacity on demand, and provides policy-based automation.

The combined strength of Dell, Intel, and VMware can deliver significant benefits for small, medium, and large organizations across all industries and sectors:

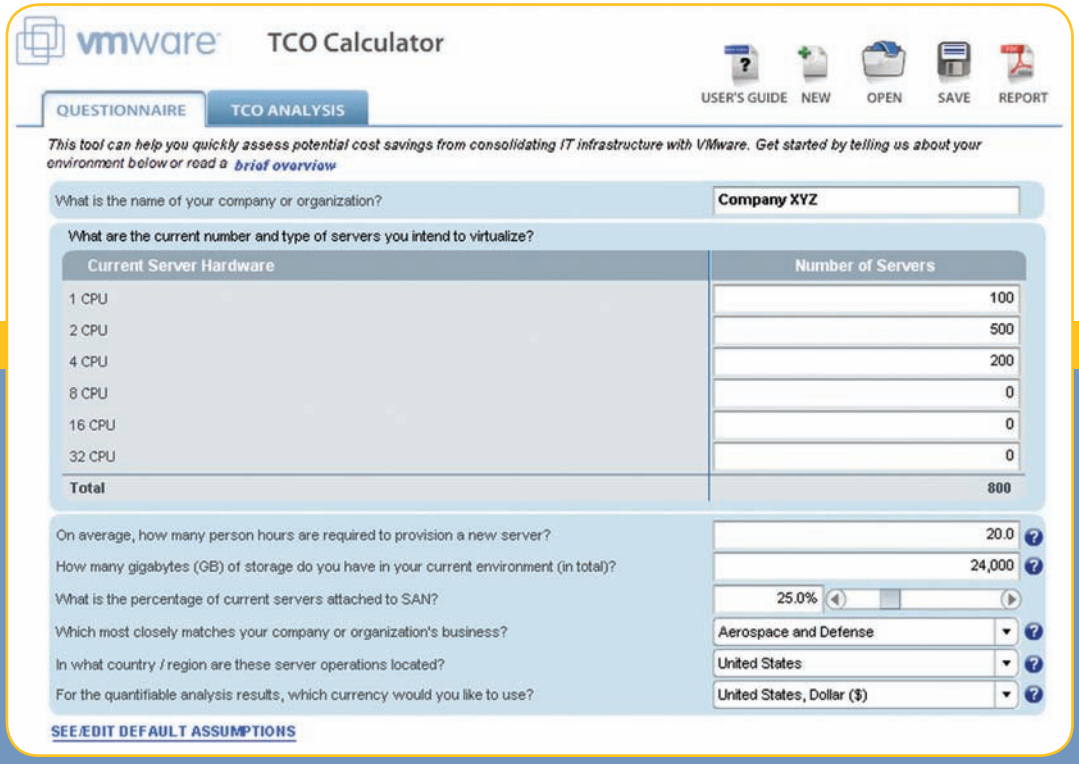
- ***Realize transformative cost savings*** through low TCO from virtualized IT infrastructures that enable effective use of budget resources and help decrease operational costs
- ***Increase operational flexibility and efficiency*** through quick deployment of software applications and services for fast time to productivity
- ***Minimize risk and enhance IT service levels*** through zero-downtime maintenance capabilities and rapid recovery times for high availability and streamlined disaster recovery scenarios across the data center
- ***Optimize IT environments*** through VMware virtual infrastructures that can help optimize and manage the enterprise—from Dell PowerEdge servers to Dell OptiPlex™ desktops and Dell Latitude™ notebook PCs

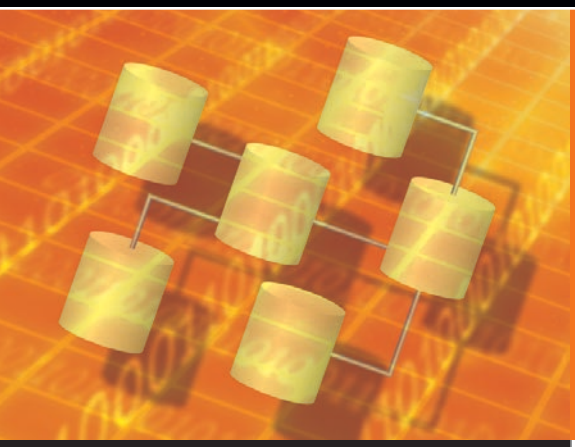
In addition, the quad-core Intel Xeon 5300 series processors incorporated in Dell PowerEdge servers enable a new level of consolidation, improving server efficiency across various criteria including price/performance, performance per watt, and performance per square foot of data center space.

Savings beyond power and cooling

Power, cooling, and space savings are just some of many ways that Dell and VMware virtual infrastructure solutions can dramatically reduce operation costs in the IT environment—these are savings that a business or organization can take back to its bottom line. To understand the total impact of virtualization on your organization—try our online ROI calculator and see the dramatic savings instantly.

To learn more, visit www.vmware.com/dell or www.intel.com/business/technologies/virtualization.htm. Calculate your cost savings today at www.vmware.com/go/calculator.





iSCSI: Changing the Economics of Storage

Part 2—Deploying iSCSI in Virtualized Data Centers

BY MATT BAKER

TRAVIS VIGIL

Integrating virtualized servers with shared storage is necessary for flexible virtual machine (VM) mobility, but can be more complicated than many enterprises expect. The second article in this ongoing series details the advantages Internet SCSI (iSCSI) offers in virtualized environments, including simplified deployment, comprehensive storage management and data protection functionality, and seamless VM mobility.

Related Categories:

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Storage

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Virtualization can provide many advantages in enterprise environments, including increased operational efficiency and flexibility, resource utilization, and availability. However, integrating virtualized servers with shared storage to enable flexible virtual machine (VM) mobility can be complex. This is particularly true of traditional Fibre Channel–based storage area networks (SANs), which not only involve specialized knowledge and reconfiguration, but can require sacrificing high-level storage management and data protection functionality to take advantage of virtualization's benefits.

Internet SCSI (iSCSI) can help enterprises avoid these issues. Based on standard Ethernet components, iSCSI-based SANs help simplify configuration and storage management in virtualized environments while avoiding the functionality trade-offs of Fibre Channel. Importantly, iSCSI enables administrators to manage the relationship between VMs and shared storage just as they do with physical servers—a key point for enterprises implementing their first SAN or first virtualized environment and looking for an approach that is familiar, easy to deploy, cost-effective, and able to integrate with their existing storage management and data protection processes.

Part 1 of this series[1] outlined the basics of iSCSI, which allows enterprises to create Ethernet-based SANs at a lower cost of entry than Fibre Channel without requiring specialized equipment or expertise, and included a discussion of how enterprises can implement iSCSI using Dell™ PowerVault™ and Dell/EMC storage arrays. This second installment focuses on how administrators can combine iSCSI and virtualization to build an efficient data center that is optimized for enterprise workloads.

Understanding virtualization and storage

Virtualization software enables multiple isolated environments to run in individual VMs on the same physical server, with each VM having its own virtual BIOS, processors, memory, and so on. Abstracting the OS platform from the hardware allows administrators to easily consolidate physical resources and flexibly move VMs between servers as needed for load balancing and failover.

Along with these advantages, however, virtualization can bring its own set of challenges—and integrating VMs with a shared storage back end can be a cause of administrator headaches. Fibre Channel–based SANs can be complex, particularly for enterprises deploying shared storage for the first time. Fibre Channel does offer many advantages, in particular high performance for high-throughput, low-latency

[1] "iSCSI: Changing the Economics of Storage; Part 1—Understanding iSCSI in Enterprise Environments," by Travis Vigil, in *Dell Power Solutions*, May 2007, www.dell.com/downloads/global/power/ps2q07-20070335-Vigil.pdf.

applications such as large-scale decision support. However, iSCSI can help enterprises address three common issues encountered in virtualization deployments:

- **Managing complex storage relationships:** SANs can be complex to deploy and manage on their own. By creating a large number of VM-to-storage relationships that must be managed by the hypervisor—the software layer providing the virtualized environment—virtualization can increase that complexity.
- **Enabling storage management and data protection:** Storage management and data protection operations must be re-created in the hypervisor when using Fibre Channel–based shared storage. Not only does this configuration require specialized knowledge, but in some cases, array-based functionality may not be available with the hypervisor, and scripts developed for some backup applications in non-virtualized environments may no longer function or may need to be rewritten entirely in virtualized environments.
- **Enabling VM mobility:** The ability to move VMs freely between physical servers is essential for load-balancing and failover capabilities. However, enabling this mobility on Fibre Channel–based SANs can result in administrative complexity for enterprises unfamiliar with managing shared storage for virtualized environments.

> "iSCSI-based SANs help simplify configuration and storage management in virtualized environments while avoiding the functionality trade-offs of Fibre Channel."

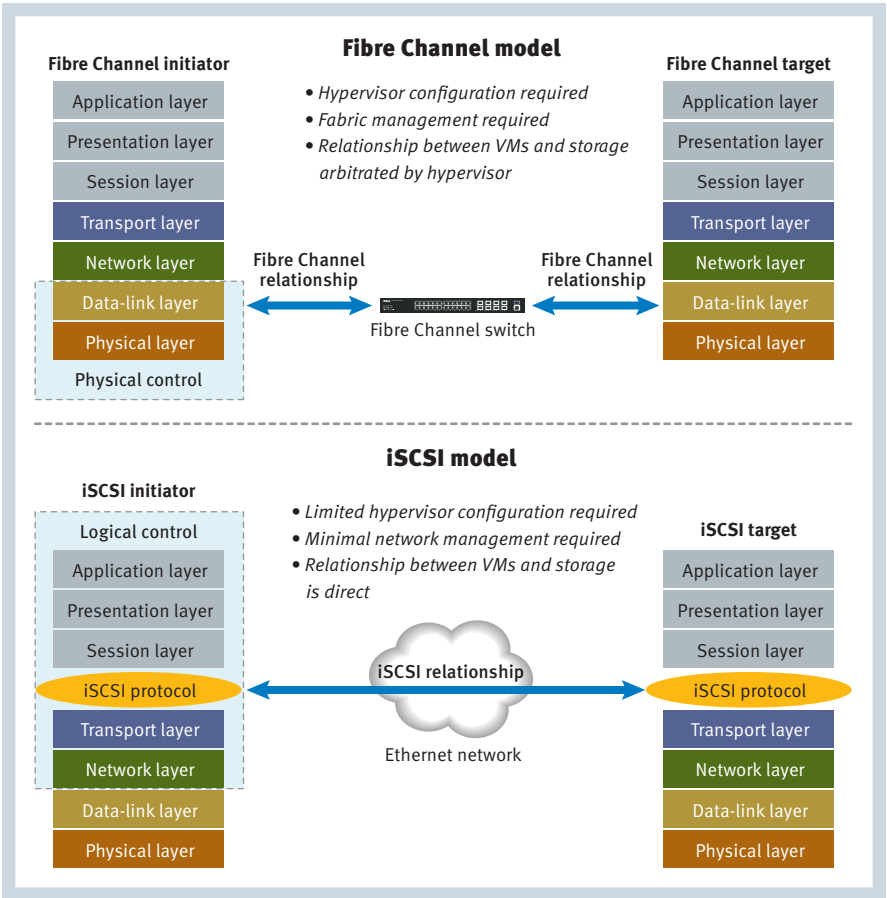

Figure 1. *Fibre Channel and iSCSI storage management models*

In the future, initiatives such as N_Port ID Virtualization (NPIV)—which allows multiple Fibre Channel initiators to share a single physical port—may help simplify the configuration and management of Fibre Channel–based SANs, particularly in virtualized environments. However, iSCSI can mitigate or help eliminate these problems now, allowing administrators to benefit from the advantages of SANs and virtualization while helping simplify deployment and management—and avoiding the functionality limitations currently incurred in a Fibre Channel–based virtualization deployment.

Comparing Fibre Channel and iSCSI in virtualized environments

iSCSI can help enterprises meet all three of the major challenges listed in the preceding section, streamlining the management of complex storage relationships, allowing the same comprehensive storage management and data protection in both virtualized and non-virtualized environments, and enabling easy VM mobility with less storage-specific hypervisor configuration than can be required with Fibre Channel.

Managing complex storage relationships

One difference between Fibre Channel and iSCSI in virtualized environments lies in how they construct the relationships between VMs and storage. Although neither strictly adheres to the Open System Interconnection (OSI) model, it can be helpful to think of Fibre Channel as controlled at the lowest OSI layers (the physical and data-link layers) and iSCSI as controlled at the higher, logical layers, as shown in Figure 1.

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The difficulties of managing Fibre Channel–based storage in virtualized environments stem primarily from its *hypervisor-managed storage* approach, in which the relationships between VMs and storage are arbitrated by the hypervisor (see Figure 2). Hypervisor-managed storage does offer the advantage of quick and easy VM creation, and can be particularly useful when each VM has only one virtual disk, a common setup for non-data-intensive workloads. Hypervisor-managed storage also offers the advantage of hypervisor-specific backup and data-protection capabilities (such as those of VMware® Consolidated Backup), which are optimized for quick and easy mass backups of VMs' storage. But hypervisor-managed storage can also require significant configuration, especially when the VMs are running applications that must access large amounts of data. For example, administrators must first assign storage resources to the World Wide Name (WWN) associated with the physical server, then use the virtualization software to provision these resources to the VMs.

In contrast, software initiators allow iSCSI to function independently of the hypervisor. Hypervisor-managed storage is still required for boot logical units (LUNs), and can offer iSCSI the same benefits it does for Fibre Channel. However, using iSCSI also allows administrators to take advantage of the *storage direct* approach (see Figure 3). This model enables one of the most compelling benefits of iSCSI in virtualized environments: creating direct relationships between VMs and storage without hypervisor configuration. In doing so, iSCSI streamlines network management, allowing administrators to treat the storage associated with VMs the same way they treat storage in non-virtualized environments and dramatically simplifying SAN configuration and management. For data-intensive workloads such as Microsoft® Exchange and SQL Server™ software, this simplification can be crucial.

Figure 4 summarizes some of the features and advantages of two examples of hypervisor-managed storage—VMware Virtual Machine File System (VMFS) and raw device mapping (RDM)—and the storage direct method.

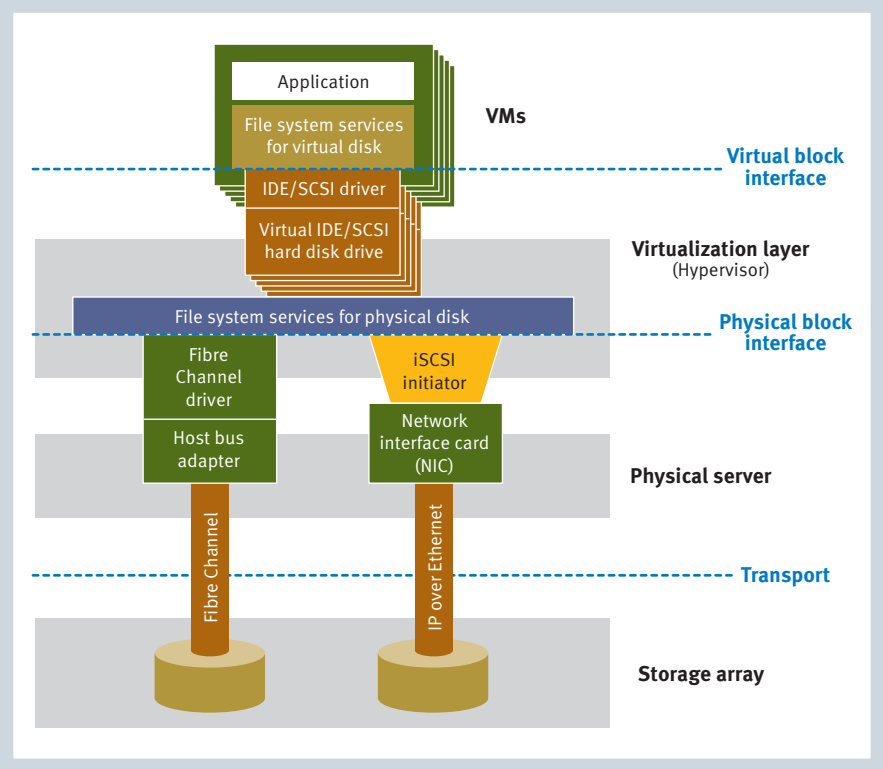

Figure 2. *Hypervisor-managed storage architecture in a virtualized environment*

Enabling storage management and data protection

Storage management and data protection tools—such as array management, snapshot, and backup and recovery software—are essential to many enterprises, allowing administrators to efficiently monitor and manage storage resources and helping ensure the availability of critical data. But use of this functionality may be limited in certain ways when using Fibre Channel:

- **Unfamiliar methods:** Administrators cannot use these tools in virtualized environments the same way they do in non-virtualized environments. As a result, they must learn and implement different ways to manage, back up, and recover storage.
- **Limited functionality:** Even after carrying out the reconfiguration necessary to re-create standard functionality at the hypervisor level, administrators may discover that some functionality readily available in non-virtualized environments is still not available after the move to a virtualized environment. In particular, array-based management, snapshot integration into popular software like Microsoft Exchange and SQL Server, and multipath functionality can be limited. In addition, backup applications or scripts that utilize Microsoft Volume Shadow Copy Service (VSS) do not function when run in the hypervisor unless the independent software vendors have enabled them to do so and support VSS in the hypervisor.
- **Difficult migrations:** Migrating applications, images, and scripts from a physical server to a VM, from a VM to a physical server, or between two different virtualized environments over Fibre Channel can require reconfiguration and re-qualification by expert administrators, and any errors may cause migrated applications to fail.

The iSCSI storage direct approach is designed to significantly simplify the use of storage management and data protection tools in virtualized environments:

- **Familiar methods:** Administrators can easily use storage management software and agents—such as VSS providers and the EMC® Navisphere® command-line interface—and create direct backups to tape or disk the same way they would in non-virtualized environments.
- **Robust functionality:** The storage direct method helps preserve array-based management functionality, including single-mailbox restores for Microsoft Exchange servers, single-LUN restores, point-in-time snapshots, and so on. Comprehensive multipath and scripting capabilities are designed to function the same way in both virtualized and non-virtualized environments.
- **Streamlined migrations:** Applications, images, and scripts developed on a physical server can function on a VM the same way they do on the physical server without complex reconfiguration, and vice versa.

Figure 5 summarizes characteristic differences between Fibre Channel and iSCSI for storage management and data protection tools in virtualized environments.

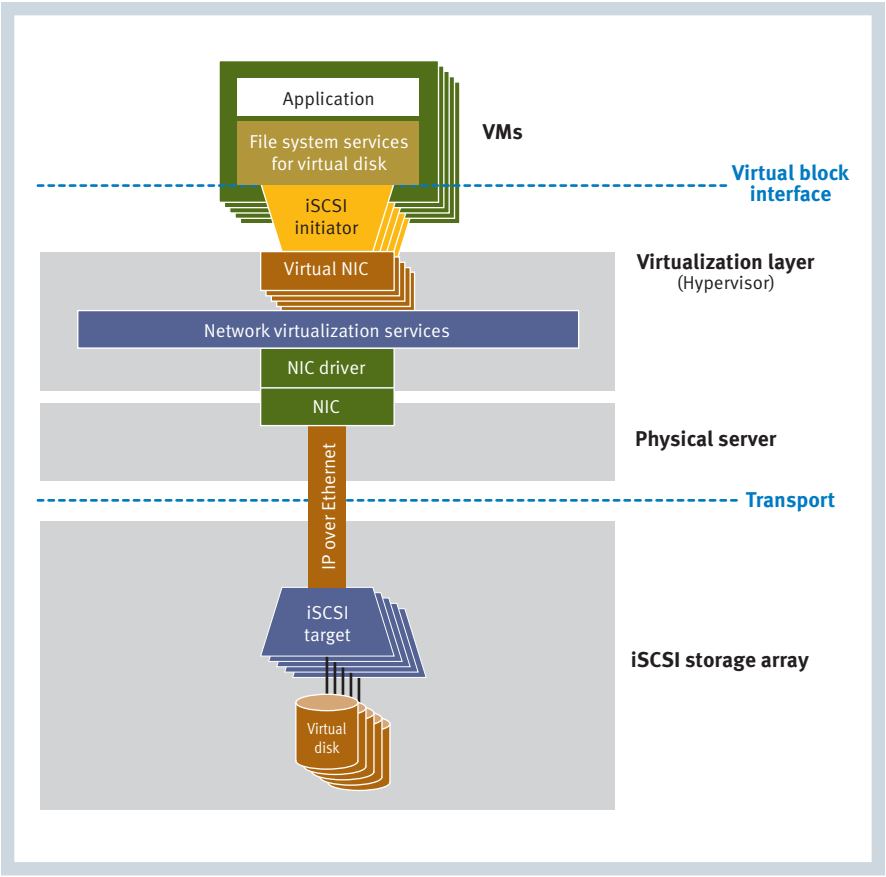

Figure 3. *Storage direct architecture in a virtualized environment*

Enabling virtual machine mobility

The ability to move VMs across physical servers quickly and easily to accommodate load balancing and failover is a key advantage of virtualization—provided the infrastructure can accommodate dynamic resource allocation. As with the relationship between VMs and storage, however, enabling VM mobility in Fibre Channel–based SANs typically requires hypervisor arbitration to allow VMs to maintain storage access from different physical servers. In addition, enabling VM mobility can raise concerns about data integrity due to administrator mis-configuration: giving every server access to all storage resources requires administrators to have multiple servers accessing the same LUN.

Because each iSCSI initiator and target have a unique name—usually the iSCSI Qualified Name (IQN)—each VM has a unique, direct relationship with storage resources

	Hypervisor-managed storage		Storage direct
	VMFS	RDM	
Support	Fibre Channel and iSCSI	Fibre Channel and iSCSI	iSCSI only
Advantages	• Allows easy VM creation • Provides basic snapshot functionality, and can be used with VMware Consolidated Backup for quick and easy mass backup of VMs • Requires minimal administrator interaction with guest operating systems • Enables access to array-based applications (with limitations)	• Allows 1:1 LUN mapping similar to storage direct • Provides more granular snapshot and clone functionality than VMFS • Requires minimal administrator interaction with guest operating systems • Enables greater access to array-based applications than VMFS (but still with some limitations) • Offers increased performance over VMFS	• Provides the most granular snapshot and clone functionality of these methods • Can integrate snapshots and clones with Microsoft applications based on Microsoft VSS and Virtual Disk Service (VDS) backups—such as Exchange and SQL Server—allowing administrators to use familiar tools • Enables full access to array-based applications, and supports robust multipath functionality for load balancing and failover • Offers increased performance compared with hypervisor-managed iSCSI • Supports secure connections between guest operating systems and targets as well as seamless VM mobility • Simplifies virtual-to-physical and physical-to-virtual migrations by helping eliminate the need to retest and reconfigure storage

Figure 4. *Comparison of the VMware VMFS and RDM hypervisor-managed storage methods and the storage direct method*

	Fibre Channel	iSCSI (storage direct)
Storage management	Managed at both the VM and hypervisor level, with limited functionality	Directly managed at the VM level, with comprehensive functionality
Backup and recovery	Managed and arbitrated at the hypervisor level	Enabled through a direct relationship between the VM and the tape or disk storage
Multipath	Functionality typically limited to failover	Comprehensive functionality available
Migration	Applications, images, and scripts developed on physical servers can require significant modification to run on VMs, and vice versa	Applications, images, and scripts developed on physical servers can run seamlessly on VMs, and vice versa

Figure 5. *Comparison of storage management and data protection capabilities in virtualized environments using Fibre Channel and iSCSI*

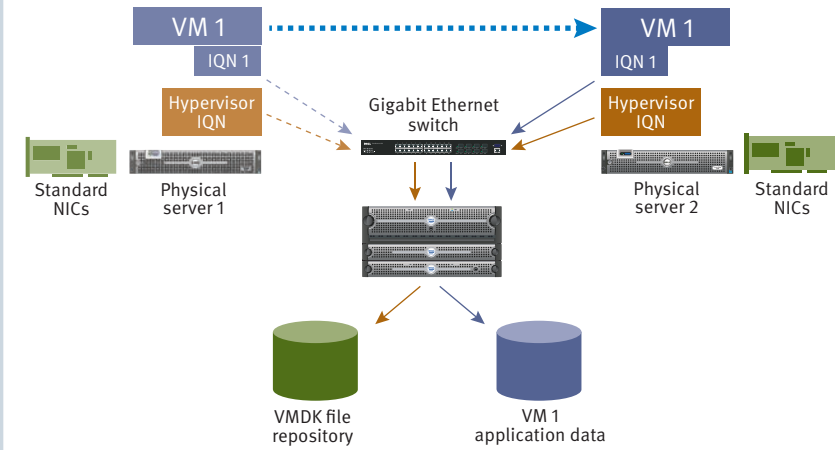

Figure 6. *Seamless virtual machine mobility using the iSCSI storage direct approach*

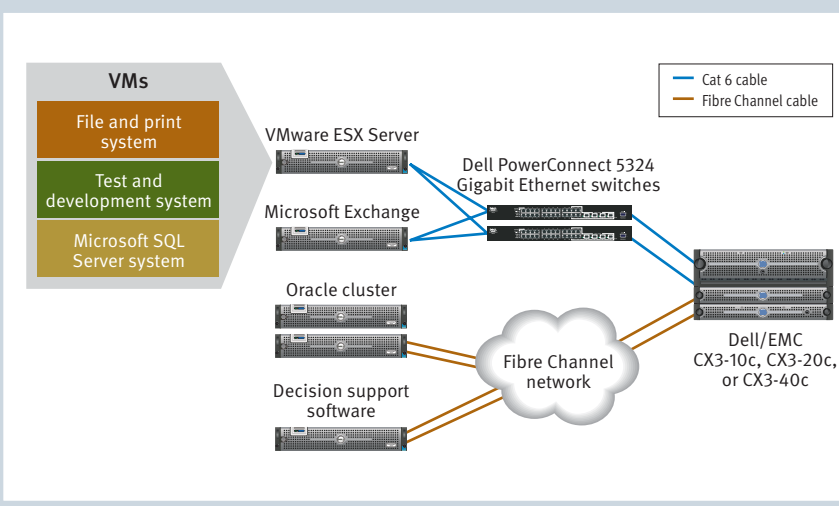

Figure 7. *Example environment combining Fibre Channel and iSCSI with Dell/EMC storage in a tiered storage structure*

distinct from the relationship between the physical server and storage, helping preserve tight access control. And because this relationship persists independently of the physical host and the hypervisor, VMs can move seamlessly between physical servers with less storage-specific hypervisor configuration than can be required with Fibre Channel. Figure 6 illustrates this process: to balance workloads or move them for proactive maintenance, a VM can easily migrate to another server while maintaining its unique identity and storage access on the new host.

Building a tiered data center

Enterprises can take advantage of storage arrays offering iSCSI functionality, such as the Dell/EMC AX150i, Dell/EMC CX3 series, and Dell PowerVault NX1950, to create a tiered storage architecture designed to optimize resources based on server workload. For example, an investment in Fibre Channel is typically appropriate for high-throughput, low-latency applications running on non-virtualized servers, while iSCSI offers distinct advantages for applications with random I/O and those running on virtualized servers. To provide additional flexibility for enterprises creating such a tiered environment, the Dell/EMC CX3-10c, CX3-20c, and CX3-40c offer both Fibre Channel and iSCSI connectivity.

Figure 7 illustrates an example optimized environment deploying both Fibre Channel and iSCSI. The file and print, test and development, and Microsoft SQL Server systems run on VMs based on the VMware ESX Server virtualization platform, and use iSCSI to take advantage of its strengths in virtualized environments. Similarly, the Microsoft Exchange server uses iSCSI to take advantage of its cost-effectiveness and performance for random I/O workloads. The Oracle® database cluster and decision support software, meanwhile, run directly on physical servers and utilize Fibre Channel to take advantage of its strengths for those types of applications.

Figure 8 illustrates another type of tiered environment using the flexible Dell PowerVault NX1950 networked storage solution, which can store both file and application data and is

designed to work with multiple operating environments and communication protocols. In the example environment, the virtualized file and print, test and development, and Exchange systems use iSCSI for block-level access to the storage. The clients running the Microsoft Windows® and Linux® operating systems, meanwhile, use Common Internet File System (CIFS) and Network File System (NFS) for file-level access and sharing. Administrators can use the central console in the included Microsoft Windows Unified Data Storage Server 2003 OS to easily create and manage file shares, iSCSI targets, point-in-time snapshots, performance logs and metrics, and more.

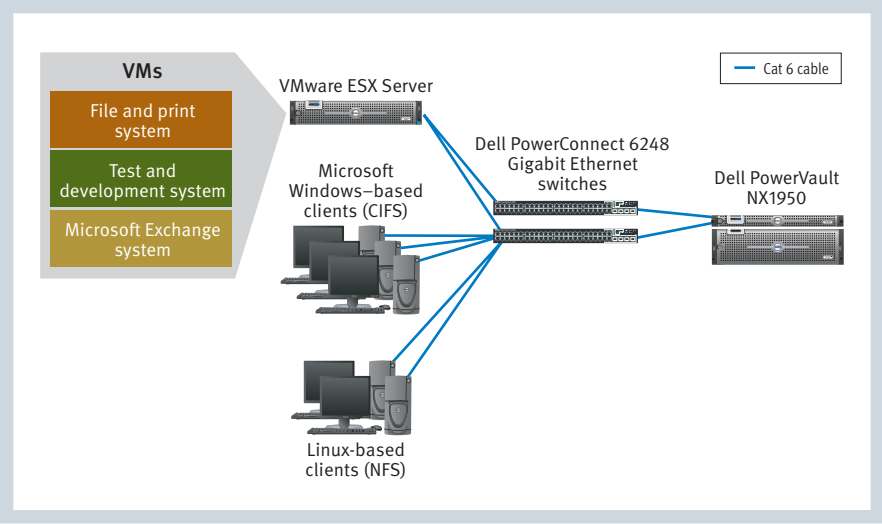

Figure 8. *Example environment combining block-level access over iSCSI for servers and file-level access for clients with the Dell PowerVault NX1950*

Deploying flexible, cost-effective virtualization

Enterprises can face multiple challenges when integrating a virtualized environment with a shared storage back end. Fibre Channel may be the best choice for virtualization for enterprises that have already broadly deployed Fibre Channel–based SANs or those whose environments require high performance. However, combining Fibre Channel with virtualization may require specialized expertise to re-create basic functionality at the hypervisor level and reconfiguration to enable VM mobility for load balancing and failover. In addition, using Fibre Channel with virtualization may limit array-based management, backup and recovery, and multipath functionality.

Besides allowing enterprises to create SANs using standard, familiar Ethernet equipment with a lower cost of entry than Fibre Channel, iSCSI can offer significant advantages in virtualized environments. Its potential benefits include simplified deployment based on direct relationships between VMs and storage, which allows administrators to manage VMs the same way they do physical servers; comprehensive storage management and data protection for both VMs and physical servers; and seamless VM mobility without complex reconfiguration. By deploying iSCSI on its own or in addition to Fibre Channel, enterprises can easily integrate virtualized servers with shared storage and create a tiered environment optimized for their particular needs.

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Advanced System Protection with **Symantec Backup Exec System Recovery 7.0**

BY CHARLES BUTLER
CAROLINA MARTINEZ
KYON HOLMAN

Symantec® Backup Exec™ System Recovery is designed to provide advanced protection for systems running Microsoft® Windows® operating systems, enabling flexible recovery to dissimilar hardware platforms, virtual environments, and unattended remote locations. This article outlines the key features and enhancements of Backup Exec System Recovery 7.0.

Related Categories:

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Storage

Storage software

Symantec

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Symantec Backup Exec System Recovery 7.0 is a comprehensive disk-based system recovery solution for servers, desktops, and notebooks running Microsoft Windows operating systems, allowing enterprises to quickly recover from system failures or disasters, even when restoring to dissimilar hardware platforms, virtual environments, or unattended remote locations. It is designed to capture recovery points for live Windows-based systems, including the OS, applications, system settings, configurations, and files, without affecting productivity. Administrators can easily save these recovery points to media or disk storage devices—including storage area networks, network attached storage, direct attach storage, RAID volumes, CD/DVD drives, and so on—and then quickly restore them without requiring lengthy and error-prone manual processes.

Key features of Backup Exec System Recovery 7.0 include the Backup Exec System Recovery Manager console, the Restore Anyware™ and LightsOut Restore features, the Exchange Retrieve Option, the Convert to Virtual Disk wizard, and other enhancements.

Backup Exec System Recovery Manager

Backup Exec System Recovery Manager—introduced as part of Backup Exec System Recovery 7.0—allows administrators to monitor and manage multiple Backup Exec System Recovery instances from a centralized console that provides a simplified view of the current protection status of managed systems (see Figure 1). Administrators can use this console to perform key monitoring and management tasks, including the following:

- Viewing real-time status of backup jobs; filtering jobs based on system name, job type, job name, and IP address; and examining errors to troubleshoot problems
- Viewing system details, including volume name, size, amount and percentage of space used, file system type, and last recovery point time and location
- Enabling end users to recover files and folders without administrator intervention through an intuitive, Web browser–based search using Symantec Backup Exec Retrieve
- Defining recovery point policies for groups of servers, desktops, or notebooks with similar requirements, then simply dragging and dropping to deploy the policies
- Generating predefined reports or creating custom reports and exporting them to .csv, .html, .xls, or .xml files for easy distribution
- Enabling varying levels of role-based administration
- Setting default configuration settings for individual systems or groups of systems, including performance throttling, network bandwidth utilization, and notifications through e-mail or Simple Network Management Protocol (SNMP) traps
- Jump-starting recovery point creation on remote systems when jobs are missed

Backup Exec System Recovery Manager supports centralized administration for existing installations of Backup Exec System Recovery 6.5 and includes access to the Backup Exec System Recovery Download Center, an automated Web site for client download and distribution.

Restore Anyware

The Restore Anyware feature of Backup Exec System Recovery is designed to provide flexible hardware-independent recovery, enabling administrators to easily recover or migrate systems to dissimilar hardware platforms, virtual environments, or unattended remote locations. It can help administrators do the following:

- Reduce recovery times and the need to deploy and maintain identical hardware
- Easily migrate end-user systems without requiring a complete reinstallation
- Convert system recovery points into virtual machines (VMs) for the VMware® or Microsoft Virtual Server virtualization platforms and vice versa, allowing administrators to test patches, applications, and other software in a virtual environment

When used in conjunction with Backup Exec System Recovery Manager, Restore Anyware also helps administrators perform one-to-many management, monitoring, and reporting of Backup Exec System Recovery clients throughout an enterprise IT environment—directly benefiting administrators by eliminating existing redundant IT capacity and the need to purchase identical hardware.

LightsOut Restore

The LightsOut Restore feature of Backup Exec System Recovery uses Symantec pcAnywhere® technology to allow administrators to remotely monitor servers in unattended environments through management controllers such as the Dell™ Remote Access Controller (DRAC), then restore those servers following a failure. This feature installs a customized version of the Symantec recovery environment directly in the file system of each server and places a Symantec recovery environment boot menu option in the Windows boot menu. If a server fails, administrators can boot into the Symantec recovery environment remotely and quickly recover individual files or a full system. LightsOut Restore also enables administrators to add hardware drivers to a Symantec Recovery Disk located in the boot volume, helping ensure that the latest drivers are included during system recovery.

Exchange Retrieve Option

The Exchange Retrieve Option, introduced for Backup Exec System Recovery 7.0, is designed to protect entire Microsoft Exchange servers quickly and easily and enable administrators to perform granular and full system recoveries of Exchange objects from recovery points without requiring full mailbox backups. Before administrators can use this option, they must first capture a recovery point for an Exchange server using Backup Exec System Recovery. They can then use the Exchange Retrieve Option to automatically locate Exchange database files from selected recovery points to prepare for granular recovery; quickly and easily search for and recover Exchange mailboxes, folders, messages, and attachments; and forward these objects directly to Microsoft Office Outlook® e-mail clients if desired.

Best practices to help maximize protection and efficiency when using the Exchange Retrieve Option include the following:

- Select the option to back up your computer, not the option to back up selected files and folders.
- When selecting Exchange server drives to back up, ensure that all drives are selected.
- When choosing the type of recovery point to create, select "Recovery Point Set" rather than "Independent Recovery Point," which helps reduce the size of recovery points.
- Schedule backups to occur when the server is not at its peak load.

Convert to Virtual Disk wizard

Administrators can use the Convert to Virtual Disk wizard in Backup Exec System Recovery (see Figure 2) to convert recovery points directly to VMs for the VMware or Microsoft Virtual Server virtualization platforms. This wizard allows administrators to select the recovery point, choose either VMware virtual disk (.vmdk) or Microsoft virtual hard disk (.vhd) as the VM type, configure the VM settings, and perform the conversion. They can

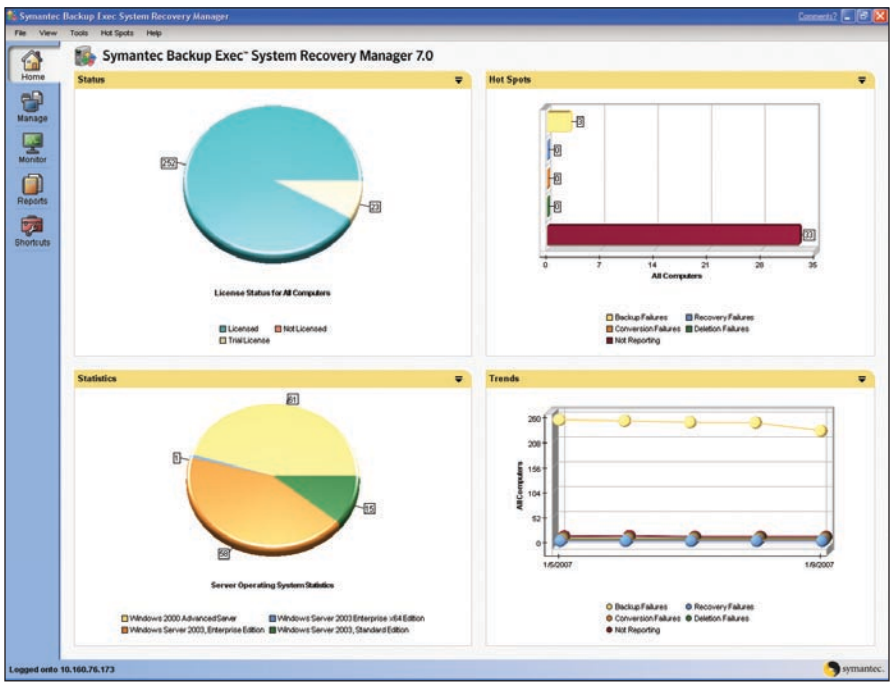

Figure 1. *Symantec Backup Exec System Recovery Manager console*

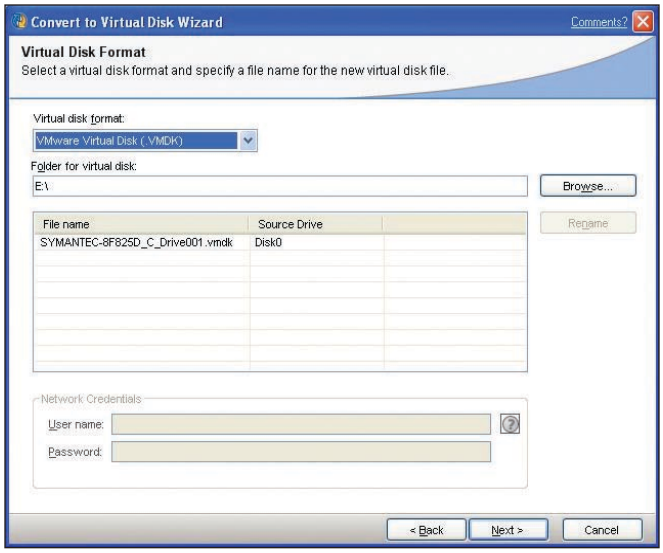

Figure 2. *Symantec Backup Exec System Recovery Convert to Virtual Disk wizard*

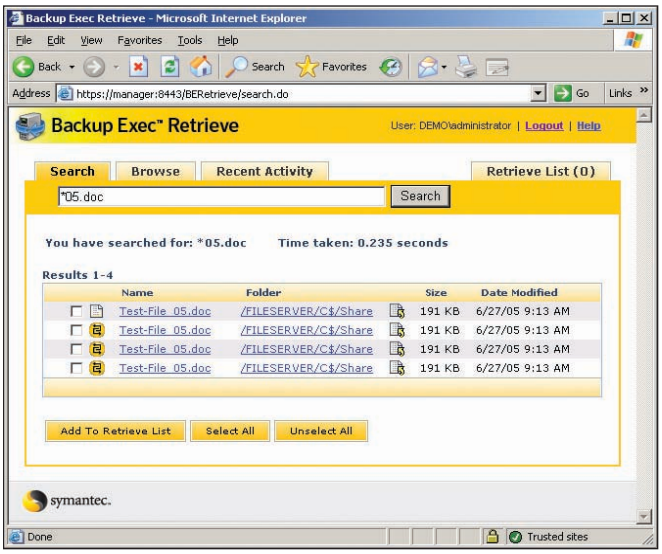

Figure 3. *Symantec Backup Exec Retrieve*

also upload VMs directly to the VM host if desired.

Other enhancements in Backup Exec System Recovery 7.0

In addition to the features and options discussed in the preceding sections, Backup Exec System Recovery 7.0 also includes several other enhancements, including the following:

- **File and folder backup:** Administrators can back up selected files and folders on a different schedule from full system or volume recovery points, and can search for and retrieve previous versions of files when creating separate file and folder backup jobs.
- **Expanded OS support:** Backup Exec System Recovery 7.0 adds support for 32- and 64-bit versions of the Microsoft Windows Vista™ OS and Microsoft Windows Server® 2003 x64 Editions.
- **Custom Symantec Recovery Disks:** Administrators can create and update Symantec Recovery Disks customized for their environment, and can add updated hardware drivers as needed. Backup Exec System Recovery can search the system for drivers not included in the Symantec Recovery Disk.
- **Accelerated Symantec Recovery Disk boot:** Symantec Recovery Disks are now based on Windows Vista, helping reduce the time required for booting and bare-metal system recovery.
- **Indexed recovery points:** Recovery points are indexed, allowing administrators and end users to perform document-level retrieval through integration with Google Desktop Search or Backup Exec Retrieve (see Figure 3), included with Backup Exec 10d and 11d for Windows Servers.

	Supported operating systems
Desktop Edition	• Microsoft Windows 2000 Professional with Service Pack 4 (SP4) or later • 32- and 64-bit versions of Microsoft Windows XP Home Edition and Professional Edition with SP2 or later • 32- and 64-bit versions of Microsoft Windows Vista Home Basic Edition, Home Premium Edition, Business Edition, and Ultimate Edition
Small Business Server Edition (includes Exchange Retrieve Option)	• Microsoft Windows Small Business Server 2000 • Microsoft Windows Small Business Server 2003
Server Edition	• Microsoft Windows 2000 Server with SP4 or later • Microsoft Windows 2000 Advanced Server with SP4 or later • Microsoft Windows Server 2003 and Windows Server 2003 x64 Editions

Figure 4. *Symantec Backup Exec System Recovery 7.0 editions and supported operating systems*

Different editions of Backup Exec System Recovery 7.0 are designed to meet different needs. Figure 4 summarizes these editions and their supported operating systems.

Advanced, flexible backup and recovery

Symantec Backup Exec System Recovery 7.0 and features such as Restore Anyware, LightsOut Restore, the Exchange Retrieve Option, and the Convert to Virtual Disk wizard are designed to offer advanced, flexible protection for Microsoft Windows–based systems while simplifying recovery management. Implementing these tools can help create rapid, reliable system recovery processes for enterprises of all sizes.

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Kyon Holman *is a lead software engineer in the Dell Enterprise Product Group.*

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Optimizing iSCSI SANs with Intel PRO Server Adapters and iSCSI Remote Boot

BY JORDAN PLAWNER

As organizations move toward virtualized data centers with shared resources to increase capacity and resource utilization, Dell™ PowerEdge™ servers with Intel® PRO server adapters can help multiply the advantages of Internet SCSI (iSCSI) technology in storage area networks (SANs) by offering remote boot-from-SAN capabilities and enhanced I/O throughput.

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Enterprises in a wide range of fields are searching for simple, cost-effective ways to manage their ever-increasing storage capacity requirements. The rise in e-mail traffic, the proliferation of large multimedia files, and the move toward server virtualization are all contributing to the need for increased storage capacity. At the same time, government regulations—such as the Sarbanes-Oxley Act and the Health Insurance Portability and Accountability Act (HIPAA) in the United States as well as regulations from around the world that affect global enterprises—are forcing organizations to rethink their approach to storage. Storage area networks (SANs) that use the Internet SCSI (iSCSI) protocol can provide organizations with a cost-effective, consolidated, and flexible storage environment to meet the growing demand for storage capacity while facilitating the transformation to a virtualized data center.

SANs, which provide servers with a single shared pool of storage, offer distinct advantages over dedicated direct attach storage (DAS) systems. For example, even with the increased scalability of advanced DAS systems such as the Dell PowerVault™ MD3000 modular disk storage array, scaling DAS capacity can be expensive, and only a handful of servers may be able to share the same storage resource. In contrast, organizations can scale SANs easily and cost-effectively simply by installing additional storage devices and SAN network resources.

Although the DAS distance limit of 6 meters (19.7 feet) is sufficient for in-stack connectivity, that limitation can make connecting servers on different racks a challenge. SANs can be located long distances from the LAN, helping simplify data center and storage centralization efforts while offering geographical redundancy for disaster recovery.

Many organizations are also turning to SANs because of their ability to simplify provisioning and ongoing storage management. For example, the ability to boot servers from a SAN can dramatically reduce administrative burdens. Booting from a SAN can help accelerate distribution of OS images and updates as well as recovery from server failures, allowing administrators to boot a spare server in place of a failed or unavailable one instead of going through the time-consuming process of retrieving boot data or restoring the server from tape or CD.

In addition, SANs provide opportunities for centralized storage management. When all data is stored on a SAN, administrators can manage that data from a single console to greatly simplify the processes of provisioning, reconfiguring, and restoring server data. With the appropriate management tools, administrators can balance workloads so that high-demand applications with frequently used data do not overload some servers while leaving others idle.

iSCSI helps reduce costs, simplify management, and enhance flexibility

In the past, SANs have typically been implemented using a Fibre Channel fabric. Fibre Channel technology can provide

exceptional performance for extremely heavy transaction processing or high-speed, large-block data transfers. Nevertheless, deploying a Fibre Channel SAN can be too costly for some organizations. Fibre Channel SANs require the use of Fibre Channel host bus adapters (HBAs), which connect the servers to devices on the SAN, as well as specialized switches or routers that connect to the various storage devices. The servers, meanwhile, still require network interface cards (NICs) to provide Ethernet connectivity. In addition, the processes of installing, maintaining, and operating a Fibre Channel SAN require an IT staff with specialized skills and knowledge.

iSCSI offers a cost-effective, simplified alternative to Fibre Channel. Because iSCSI encapsulates SCSI commands in TCP/IP packets and enables block data transport over IP networks, administrators can implement iSCSI SANs using standard, familiar, and relatively inexpensive Ethernet NICs, switches, and cabling (see Figure 1).

The Ethernet and TCP/IP compatibility of iSCSI SANs also enables greater geographic flexibility than a Fibre Channel system. Whereas Fibre Channel connections are limited to 10 kilometers (6.2 miles), an iSCSI SAN can be accessed from anywhere in the world that has Internet connectivity. As a result, organizations can use iSCSI SANs to provide storage access to geographically remote field offices, branch offices, and stranded servers. At the same time, iSCSI SANs enable enterprises to optimize storage centralization and enhance disaster recovery for data centers.

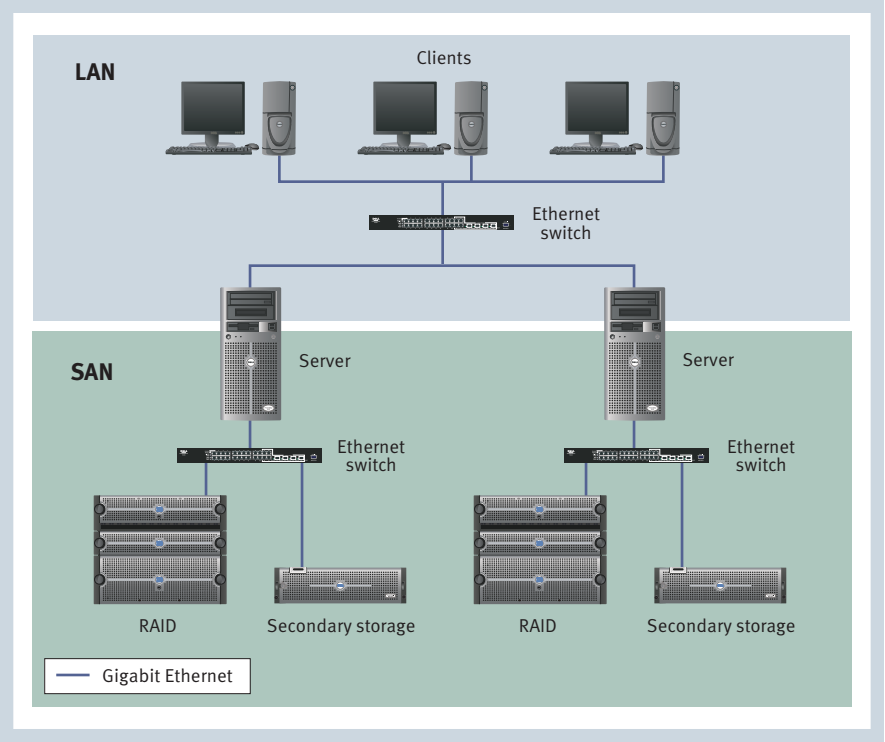

Figure 1. *Example of a small site configuration using an iSCSI SAN*

Of course, the emergence of iSCSI SANs does not mean that enterprises should abandon their Fibre Channel SANs. In fact, iSCSI and Fibre Channel SANs can easily coexist. Dell/EMC SANs, including Dell/EMC CX3 series arrays, offer dual-mode Fibre Channel/iSCSI technology to enhance flexibility. With dual functionality, organizations can cost-effectively expand their existing SANs by creating tiered host connectivity based on performance requirements and introducing the familiar, cost-effective Ethernet network components of an iSCSI SAN as appropriate.

iSCSI software initiators help facilitate iSCSI SAN adoption

The growing availability of iSCSI software initiators in popular server operating systems is helping spur adoption of iSCSI SANs. Software initiators perform the necessary functions to send SCSI packets over TCP/IP and Ethernet networks. By using operating systems with iSCSI software initiators, administrators can avoid relying on expensive HBAs and third-party network stacks, which also helps eliminate interoperability issues. Certified and standardized

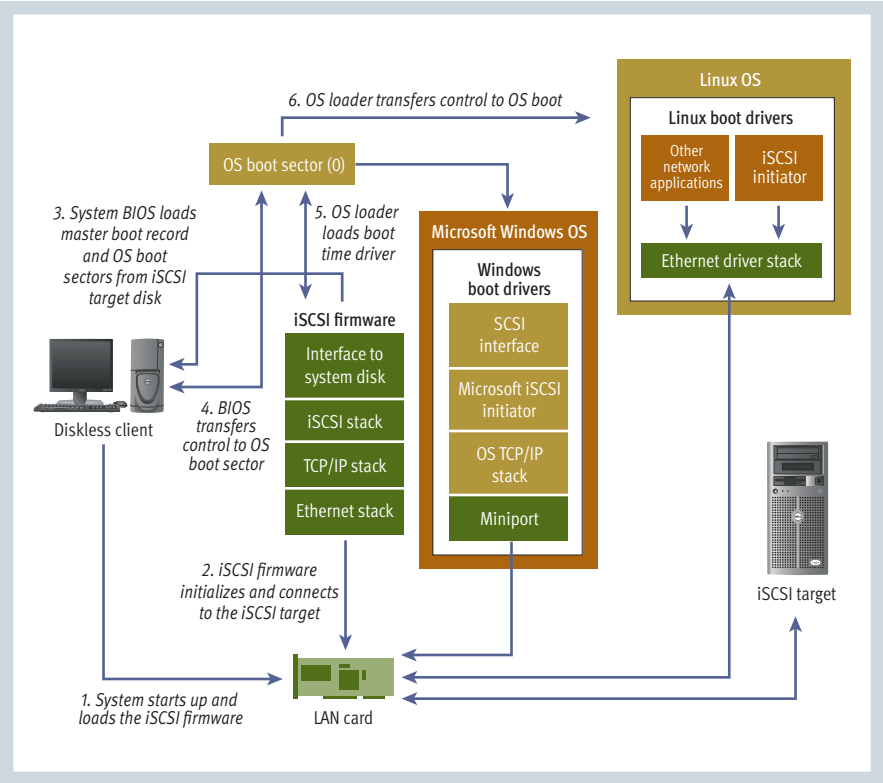

Figure 2. *Example iSCSI boot process*

initiators in the OS enable administrators to use standard Ethernet switches and NICs for iSCSI SANs, such as the Intel PRO/1000 server adapter family (see the "Intel PRO/1000 server adapters" sidebar in this article).

Remote boot capabilities further simplify iSCSI SAN management

In addition to offering a cost-effective alternative to HBAs and third-party network stacks, Intel PRO/1000 server adapters for PCI Express (PCIe) now offer iSCSI SAN remote boot capabilities. Remote boot functions can help administrators create a consolidated and virtualized server environment with centralized management and enhanced disaster recovery capabilities. Figure 2 illustrates a typical iSCSI boot process.

Detaching the OS image and data from the physical server is a critical step in creating a flexible virtualized data center with both shared pools of storage (in a SAN) and consolidated virtualized servers. iSCSI remote boot capabilities make it easy to connect the OS image to a different server quickly. iSCSI also enables easy migration of virtual machines (VMs) to a different physical server for load balancing.

The remote boot capabilities offered by Intel PRO/1000 server adapters can help administrators establish a centralized management environment. By storing OS images on a SAN, administrators can streamline server provisioning and management. In addition, booting from the SAN enables administrators to easily deploy upgrades and patches to servers, requiring them to perform those upgrades only on the central OS image instead of the multiple individual OS images on servers' direct attach disks.

Remote boot capabilities also enhance and accelerate disaster recovery. Administrators using a SAN with remote boot capabilities can easily duplicate the boot information, OS image, applications, and data on the remotely located SAN. If a server fails, administrators can simply boot a spare or new server from that remote SAN (see Figure 3). Because iSCSI SANs can be located anywhere that Internet connectivity is available, organizations can help ensure that the disaster recovery data centers are sufficiently far away from the primary data center, helping protect against catastrophic events.

Intel has led the way in working with major OS vendors to provide remote boot capabilities for standard LAN adapter cards with OS iSCSI initiators. As a result, the Intel PRO/1000 remote boot capability for PCIe adapters is designed to work with many major operating systems, including Microsoft® Windows Server® 2003 with Service Pack 1 (SP1) and Microsoft iSCSI Software Initiator 2.02, Red Hat® Enterprise Linux® 4 Update 3 and later with Linux iSCSI initiators, and Novell® SUSE® Linux Enterprise Server 9.0 with SP3 and later with Linux iSCSI

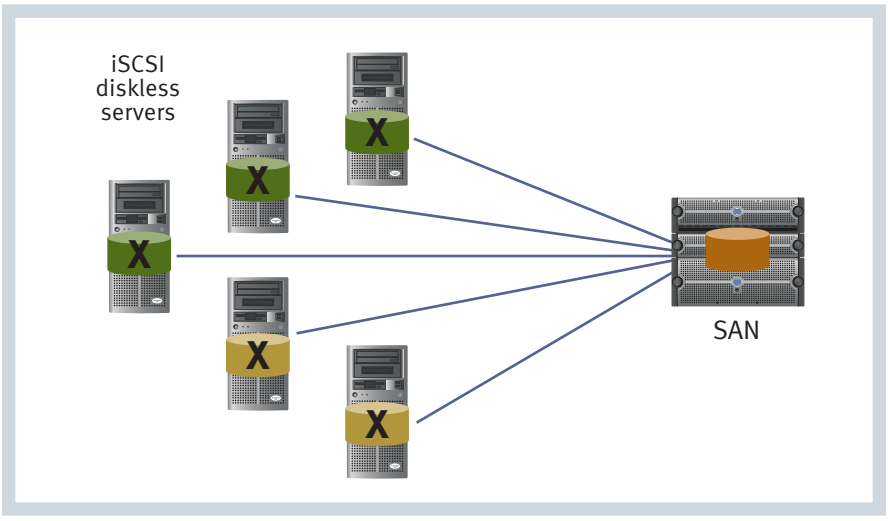

Figure 3. *Consolidated server environment with centralized management and enhanced disaster recovery capabilities created using remote boot functions*

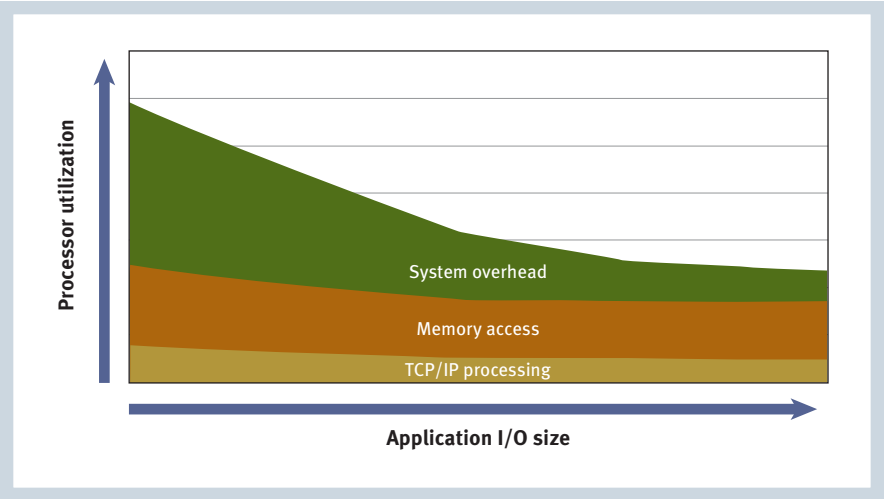

Figure 4. *Typical example of relative system overhead, memory access, and TCP/IP processing utilization for increasing application I/O sizes using Intel I/OAT*

initiators. The remote boot ROM code is also available from Intel at www.intel.com/network/connectivity/products/iscsiboot.htm.

Intel I/OAT enhances iSCSI SAN performance

When iSCSI was introduced, some organizations were reluctant to adopt it because they were concerned that the increased overhead from TCP/IP packet processing would impede throughput. Today, the availability of processor acceleration technology can help alleviate this overhead and increase throughput without significantly adding to the cost of the SAN. Included in Intel Xeon® processor–based Dell PowerEdge servers, Intel I/O Acceleration Technology (Intel I/OAT) provides an easy way to enhance I/O performance in iSCSI SAN environments.

Developed to address I/O bottlenecks, Intel I/OAT is a platform-oriented approach that comprises processor, chipset, motherboard, LAN silicon, and software components. This technology, which is now available on dual-core and quad-core Intel Xeon processor–based Dell PowerEdge servers, addresses I/O processing aspects that can burden the processor, including system overhead, memory access, and TCP/IP processing. Intel I/OAT is designed to offer system-wide increases in I/O performance through minimized system overhead as a percentage of processor use, fast memory access, and highly efficient packet processing, helping decrease overall I/O overhead as application packet size increases (see Figure 4).

At the same time, Intel I/OAT helps streamline system administration. For example, Intel I/OAT preserves key network configurations, such as teaming and failover, helping avoid the OS or application modifications that can be required when implementing other technologies that attempt to enhance processor performance. Intel I/OAT also offers OS flexibility by supporting both the Microsoft Windows Server 2003 OS and leading Linux distributions. And importantly, Intel I/OAT is supported by all Intel PRO server adapters for PCIe, helping administrators realize the iSCSI SAN advantages of those adapters while minimizing processor utilization.

Dell servers with Intel PRO server adapters offer outstanding iSCSI SAN performance

Several Dell PowerEdge servers offer the option of adding Intel PRO/1000 server adapters for PCIe, helping provide cost-effective iSCSI connectivity with remote boot capabilities for iSCSI SANs. For example, the Dell PowerEdge 6800 server can be equipped with single-, dual-, or quad-port Intel PRO/1000 server adapters for PCIe, which support Intel I/OAT to help relieve processor overhead and increase iSCSI traffic throughput. The PowerEdge 6800 server combines high-performance technologies, such as second-generation dual-core Intel Xeon 7100 series processors, with management tools and storage features designed for critical database environments.

The Dell PowerEdge 2950 server provides a rack-dense configuration that can include single-, dual-, or quad-port Intel PRO/1000 server adapters for PCIe. The PowerEdge 2950 server is designed to deliver high performance with 64-bit quad-core Intel Xeon processors along with internal expandability (by adding drives or integrating additional PCIe and PCI Extended cards), all in a 2U enclosure.

The drive for increased storage capacity is unlikely to wane anytime soon. With the advent of iSCSI software initiators and iSCSI remote boot capabilities, iSCSI SANs now provide viable storage options with numerous potential benefits. For many organizations, iSCSI SANs can help reduce storage costs while streamlining management and enhancing flexibility. Dell PowerEdge servers with Intel PRO/1000 server adapters for PCIe can help enterprises realize the promise of those iSCSI SAN environments.

Jordan Plawner *is a product planner and technologist in the Intel LAN Access Division. He is responsible for planning Ethernet products and developing storage networking solutions. He has a master's degree from the University of California, San Diego.*

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Intel iSCSI remote boot:
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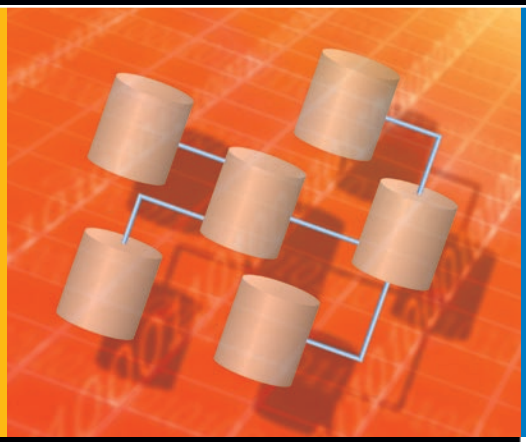
Intel I/O Acceleration Technology:
www.intel.com/go/ioat



Protecting Data Archives with Drive-Level Encryption in the Dell PowerVault LTO-4 Tape Family

BY CURT KREMPIN

Dell™ PowerVault™ Linear Tape-Open Ultrium 4 (LTO-4) tape drives and libraries afford exceptional storage security and performance to accelerate regulatory compliance and business continuance as well as routine data center backups. Features include native physical capacity of up to 800 GB, native data transfer rates of up to 120 MB/sec, and drive-level encryption.

Related Categories:

Data archiving

Dell PowerVault storage

Disaster recovery

LTO-4

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Complex regulations, security requirements, and business continuity challenges are transforming the enterprise backup and recovery process and setting new standards for data encryption and archiving. Many organizations are revising their strategy for information life cycle management to comply with legislative mandates that dictate how information must be stored and how long it must be retained. Addressing today's diverse service-level agreements (SLAs) requires organizations to establish secure ways for customers, end users, and even litigators to access vital enterprise records. At the same time, they must ensure that the overall storage infrastructure has the capacity to grow quickly, flexibly, and cost-effectively.

While disk is clearly the ideal approach for online storage, tape remains a critical component of the overall information life cycle management strategy—particularly for long-term data retention, regulatory compliance, and business continuance. Linear Tape-Open Ultrium 4 (LTO-4) tape technology advances security with drive-level data encryption that helps organizations prevent tampering with stored data. The encryption is performed at line speed in the tape device hardware so it does not affect throughput performance—enabling LTO-4 devices to reduce backup windows with native data transfer rates of up to 120 MB/sec, which is 50 percent faster than the specified throughput performance for previous-generation LTO-3 devices. Plus, double-density LTO-4 tape media offers up to 800 GB of native physical capacity, which is twice the specified capacity of previous-generation LTO-3 tape media.

Understanding the role of tape in the data center

Figure 1 compares typical characteristics of disk and tape technology and how they factor into the overall storage infrastructure. Although each has particular strengths—and neither replaces the other—continuing developments in both allow administrators to combine tape and disk technology to best advantage for specific enterprise backup and archiving solutions.

Long-term archiving requirements for data storage and in some cases paper records have IT departments clamoring for low-cost, high-capacity tape media. However, compliance with strict data retention regulations may require fixed-content authenticity—for example, assurance that media files and e-mails remain in their original state while stored. Before selecting appropriate media for any given backup and storage strategy, best practices advise administrators to thoroughly understand architectural approaches and technology capabilities.

Often considered a front-runner for long-term storage, tape enables low-cost, offline backups at a remote site. Importantly, this data portability allows businesses to restore files after a disaster on whatever hardware platform is available—allowing the data to be restored by other tape

> "Device-level encryption enables Dell PowerVault LTO-4 tape media to protect stored data even if the machine is lost, stolen, or misplaced in a remote location."

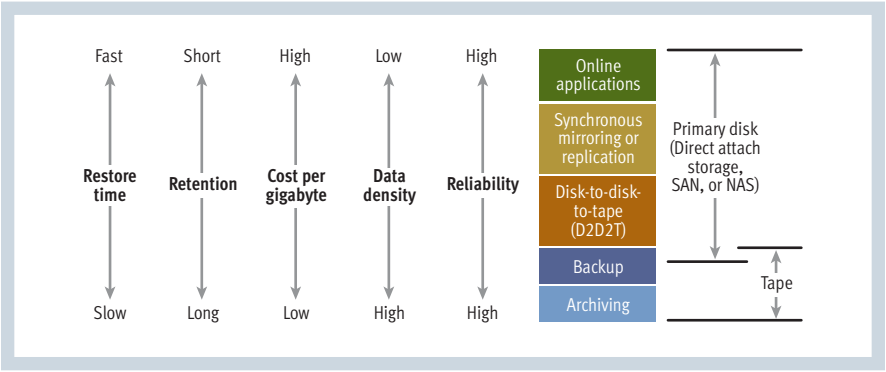

Figure 1. *Key considerations for disk and tape technology in enterprise storage solutions*

drives in the event the original drives suffered damage or were otherwise destroyed. However, to play this role in data center environments, tape technology must keep up with burgeoning data storage requirements by providing fast transfer rates, high capacity, data encryption, and an effective methodology for protecting archived content. LTO Ultrium tape technology is a scalable, open systems tape format that was established nearly a decade ago to enable tape and drive compatibility among vendors.

Exploring LTO-4 technology enhancements

The fourth generation of LTO Ultrium technology, LTO-4 is designed to deliver outstanding performance and security. With a native physical capacity of up to 800 GB, a single LTO-4 tape cartridge offers double the specified capacity of LTO-3—allowing administrators to store twice as much data in the same amount of space for about the same price point. In addition, LTO-4 provides a native data transfer rate of up to 120 MB/sec, which is 50 percent faster than the specified rate for LTO-3. To ease the upgrade path, LTO-4 enables data interchangeability so that LTO-4 tape devices can read and write LTO-3 tapes (non-encrypted) and read LTO-2 tapes. Figure 2 describes LTO Ultrium technology specifications, including current plans for developing the next two generations.

Digital video, data mining, and supply chain management are just a few of the data-intensive business activities entering mainstream storage environments. Such usage scenarios necessitate high-capacity storage and high-performance streaming backup. The significant leap in storage capacity and data transfer speeds afforded by LTO-4 tape media eases the strain on managing data-intensive storage volumes and helps lower total cost of ownership (TCO). Moreover, LTO-4 devices are designed for low power consumption and enhanced energy efficiency, which helps lower overall TCO in busy data center environments (see the "Powering down consumption, powering up savings" sidebar in this article).

Benefiting from Dell PowerVault LTO-4 tape drives and libraries

Dell PowerVault LTO-4 tape drives—as external stand-alone peripherals or integrated into Dell PowerVault TL2000, TL4000, and ML6000 tape libraries—offer storage administrators a top-flight approach for backing up and archiving critical data in their environment at mid-range price points. The PowerVault LTO-4 family supports 4 Gbps native Fibre Channel and 3 Gbps Serial Attached SCSI (SAS).

Device-level encryption enables Dell PowerVault LTO-4 tape media to protect stored data even if the machine is lost, stolen, or misplaced in a remote location. Providing this enhanced protection in hardware along with up to 800 GB of native physical storage capacity per cartridge and native data transfer rates of up to 120 MB/sec helps relieve administrative overhead and shorten backup windows compared with LTO-3 devices. These advances make PowerVault LTO-4 tape drives and libraries suitable for data-rich applications requiring high performance and superior protection.

The PowerVault LTO-4-120 tape drive is a double-density version of the PowerVault 110T LTO-3 tape device, and has approximately the same form factor as its predecessor. In addition, the PowerVault LTO-4-120 drive has a 256 MB internal data buffer that helps improve data access rates and helps reduce cartridge fill and rewind times.

			WORM	WORM	WORM	WORM
	Generation 1	Generation 2	Generation 3	Generation 4	Generation 5	Generation 6
Native capacity	100 GB	200 GB	400 GB	800 GB	1.6 TB	3.2 TB
Native transfer rate	Up to 20 MB/sec	Up to 40 MB/sec	Up to 80 MB/sec	Up to 120 MB/sec	Up to 180 MB/sec	Up to 270 MB/sec

Note: Current specifications are subject to change; products based on future specifications may not become available.

Figure 2. *LTO Ultrium capacity and performance specifications*

POWERING DOWN CONSUMPTION, POWERING UP SAVINGS

Besides helping to improve the speed, flexibility, and security of data backups for Dell PowerEdge™ servers and PowerVault network attached storage (NAS) servers, Dell PowerVault LTO-4 tape drives and libraries are designed to reduce power consumption compared with LTO-3 devices. Enhanced energy efficiency and an idle mode also contribute to lower TCO for data backups and archiving.

(Clockwise from top right) Dell PowerVault LTO-4-120 tape drive, PowerVault TL2000 and TL4000 tape libraries, and PowerVault ML6000 Series tape library

For more information about how energy-efficient Dell products are designed to lower power consumption and TCO across the data center, visit www.dell.com/energy.

PowerVault LTO-4 tape libraries enhance scalability for a broad range of secure enterprise storage options, with automation features designed to streamline operations and reduce administrative overhead. The PowerVault TL2000 offers up to 19.2 TB of native capacity; the PowerVault TL4000, up to 38.4 TB of native capacity; and the PowerVault ML6000 family of tape libraries, up to 321 TB of native capacity. Besides supporting drive-level encryption, these PowerVault LTO-4 tape devices employ built-in data protection features such as on-site backup copies to avoid data loss and write-once, read-many (WORM) capabilities designed to create unalterable records. Key features for simplified, automated tape storage operations include a user-friendly interface, bar-code inventorying, and connectivity for 4 Gbps native Fibre Channel and 3 Gbps SAS interfaces.

The PowerVault TL2000 tape library is a suitable entry point for organizations requiring cost-effective yet powerful storage, while the PowerVault TL4000 tape library is an expandable version for growing mid-range businesses. For world-class scalability, the PowerVault ML6000 modular tape library family facilitates nondisruptive on-demand expansion with modules that allow easy customization. Intelligent diagnostics and intuitive wizards help predict and isolate failures while speeding resolution times. To help optimize data throughput, tape longevity, and resource productivity, LTO-4 data transfers are facilitated by the Digital Speed Matching feature and accelerated load/unload cycle times designed to synchronize with the data rate of the server.

Encrypting data to help protect archived information assets

Data is the most important business asset for many organizations. As archived data consumes an increasing percentage of the overall storage environment, it is essential to implement secure, efficient, and cost-effective backup and retrieval systems. To comply with exacting legislative mandates and rigorous SLAs, storage organizations must protect enterprise data regardless of where it is located, even during transit. Lost or unrecoverable records are very costly for organizations—whether the loss is measured in time, expense, or public image. However, determining the most suitable approach for preserving data and validating document authenticity can be tricky. Sophisticated proprietary encryption software tends to be expensive and to add

complexity to an already multifaceted archiving and retrieval process.

Businesses are being called upon to ensure an unbroken "chain of custody," which involves proving that long-term fixed content—such as e-mails, scanned contracts, and point-in-time images—remains in its original state throughout the time it is stored. If this type of keep-forever data is compromised, serious consequences can include theft or exposure of personal and business records, or the loss of private information such as medical images. The ramifications of such security breaches can be far more expensive than re-creating lost data or paying regulatory penalties if negative publicity leads to a loss in customer confidence, ultimately leading to a loss in business.

Dell PowerVault LTO-4 tape drives and libraries are designed to prevent these scenarios. Introduced in the previous-generation LTO-3 technology, the WORM feature is one way to bolster security for archiving and compliance requirements. WORM technology stores data cost-effectively the first time it is written to the tape cartridge. Because no further modification of the data is allowed once it is written, records cannot be modified or altered. This added level of security and control is accomplished with an encoding formula that is mastered on the tape media at the time of manufacture to help prevent tampering.

Device-level data encryption is another enhancement introduced with PowerVault LTO-4 devices that helps further increase data security for long-term storage. This approach is designed to render information unreadable by anyone except the key manager. Device-level encryption also helps improve performance, streamline archive management, and lower TCO because integrated hardware performs the encryption at line speed in the tape drive, avoiding the need for added encryption hardware or costly and complex proprietary encryption software—and the associated drain on server resources. Because the drive encrypts information internally once received, the data is protected in transit to help ensure integrity during the enciphering and deciphering processes.

"Dell PowerVault LTO-4 tape libraries enhance scalability for a broad range of secure enterprise storage options, with automation features designed to streamline operations and reduce administrative overhead."

The hardware encryption feature is based on the Advanced Encryption Standard (AES), which is the industry standard for computer cryptographic security. AES specifies the use of a cryptographic algorithm with a symmetric block cipher mode of operation that encrypts and decrypts information using binary fields and then authenticates the encryption process to protect electronic data. Encryption converts information into a garbled form of text, known as cipher text, rendering the encrypted data unintelligible. Once the information is ready to be deciphered, a decrypting process converts the data back into its original form, or plain text.

AES hardware is formulated for high-speed encryption with low cost and low latency by using cryptographic keys that are measured in bits, to encrypt and decrypt the data in blocks. The speed of cryptographic keys is important to the rate of data transfer. The AES algorithm can use cryptographic keys of 128, 192, and 256 bits to encrypt and decrypt information in 128-bit blocks. PowerVault LTO-4 tape devices employ a secret 256-bit key to enable encryption after the host data is received. This is the fastest key rate currently available, helping to speed the execution of data conversion without affecting the tape drive's data transfer performance, even when using high-capacity cartridges.

Providing "vault safe" archive and retrieval systems

Dell PowerVault LTO-4-120 tape drives and PowerVault TL2000, TL4000, and ML6000 tape libraries parlay state-of-the-art encryption and industry-standard LTO-4 technology to deliver outstanding data transfer rates, double-density native storage capacity, and "vault safe" data encryption. By adhering to stringent standards and compliance verification tests, the PowerVault LTO-4 lineup helps organizations measure up to exacting legislative mandates and rigorous SLAs with lots of room for growth, to safeguard valuable enterprise data wherever it resides—even during transit.

Curt Krempin *is a product marketing manager in the Dell Enterprise Product Group. He is currently responsible for product marketing for data protection solutions. Curt has a B.S. in Computer and Electrical Engineering from the University of Florida and an M.B.A. from the University of Texas.*

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Fast, Flexible, and Secure:

LTO Ultrium 4 Tape Technology Clinches Dell PowerVault Lineup

Featuring a scalable industry-standard format, Dell™ PowerVault™ Linear Tape-Open Ultrium 4 (LTO-4) tape drives and libraries offer lots of room to grow, with outstanding data transfer rates, double-density native storage capacity, and enhanced data encryption capabilities.

Dell PowerVault LTO-4-120 tape drive

To keep pace with mounting storage demands, IT administrators must find cost-effective solutions for data archiving and disaster recovery that are flexible enough to meet evolving service-level agreements and strict regulatory requirements. Dell PowerVault tape drives and libraries based on the Linear Tape-Open Ultrium 4 (LTO-4) format offer a common ground for growth and stability, enhancing protection for mission-critical data while helping reduce operational and energy costs.

Understanding the generation gap

Packaged in a small, energy-efficient footprint, LTO-4 Dell PowerVault tape products are designed to deliver drive-level data encryption, double-density native storage capacity, and 50 percent faster data transfer speed than previous-generation LTO-3 devices. As a result, PowerVault LTO-4-120 tape drives—either as stand-alone peripherals or integrated in PowerVault TL2000, TL4000, and ML6000 tape libraries—are well equipped to help data centers achieve performance and security unattainable with previous-generation tape technology.

Higher-capacity tape media allows more enterprise data to be stored on fewer tape cartridges, enabling more compact, cost-effective archiving than previous-generation tape technology. PowerVault LTO-4-120 tape drives are designed to deliver up to 800 GB of native physical space—double the specified native physical capacity of LTO-3 tape drives and four times the specified native physical capacity of LTO-2 tape drives—while keeping approximately the same form factor as previous-generation tape drives.

Accelerated data transfers help reduce the time required to conduct storage backups and data retrievals—all the better to support data-intensive applications and documents. PowerVault LTO-4 tape drives are designed to deliver outstanding native data transfer rates—up to 120 MB/sec, 50 percent faster than the specified rate for LTO-3 technology.

With business competition and regulatory penalties on the rise across many industries, the price to pay for lost or compromised data can be extremely high. LTO-4 technology enables an unprecedented level of data security with tested write-once, read-many (WORM) functionality and enhanced encryption capabilities. LTO-4 drive-level data encryption uses a secure, industry-standard cryptographic algorithm and high-speed encryption keys to help safeguard electronic data during the encoding, transport, and deciphering processes—without affecting the tape's throughput performance.

Driving powerful, highly scalable storage solutions

The Dell PowerVault LTO-4 family enables the speed, flexibility, and security necessary to meet high-performance storage demands and help lower total cost of ownership. Besides top-flight native data transfer rates and outstanding native storage capacity, PowerVault LTO-4 products feature low power consumption and an idle mode for enhanced energy efficiency. PowerVault LTO-4 technology enables data interchangeability to ease implementation and help protect investments by reading and writing to LTO-3 tapes (non-encrypted) and reading LTO-2 tapes.

In addition, the PowerVault LTO-4-120 tape drive is outfitted with a 3 Gbps Serial Attached SCSI (SAS) interface plus drive-level data encryption and portability—making this device well suited for state-of-the-art data storage security.

PowerVault TL2000 and PowerVault TL4000 tape libraries offer built-in LTO-4 performance and security features together with easy-to-use graphical wizards that help simplify bar-coding activities, speed tape backup automation, and implement reliable storage area network (SAN) connectivity. Both tape libraries enable cost-effective storage solutions for LAN backup and archiving: the PowerVault TL2000 offers up to 19.2 TB of native capacity, and the PowerVault TL4000 offers up to 38.4 TB of native capacity.

For versatile, world-class backup and archiving, the PowerVault ML6000 modular tape library family offers enterprises up to 321 TB of native capacity. Intelligent automation and intuitive diagnostic capabilities together with LTO-4 speed, capacity, and security enable the ultimate in tape storage performance, flexibility, and scalability—plus easy library customization, on-demand expansion, and quick problem resolution.

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Unified Messaging with Microsoft Exchange Server 2007

BY FARRUKH NOMAN

SUMAN KUMAR SINGH

Implementing the Microsoft® Exchange Server 2007 Unified Messaging feature to integrate e-mail, voice mail, and fax messages requires configuring and coordinating multiple systems. This article provides a guided tour of the basic components of Unified Messaging infrastructures and explains how administrators can deploy them in their own data centers.

Related Categories:

Microsoft Exchange Server 2007

Unified communications

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Voice mail and fax have increasingly given way to e-mail as the primary means of enterprise communication. The Microsoft Exchange Server 2007 Unified Messaging feature is designed to integrate these communications by connecting Exchange and telephony networks to deliver e-mail, voice mail, and fax messages to a single location—the e-mail in-box. Unified Messaging also enables Outlook Voice Access, which allows users to access their e-mail, calendar, personal contacts, and directories and perform other operations (such as accepting or rejecting meeting requests and responding to e-mail messages) over the phone. By providing a centralized message repository, Unified Messaging helps simplify communications management for both users and administrators.

Microsoft Exchange Server 2007 Unified Messaging infrastructure

The major elements typically required to implement Unified Messaging in an existing Exchange Server 2007 infrastructure include a telephone system, a voice over IP (VoIP) gateway, and a Unified Messaging server.

Telephone system

Enterprise telephone systems typically use private branch exchange (PBX) equipment, which acts like a small telephone switching network to connect calls between telephones within the enterprise and to external plain old telephone service (POTS) lines on the public switched telephone network (PSTN). Two common interfaces found in analog PBX systems are the Foreign Exchange Office (FXO) and Foreign Exchange Subscriber (FXS) ports. FXO ports are designed to receive line voltage and ringing current from the PSTN office, and FXS ports are designed to supply the dial tone. FXS ports are configured with unique IDs that correspond to the extension numbers for devices connected to the internal telephone network. These extension numbers or resources are configured into *hunt groups* to help efficiently distribute incoming and outgoing calls.

VoIP gateway

Telephone networks use circuit-switched protocols to provide dedicated links between users. Exchange Server 2007 uses a packet-switched protocol, where information travels as packets over a shared link, so routing voice transmissions to the Exchange network requires converting information from one protocol to the other. This conversion is typically performed by a VoIP gateway, which provides an interface connecting incoming calls from a PBX system to the Exchange Unified Messaging server, although advanced IP-PBX hardware can directly implement VoIP and communicate with the Unified Messaging server without this gateway.

Figure 1 shows a simplified architecture using an FXO-based VoIP gateway connecting to a PBX system through voice

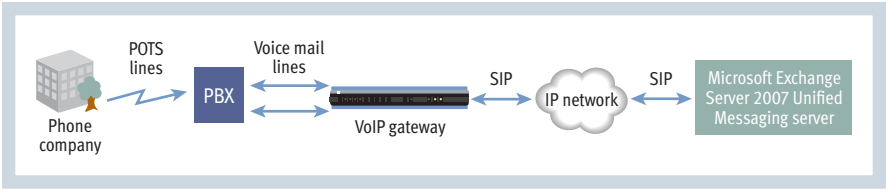

Figure 1. *Simplified Microsoft Exchange Server 2007 Unified Messaging architecture*

mail lines and to an Exchange Unified Messaging server through an IP network. The FXO ports on the VoIP gateway receive line voltage and ringing current from the PBX system. The PBX system and VoIP gateway are configured through a set of routing tables to deliver voice mail or fax messages to recipients in the messaging domain, with each subscriber's access verified through the user information stored in the Microsoft Active Directory® directory service.

Unified Messaging server

While other Exchange Server 2007 server roles enhance features such as internal and external message handling, in-transit message policy configuration, and message filtering and security, the Unified Messaging server role hosts the services and functionality required to implement Unified Messaging and integrate Exchange and telephony networks. This server accepts incoming call requests from a VoIP gateway and communicates with the rest of the messaging system. Active Directory objects on the server logically represent hardware entities and implementation policies associated with Unified Messaging–enabled Exchange users. For each mailbox user, the phone extension stored in Active Directory must match the information stored in the PBX system. Users may be grouped together in Unified Messaging dial plan objects based on geographic site, specific features, or PBX system, which helps ensure the uniqueness of associated phone extensions. To enable communication between a Unified Messaging dial plan and the VoIP gateway, administrators can configure Unified Messaging hunt groups on the Unified Messaging server, which are logical representations of PBX hunt groups and coordinate with one another to both verify information and route incoming calls.

The VoIP gateway establishes sessions with the Unified Messaging server using Session Initiation Protocol (SIP) and transfers live voice traffic using Real-Time Transport Protocol (RTP). The Unified Messaging server processes the voice information and compresses it into a supported digital format using one of three audio codecs: Microsoft Windows Media® Audio (WMA), Global System for Mobile Communications (GSM) Full Rate (European Telecommunications Standards Institute [ETSI] 06.10), or linear pulse-code modulation (International Telecommunication Union Telecommunication Standardization Sector [ITU-T] G.711). These codecs have different bit rates and compression properties, which administrators should take into account when configuring an appropriate balance between sound quality and file size: high bit rates typically enhance sound quality while increasing message size, whereas high compression typically decreases sound quality while also reducing file size.

Incoming fax messages from the VoIP gateway are transported to the Unified Messaging server using the ITU-T T.38 fax relay protocol, and encoded as Tagged Image File Format (TIFF) files. For voice mail or fax messages, the Unified Messaging server creates a Multipurpose Internet Mail Extensions (MIME) format file with the encoded audio message or TIFF image attachment and sends it to the Exchange Hub Transport server using Simple Mail Transfer Protocol (SMTP). The Hub Transport server then relays the messages to the appropriate Exchange Mailbox servers, which store them in user in-boxes.

In addition to receiving and processing incoming messages, the Unified Messaging server provides an Outlook Voice Access feature that allows users to access their mailboxes from internal or external phones and perform various tasks: listening to voice mail or e-mail messages, calendar appointments, and contact information; accepting or rejecting meeting requests; sending "running late" messages to meeting participants; connecting to contacts; or searching their directory. The Unified Messaging server uses the Automated Attendant feature to direct external calls to the appropriate user extension.

Example Microsoft Exchange Server 2007 Unified Messaging deployment

Administrators can deploy an Exchange Unified Messaging infrastructure using industry-standard components, helping them avoid being locked in to a proprietary system. Figure 2 shows

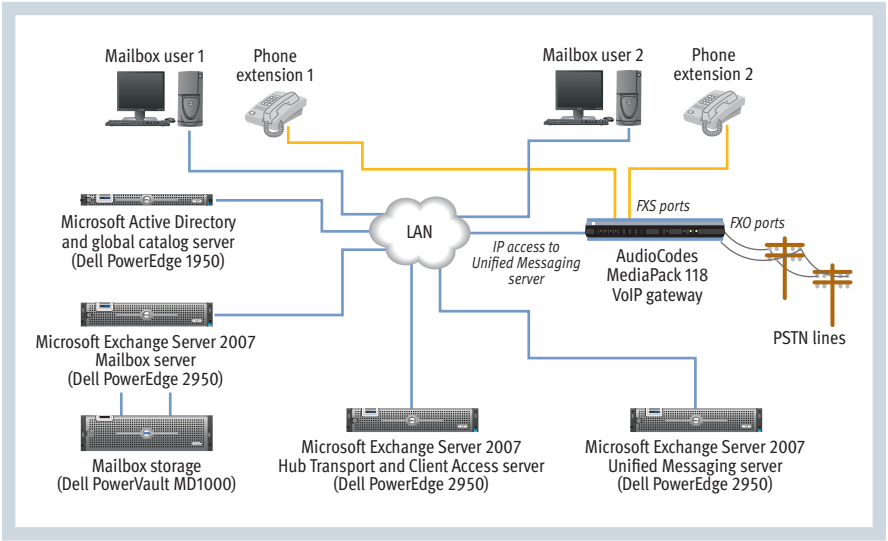

Figure 2. *Example Microsoft Exchange Server 2007 Unified Messaging deployment*

"Unified Messaging helps simplify both message management for enterprise users and archiving and compliance tasks for IT administrators."

an example deployment created by the Dell Enterprise Solutions Engineering Lab, which uses Dell™ PowerEdge™ 2950 servers for the Unified Messaging, Mailbox, and Hub Transport and Client Access servers, with mailboxes hosted by a Dell PowerVault™ MD1000 storage system. The Unified Messaging server uses a Unified Messaging dial plan to process incoming calls from the VoIP gateway. The two example mailbox users have their own phone extensions and are configured to use the Microsoft Office Outlook® 2007 e-mail client.

The AudioCodes MediaPack 118 VoIP gateway includes both FXO and FXS interfaces. In the absence of a PBX unit, the FXS ports are configured to supply the dial tone and simulate a virtual PBX to connect to the phone extensions. The FXO ports accept direct connections from the PSTN and voice mail lines (of the simulated PBX), and communicate with the Unified Messaging server over the IP network. Busy or unanswered phone signals redirect to the Unified Messaging Automated Attendant feature. Both PBX and the Unified Messaging server are also configured with a hunt group to enable routing for incoming calls.

This deployment can support multiple key operations for Unified Messaging–enabled Exchange users, including receiving voice mail and fax messages as audio or TIFF files in their Exchange in-boxes and using Outlook Voice Access to access and manage mailbox data, as described in the "Unified Messaging server" section in this article.

Integrated enterprise communications

The Microsoft Exchange Server 2007 Unified Messaging feature is designed to deliver e-mail, voice mail, and fax messages to user in-boxes and provide flexible access to mailbox data. By integrating and centralizing these various messaging networks, Unified Messaging helps simplify both message management for enterprise users and archiving and compliance tasks for IT administrators.

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High-Availability Features in Microsoft Exchange Server 2007

BY ANANDA SANKARAN
MAHMOUD AHMADIAN
FARRUKH NOMAN

The local continuous replication and cluster continuous replication features introduced in Microsoft® Exchange Server 2007 can help enterprises protect their messaging systems against system failures. This article outlines the basic design and capabilities of these features and describes test results measuring how each affects key performance metrics.

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Clustering

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Availability can be crucial for enterprise operations and a key component of meeting return-on-investment targets. In addition to enhanced setup and management features such as the Exchange Management Shell, Microsoft Exchange Server 2007 introduces high-availability features designed to provide flexible, cost-effective data protection and availability for Exchange deployments. While the native high-availability capabilities of Exchange Server 2003 were limited to shared storage clustering with Microsoft Cluster Service (MSCS)—referred to as single-copy clustering (SCC) in Exchange Server 2007—Exchange Server 2007 adds local continuous replication (LCR) and cluster continuous replication (CCR) options. These features provide additional flexibility when protecting critical messaging data against system failures.

Understanding Microsoft Exchange Server 2007 high-availability features

Figure 1 summarizes some of the key aspects of SCC, LCR, and CCR. Different deployment rules apply for each feature; support for SCC, for example, requires that the hardware configuration be certified and listed in the Cluster Solutions section of the Microsoft Windows Server® Catalog of Tested Products. These features are mutually exclusive and cannot be used simultaneously on the same Exchange Mailbox server.

Single-copy clustering

SCC is based on the same shared storage MSCS model as previous versions of Exchange, a shared-nothing architecture in which a single copy of the storage groups and databases resides on the storage. Two Exchange Mailbox servers connect to this storage to form a cluster. Only one of these servers hosts the mailbox databases and serves client requests at any given time; if that server fails, the other server takes over as the active node.

Local continuous replication

LCR is designed to increase data availability and enable rapid data recovery by creating and maintaining a copy of the storage group (the Exchange logs and database) on a second set of disk volumes connected to a single Exchange Mailbox server. Exchange creates the initial passive database copy through a seeding process to help ensure consistency with the active database. It then uses data replication to help maintain consistency between the two, creating asynchronous copies of the active database's transaction logs and replaying them locally to update the passive database copy. The amount of storage space allocated to the database and logs for the passive copy must be equal to or larger than that of the active copy.

If the active database fails, administrators can manually point the Mailbox server to the passive copy. Administrators

can also take advantage of the passive database to offload backup operations from the primary database and potentially shift from daily to weekly backups.

Cluster continuous replication

CCR is based on the MSCS majority node set (MNS) model, which does not require shared storage; instead, the two Exchange Mailbox server nodes each maintain their own copy of the mailbox databases. As with SCC, only one of these servers is active at any given time, with the other remaining passive and taking over if the active node fails.

An additional service called the file share witness, a cluster resource type introduced as part of Microsoft Windows Server 2003 Service Pack 1 (SP1), arbitrates the first two servers and allows only one to be active at a time. The cluster nodes maintain contact with one another using heartbeat signals. If they lose contact, the file share witness serves as a tie-breaker to help avoid a split-brain situation, where each node is functioning as the active node. The file share witness service should be part of the Microsoft Active Directory® domain containing the cluster nodes, and can be hosted by an Exchange Hub Transport server.

Windows Server 2003 SP1 added the ability to configure cluster heartbeats, a feature that is particularly useful for CCR and MNS clusters deployed in geographically separate locations. This feature allows administrators to configure the heartbeat parameters to help avoid unnecessary failovers during temporary network problems. The Hub Transport server role also includes a transport dumpster feature, which maintains a queue of recently delivered messages from the active Mailbox server. After a failover, all Hub Transport servers in the Active Directory domain are requested to resubmit the queued messages to the new active Mailbox server to help ensure that recently delivered messages are recorded (although this cannot be guaranteed in all situations).

With CCR, Exchange maintains the passive database copy the same way it does with LCR—by creating asynchronous transaction log copies of the active database and replaying them on the passive database. Administrators can use the passive database to increase system resiliency by deploying the active and passive nodes in geographically separate data centers, and as with LCR, they can take advantage of the passive database to offload backup operations from the primary database and potentially shift from daily to weekly backups.

Testing Microsoft Exchange Server 2007 high-availability features

To evaluate how LCR and CCR affect performance, in May 2007, Dell engineers used the Microsoft Exchange Load Generator (LoadGen) simulation tool to test LCR and CCR configurations consisting of Dell™ PowerEdge™ servers and Dell PowerVault™ storage (see Figures 2–4). The test team ran LoadGen to simulate 1,000 heavy users with LCR and CCR both disabled and enabled and evaluated three performance metrics: I/Os per second, processor utilization, and memory utilization.

Local continuous replication test results

Figures 5 and 6 summarize the LCR test results. As Figure 5 shows, database reads and writes and log reads and writes on the active copy were approximately the same regardless of whether LCR was disabled or enabled. The passive copy, meanwhile, had significantly fewer database reads and log writes per second than the active copy once LCR was enabled, but more database writes and log reads, which can be attributed to the log copy and replay process.

As Figure 6 shows, enabling LCR increased processor utilization by approximately 15 percent and memory utilization by approximately 4 percent. When using LCR, administrators typically should allocate enough resources to the Mailbox server to handle a 20 percent increase in processor utilization and approximately 1–1.5 GB of additional memory. They can also configure the same disk resources for both the active and passive copies to allow the passive copy to easily take over should the active copy fail, even though the passive copy incurs fewer database reads than the active copy.

Cluster continuous replication test results

Figures 7 and 8 summarize the CCR test results. As Figure 7 shows, database reads, database writes, and log reads for the active node all showed slight increases with CCR enabled, with the increase in log reads attributable to the log copy process. Log writes on the active node stayed approximately the same. The passive node, meanwhile, had more database reads, database writes, and log reads per second than the active node once CCR was enabled.

As Figure 8 illustrates, the active node showed only slight variations in processor and memory utilization when CCR was enabled, while the passive node had significantly lower

	Single-copy clustering	Local continuous replication	Cluster continuous replication
Availability level	Application	Data	Application and data
Automatic failover	✔		✔
Native data replication		✔	✔
Site resilience for disaster recovery			✔
Requirement that cluster solution hardware configuration be listed in Microsoft Windows Server Catalog of Tested Products	✔		
Backup enhancement		✔ (offload to passive copy)	✔ (offload to passive copy)

Figure 1. *Microsoft Exchange Server 2007 high-availability features*

		Local continuous replication	Cluster continuous replication
Mailbox server	Server	Dell PowerEdge 2950	Dell PowerEdge 2950
	Processors	Two dual-core Intel® Xeon® 5160 processors at 3.00 GHz	Two dual-core Intel Xeon 5160 processors at 3.00 GHz
	Memory	8 GB	8 GB
	OS	Microsoft Windows Server 2003 Release 2 (R2) Enterprise x64 Edition with SP2	Microsoft Windows Server 2003 R2 Enterprise x64 Edition with SP2
	Software	Microsoft Exchange Server 2007 Enterprise Edition	Microsoft Exchange Server 2007 Enterprise Edition
Hub Transport and Client Access server	Server	Dell PowerEdge 2950	Dell PowerEdge 2900
	Processors	Two dual-core Intel Xeon 5160 processors at 3.00 GHz	Two quad-core Intel Xeon X5355 processors at 2.66 GHz
	Memory	16 GB	16 GB
	OS	Microsoft Windows Server 2003 R2 Enterprise x64 Edition with SP2	Microsoft Windows Server 2003 R2 Enterprise x64 Edition with SP2
	Software	Microsoft Exchange Server 2007 Enterprise Edition	Microsoft Exchange Server 2007 Enterprise Edition
External mailbox storage	Arrays	One Dell PowerVault MD3000 for the active database and one Dell PowerVault MD1000 for the passive database	One Dell PowerVault MD1000 for each node
	Active database volume	RAID-10 with ten 146 GB, 15,000 rpm Serial Attached SCSI (SAS) drives	RAID-10 with ten 300 GB, 15,000 rpm SAS drives
	Active log volume	RAID-1 with two 146 GB, 15,000 rpm SAS drives	RAID-1 with two 73 GB, 15,000 rpm SAS drives
	Passive database volume	RAID-10 with ten 146 GB, 15,000 rpm SAS drives	RAID-10 with ten 146 GB, 15,000 rpm SAS drives
	Passive log volume	RAID-1 with two 146 GB, 15,000 rpm SAS drives	RAID-1 with two 73 GB, 15,000 rpm SAS drives
Microsoft LoadGen simulation tool	Version	08.01.0094.000	
	Simulated users	1,000 heavy users executing 94 tasks per eight-hour user day in the Microsoft Office Outlook® 2007 online mode	

Figure 2. *Hardware and software test configuration for Microsoft Exchange Server 2007 local continuous replication and cluster continuous replication*

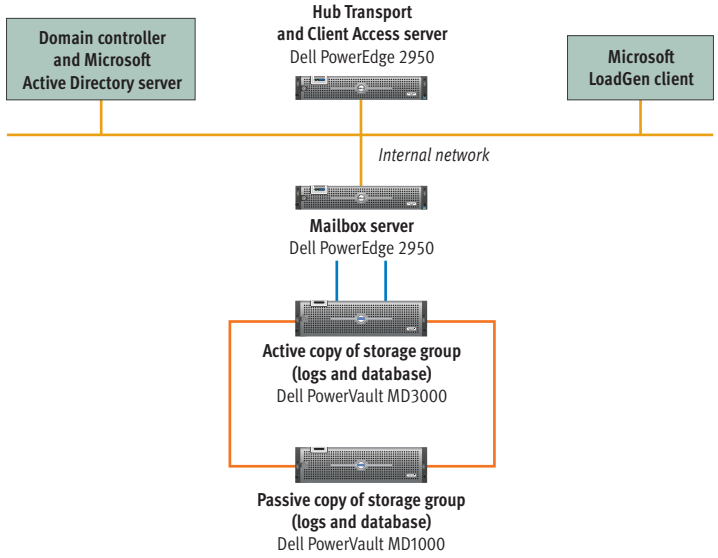

Figure 3. *Network test configuration for Microsoft Exchange Server 2007 local continuous replication*

processor and memory utilization than the active node. Administrators can typically allocate resources to CCR nodes the same way they would to a stand-alone Mailbox server. Although the passive node underutilizes these resources, administrators should still configure it with the same processors and memory as the active node to allow it to easily take over should the active node fail. In addition, although the passive node incurs more database I/Os than the active node, administrators can configure it with the same amount of disk resources as the active node because of its non-production use.

Creating highly available messaging systems

The LCR and CCR features introduced in Microsoft Exchange Server 2007 enable enterprises to easily protect their messaging systems against

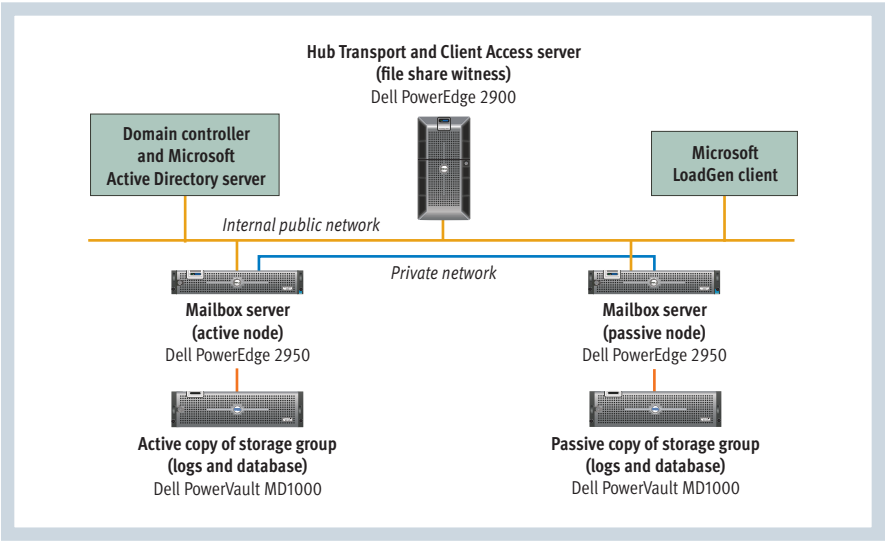

Figure 4. *Network test configuration for Microsoft Exchange Server 2007 cluster continuous replication*

hardware failures. Administrators should carefully evaluate the level and type of availability required before deciding which option is most appropriate for their environment. Implementing these features and configuring them for optimal performance can help create flexible, highly available systems in enterprise data centers.

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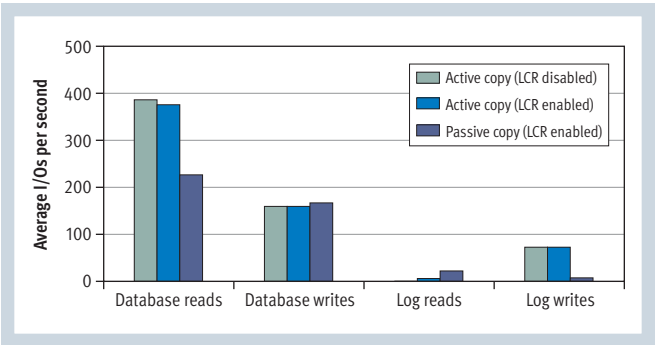


Figure 5. *I/O results in the test environment with local continuous replication enabled and disabled*

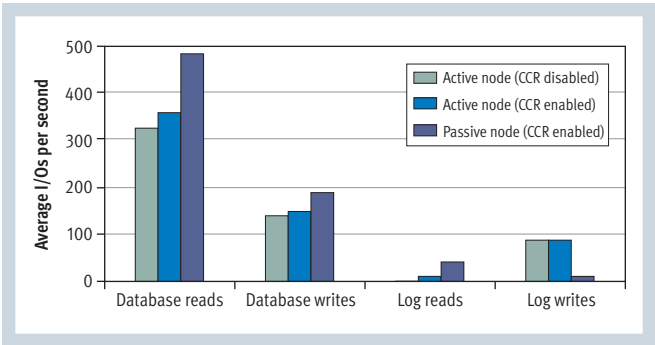


Figure 7. *I/O results in the test environment with cluster continuous replication enabled and disabled*

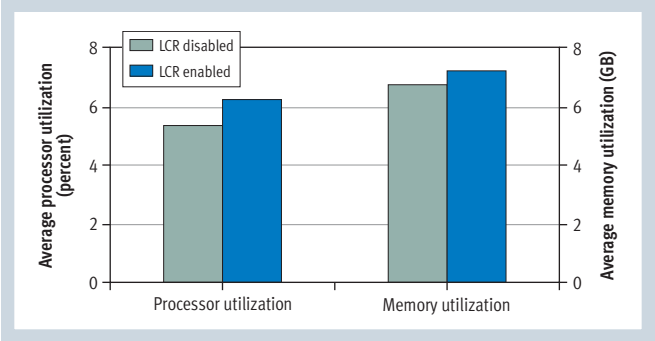


Figure 6. *Processor and memory results in the test environment with local continuous replication enabled and disabled*

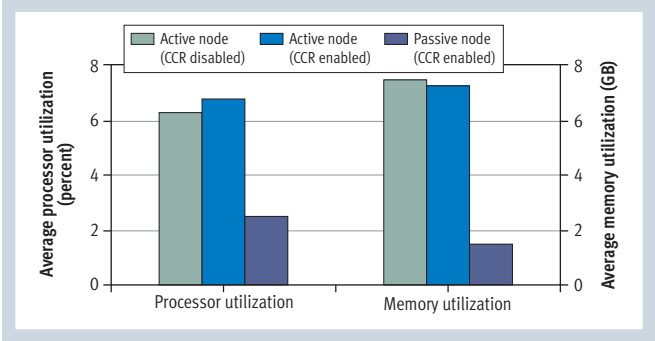
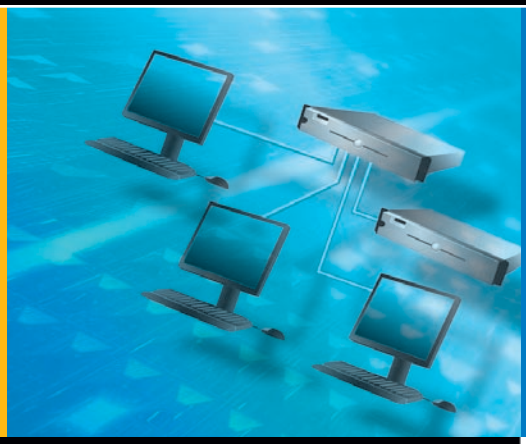


Figure 8. *Processor and memory results in the test environment with cluster continuous replication enabled and disabled*



Integrating MOM into the **BMC Software–based Dell Enterprise Management Framework**

BY DAVID RUBIO
LON ALONZO
NATHANIEL ALFARO

Integrating critical monitoring infrastructures is key to a successful enterprise management framework. By using the Integration of BMC Impact Manager to MOM connector from Seamless Technologies, the Dell IT group was able to integrate Microsoft® Operations Manager (MOM) into its BMC® software–based enterprise management framework while avoiding the pitfalls of developing a custom solution.

Related Categories:

BMC Software

Dell PowerEdge servers

Implementation study

Microsoft Operations Manager (MOM)

Microsoft Windows Server 2003

Seamless Technologies

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When the Dell IT group implemented a large Microsoft Operations Manager (MOM) 2005 monitoring infrastructure,[1] one of the major design considerations was the integration of MOM events into the Dell enterprise management framework (EMF), powered by BMC software. The ability to collect events from all of the Dell MOM management groups into this EMF is critical for capabilities such as global event reporting and ticketing—allowing events from heterogeneous sources detected using the Dell™ Management Pack for MOM 2005 and Dell OpenManage™ Server Administrator (OMSA) agents to be collected, correlated, and put into a standard format. After considering the available options to accomplish this integration, Dell IT decided to use the Integration of BMC Impact Manager to MOM connector from Seamless Technologies.

Dell IT enterprise management framework

EMFs typically consist of tools that collect events and event data from heterogeneous application sources and platforms, standardize event data into a common set of fields, correlate events from disparate sources, and provide interfaces for operators and support personnel to monitor the health of an enterprise environment. The potential benefits of these capabilities to a support organization include the following:

- **Common event stream and console:** Without an EMF, managing event data from enterprise environments can require multiple operations consoles. Using a single console helps facilitate management consistency across different platforms.
- **Standard event format:** A standard event format enables smooth integration into ticketing systems and helps ensure that support personnel can quickly and easily identify the important aspects of a particular event regardless of its source.
- **Correlation:** One of the threats to the effective management of a support group operations console or queue is event or alert flooding. Correlation collapses or suppresses events to help ensure that support teams can use consoles effectively and receive only accurate and actionable alerts. It also aids problem management by relating events from multiple sources.
- **Service modeling:** Service modeling is a key aspect of systems management architectures, enabling enterprises to monitor distinct business services and their related infrastructure components and automatically route alerts to the relevant support personnel.

The Dell IT EMF is based on BMC Service Impact Manager™ (SIM) software, which provides the necessary flexibility and

[1] For more information, see "Dell IT Designs an Enterprise Monitoring Infrastructure Using Microsoft Operations Manager 2005," by David Rubio, Lon Alonzo, and Pragnesh Rathod, in *Dell Power Solutions*, February 2007, www.dell.com/downloads/global/power/ps1q07-20070161-Rathod.pdf.

scalability to handle a global implementation. Its cell-based design allows for myriad configurations to support multiple geographic and failover considerations, and its rules language provides powerful correlation, suppression, and refinement capabilities. SIM can also be configured to support thousands of events per second globally—a necessity for a large, busy enterprise environment.

The Dell SIM environment consists of a regional instance for each of its three major regional sites—the Americas; Europe, the Middle East, and Africa; and Asia Pacific and Japan—along with a global instance in the Americas (see Figure 1). Each regional instance collects events from its region's monitoring infrastructure and forwards select events to the global instance. This design has several advantages:

- **Performance:** Each regional instance supports a sustained rate of 240 events per second, with burst rates of up to 400 events per second.
- **Scalability:** The global infrastructure for over 15,000 monitored elements consists of only nine SIM servers and eight adapter servers used for Simple Network Management Protocol (SNMP) events.
- **Reporting history:** A long-term event storage database attached to the global SIM instance provides a central repository for all events. The storage design provides over a year of history retention for event data and provides sophisticated reporting capabilities on global event activity.
- **Integration:** SIM automatically creates tickets for events and populates relevant fields in the Dell IT global BMC Remedy® Action Request System® (AR System) implementation. Every major Dell IT monitoring application is integrated using a variety of methods, including SNMP for network devices, custom adapters, BMC-provided adapters, and BMC-provided tools for integration into SIM.

Integration of Microsoft Operations Manager and BMC Service Impact Manager

When Dell IT migrated to a global monitoring infrastructure based on the Microsoft Windows Server® 2003 OS and MOM 2005, the integration with SIM presented a challenge. One key reason for implementing MOM 2005 was its tight integration with OMSA through the Dell Management Pack for MOM 2005, and integrating OMSA alerts with the SIM-based EMF was critical.

Microsoft incorporates a powerful interface in the MOM Connector Framework (MCF), and BMC provides a Web services–based application programming interface (API) for SIM integration, but neither offers an off-the-shelf option for integrating the two platforms. Dell IT evaluated several possibilities for this integration:

- **API-based custom solution:** The custom development of a connector based on the MCF and the BMC API could provide the necessary integration. But this type of development can be time-consuming and draw resources away from other parts of the project, and includes typical risks of custom development such as a lack of service and support.
- **SNMP-based custom solution:** Because MOM can be configured to send SNMP traps, using the BMC Impact Event Adapters for SNMP could allow MOM to create traps and send them to SIM for event creation. But because of the nature of SNMP object identifiers and management information bases, this type of integration can be time-consuming and difficult to implement in a robust way. Its reliance on datagrams also means that SNMP lacks guaranteed delivery.
- **BMC binaries–based method:** BMC provides a set of binaries that can be used to send event data to SIM using the `msend` command. This method requires that the monitoring application be able to interact with the OS to call the binaries, and be able to pass variables using substitution strings. It would also require that every event be configured with a corresponding response that called the `msend` binary with all the arguments to pass the relevant event data.
- **Off-the-shelf product:** An off-the-shelf product theoretically provides quick integration with minimal custom development, which both reduces time and resource requirements and

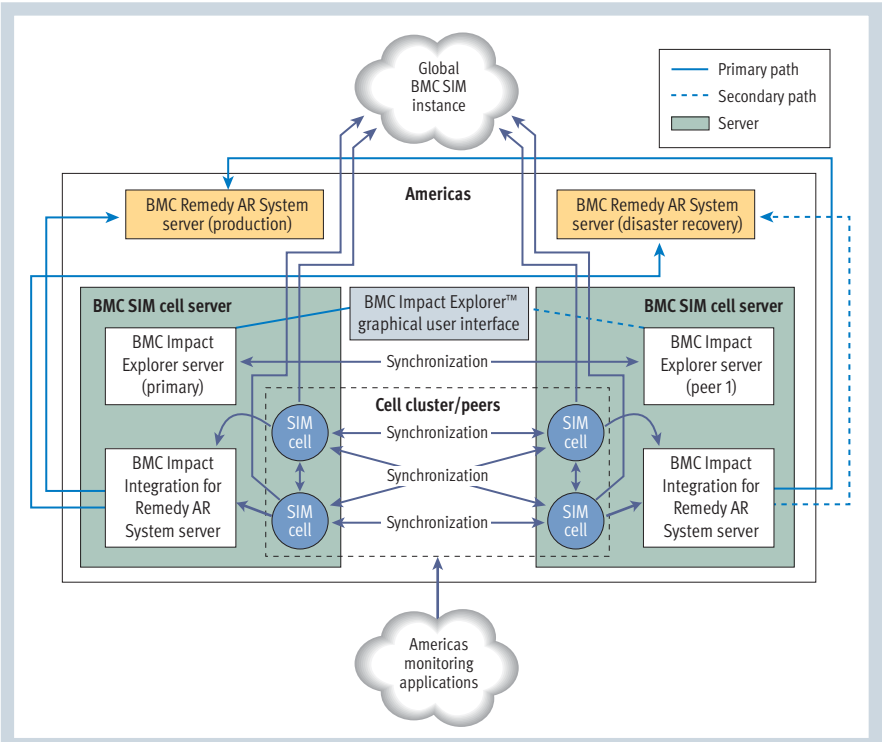

Figure 1. *Dell global enterprise management framework based on BMC Service Impact Manager*

Feature	Previous monitoring application connector	Integration of BMC Impact Manager to MOM connector
Native SIM integration		✔
Event and alert buffering	✔	✔
Bidirectional event data flow		✔
Cell redundancy		✔
Connector redundancy		✔
Connector health monitoring		✔
Included with monitoring application	✔	

Figure 2. *Comparison of previous Dell IT monitoring application connector with the Integration of BMC Impact Manager to MOM connector from Seamless Technologies*

simplifies support concerns by placing that burden on a vendor. It does, however, introduce the additional cost of purchasing the product.

Dell IT performed a cost/benefit analysis with the highest priority placed on schedule, which meant that the additional cost of purchasing an off-the-shelf product was an acceptable compromise given the schedule delays and support complications of developing a custom solution. After additional research, Dell IT chose to implement the Integration of BMC Impact Manager to MOM connector from Seamless Technologies, which is recommended by both Microsoft and BMC and was developed collaboratively with those companies using native APIs. Its key features include the following, many of which were not available in the previous Dell IT integration design (see Figure 2):

- **Event translation:** MOM events are translated into the SIM format and forwarded to the configured SIM cell(s), including the custom translation of MOM alert fields to SIM fields.
- **Event filtering:** Only configured MOM alerts are forwarded to SIM. This configuration is integrated into the MOM Administrator console, requiring no command-line interface or additional consoles.
- **Bidirectional event data flow:** Two-way data flow facilitates bidirectional event status and information updates, such as passing Remedy AR System ticket numbers to MOM.
- **Connector redundancy:** The connector supports active/active redundancy schemes to help ensure visibility into events even if a single management server fails.
- **Guaranteed delivery:** The connector is stateful, which helps ensure delivery of events from MOM to SIM. It also provides detailed trace logging for event delivery.
- **Multicell support:** Multiple destination cells can be configured, helping ensure that a single cell outage does not interrupt event flow.
- **Connector health monitoring:** The connector can alert SIM when contact with MOM is lost and vice versa, and SIM itself can generate alerts when the connector session is lost, helping ensure that support personnel know when event flow ceases.
- **Support:** Seamless Technologies can provide 24/7 support for the connector, and have now released a version supporting Microsoft System Center Operations Manager 2007, the successor to MOM 2005.

This rich feature set made the connector a convincing choice for the Dell IT integration across its global environment.

Dell IT infrastructure design

Globally, the Dell IT MOM 2005 infrastructure incorporates six primary management groups for production server monitoring as well as two

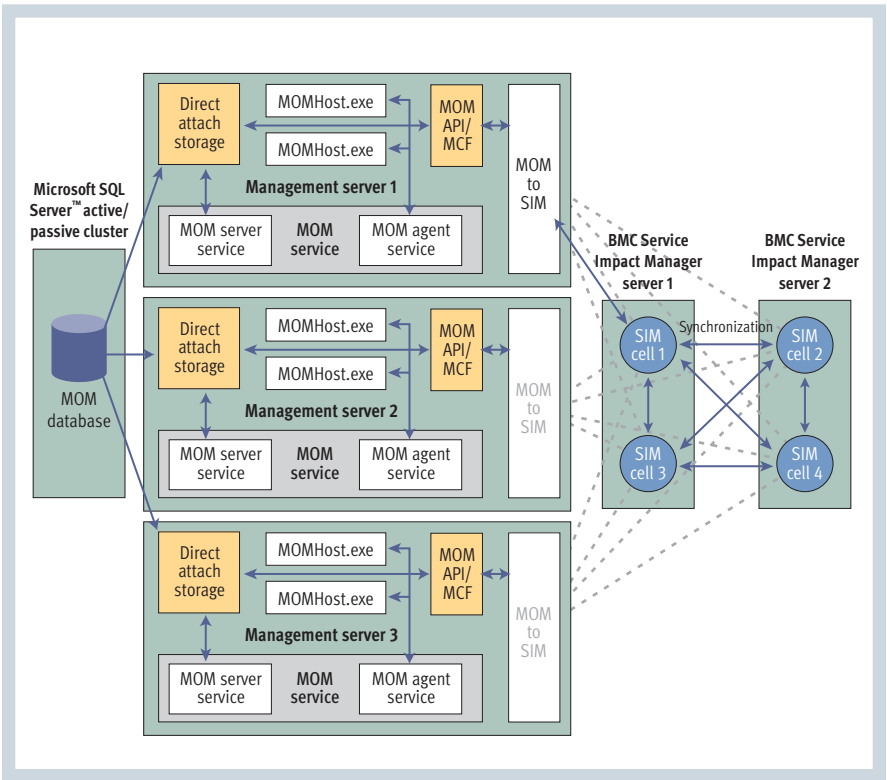

Figure 3. *Microsoft Operations Manager 2005 management group integrated with BMC Service Impact Manager in the Dell IT monitoring infrastructure*

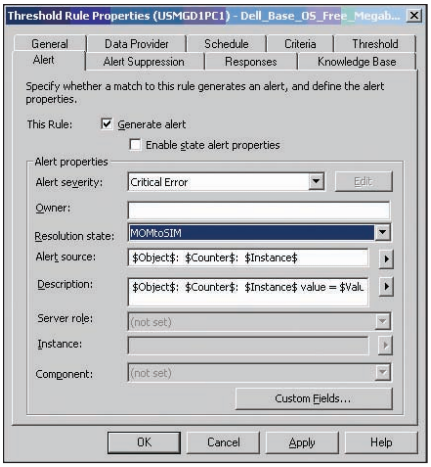

Figure 4. *MOMtoSIM resolution state in Microsoft Operations Manager 2005*

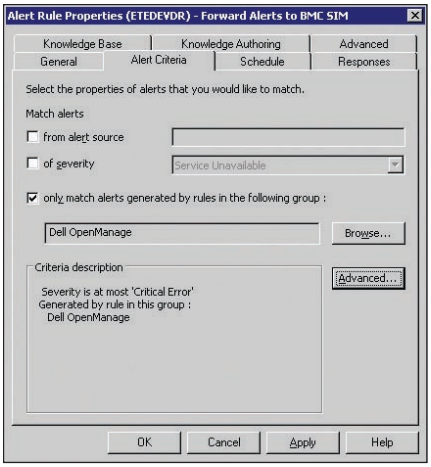

Figure 5. *Alert rule for all Dell OpenManage events with a severity of "Critical Error" or higher in Microsoft Operations Manager 2005*

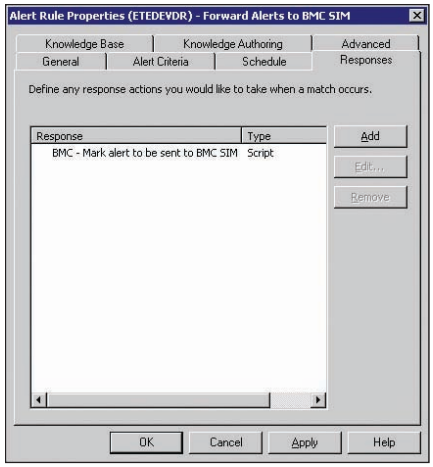

Figure 6. *Default response script used to send an alert to BMC Service Impact Manager in Microsoft Operations Manager 2005*

standby management groups for disaster recovery. Each primary management group consists of five servers: three Dell PowerEdge™ 2850 servers as the management servers, and two Dell PowerEdge 6850 servers as the MOM database cluster, which utilizes shared Dell/EMC CX series Fibre Channel–based SAN storage. Dell IT installed the Integration of BMC Impact Manager to MOM connector on each management server and configured it for all four available cells in each regional instance. This design provides both management server and SIM cell redundancy (see Figure 3).

Once the connector is installed, the MOMtoSIM resolution state appears in elements of the MOM Administrator console for that management group. Administrators can configure this resolution state in the Alert tab of the Threshold Rule Properties window for non-script-based event rules and all alert rules; however, because script-based event rules have a different Alert tab, administrators cannot configure the responses for those rules through this interface.

This design provides administrators with multiple options for sending events from MOM to SIM with the connector:

- Configure individual event rules in the Alert tab to use the MOMtoSIM resolution state (see Figure 4), which sends alerts to SIM for processing
- Use the Alert Criteria tab of the Alert Rule Properties window to configure an alert rule with a broad scope—for example, one that applies to all Dell OpenManage events with a severity of "Critical Error" or higher (see Figure 5) and uses the "BMC - Mark alert to be sent to BMC SIM" script in the Responses tab (see Figure 6)
- Configure a custom MOM script to use the Integration of BMC Impact Manager to MOM connector
- Create script-based rules to provide functionality not originally present in the connector, which can invoke the Integration of BMC Impact Manager to MOM connector within MOM to create a SIM event

Integrated global enterprise management framework

Integrating its global MOM 2005 infrastructure with BMC SIM using the Integration of BMC Impact Manager to MOM connector from Seamless Technologies allowed Dell IT to simplify hardware monitoring for heterogeneous server platforms and operating systems. By using this framework in conjunction with OMSA, the Dell Management Pack for MOM 2005, and Dell PowerEdge servers, Dell IT can configure hardware alerts to be forwarded to SIM, which then normalizes and correlates them before forwarding them to BMC Remedy AR System for ticketing and alerting.

In addition, by taking advantage of SIM service modeling, Dell IT can correlate those events to not only receive timely notification of hardware events, but also identify which business service or infrastructure is affected by the event. This capability allows the system to notify both the global server support team and the affected application's support team of performance degradation, loss of redundancy, failovers, and so on. Dell anticipates that this framework will serve as the foundation for all of the Dell IT group's future service management for the global Dell monitoring infrastructure.

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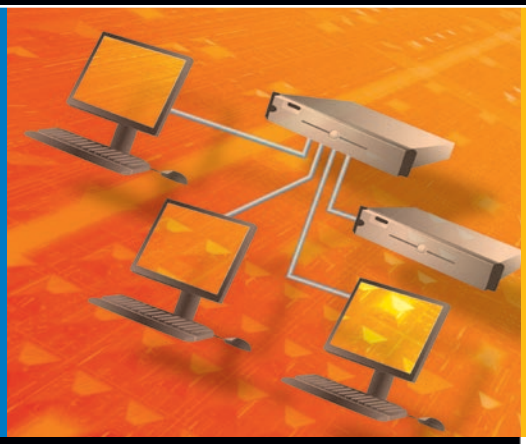

Procuring, Provisioning, and Updating Servers with LANDesk Management Solutions

BY LISA BAKER

Creating a repeatable and reliable approach to procuring, provisioning, and updating servers presents many challenges in enterprise environments. LANDesk® Process Manager and LANDesk Server Manager can help simplify and streamline this process, and include features specifically designed for Dell™ PowerEdge™ servers.

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The process of procuring, provisioning, and updating a new server can be time-consuming and complex, and may extend over several months for some enterprises. Simply securing the necessary budget approvals to purchase a server, for example, can be a major roadblock on its own, without even considering potential delays in ordering and receiving the server.

After a new server arrives, IT administrators must prepare and provision it for deployment, which brings its own challenges as well. Manual provisioning can be time-consuming and subject to human error, often relying on individual knowledge or a lengthy series of paper checklists to help ensure that each step is carried out correctly. Automated image-based processes can be well suited for desktop deployments, but they often lack the flexibility and control necessary for servers, requiring administrators to make manual adjustments to each configuration. In both cases, the inherent lack of control, repeatability, and reliability can significantly extend the time it takes to finally bring a server online.

LANDesk Process Manager and LANDesk Server Manager are designed to streamline and automate these types of processes, and include features specifically designed for environments built on Dell PowerEdge servers. Integrating these two applications into enterprise workflows allows administrators to automate many procurement, provisioning, and change and release management tasks, helping create repeatable, reliable IT processes.

Simplified server procurement

The first step is to create an efficient and repeatable process for server procurement. LANDesk Process Manager is designed to simplify this type of task, enabling enterprises to easily design, model, document, audit, automate, analyze, and optimize business processes, including server procurement. Its support for change and configuration management helps bridge process gaps between IT services and enterprise operations and enables IT managers to utilize existing financial, enterprise resource planning, customer relationship management, call tracking, e-mail, operational, and other enterprise solutions to help automate and validate procurement processes.

For example, administrators can use LANDesk Process Manager to define a preferred hardware platform for their specific environment. Then, when a department needs a new server, it can easily choose one from the approved list and initiate an internal order. Based on the enterprise's defined processes, LANDesk Process Manager can automatically carry out the necessary tasks to obtain approvals, order the server from the vendor, and notify the appropriate IT staff members when the server arrives. It can also provide status updates and automatic notifications throughout the process to allow IT staff to prepare before the server arrives.

The business process management engine in LANDesk Process Manager orchestrates, automates, and monitors procurement processes, including the validation, escalation, and management of procurement activities. It can

interpret the rules and tasks defined for specific procurement processes and then interact with other applications that participate in the process, executing and managing the workflow based on those defined rules. Not only can it execute automated services, but when human intervention or action is required, it can also prompt individuals—through e-mail or other forms of communication—to complete the necessary manual tasks.

For example, a typical workflow for procuring a Dell server might run as follows (see Figure 1):

1. Someone in the organization initiates an order for a new Dell server, either by starting the workflow manually or by using an application that then triggers an event listener and automatically starts the workflow.
2. The workflow's primary action invokes the necessary subsequent actions, which might include verifying budget availability, sending e-mails for finance approval, submitting an order, and notifying the IT department of the purchase.
3. The actions operate according to their assigned attributes, and can in turn invoke one or more actions according to their configuration. For example, all orders under US$1,000 might be automatically fulfilled, while those over US$1,000 might require finance approval first.
4. The sequential or parallel routing of the workflow continues until each action thread reaches its end, with either the order being denied or the server being delivered to a specified destination in the IT department.

The process designer in LANDesk Process Manager uses a drag-and-drop interface that enables process owners to easily work together to visually model, define, and optimize even highly complex processes. The straightforward interface is designed for ease of use, allowing nontechnical staff members to represent processes and flows in the tool without involving IT staff. In addition, the tight integration between the process designer and business process management engine means that when process owners construct models, they are not only designing the layout, but also creating the physical flow of the process, which in turn develops the actual code that the engine executes.

Customized server provisioning

What makes provisioning with LANDesk software so powerful is the integration between the processes executed by LANDesk Process Manager and the customized provisioning capabilities of LANDesk Server Manager. At a low level, a process is simply a network of specific actions that work together to achieve a desired result. In terms of server procurement and provisioning, these actions help enterprises first acquire the server they need quickly and easily and then automate provisioning to meet their specific requirements.

While LANDesk Process Manager helps simplify server procurement, LANDesk Server Manager helps simplify server provisioning, enabling IT staff to configure servers in a repeatable, reliable way once the servers have arrived. It can schedule hardware configuration tasks, install the appropriate OS and applications, set the security policies, and then store the history of these actions to provide a configuration record for each server. And, importantly, IT staff can easily reuse the same process on the next server they deploy or on duplicate hardware after rebuilding a server.

Provisioning with LANDesk Server Manager enables IT staff to use a single provisioning task to install and configure their servers, from OS installation to application deployment, patching, and configuration. However, it also allows them to split that provisioning task into easy-to-manage segments such as the following, the same way they would when setting up a system manually:

- Planning and assessing needs
- Creating reusable building-block tasks for common operations
- Designing and testing system configurations
- Deploying an OS to one system or a group of systems
- Performing post-OS tasks, such as installing applications, updating virus definitions, and applying OS patches
- Verifying that the installation was successful, perhaps by running sample test applications

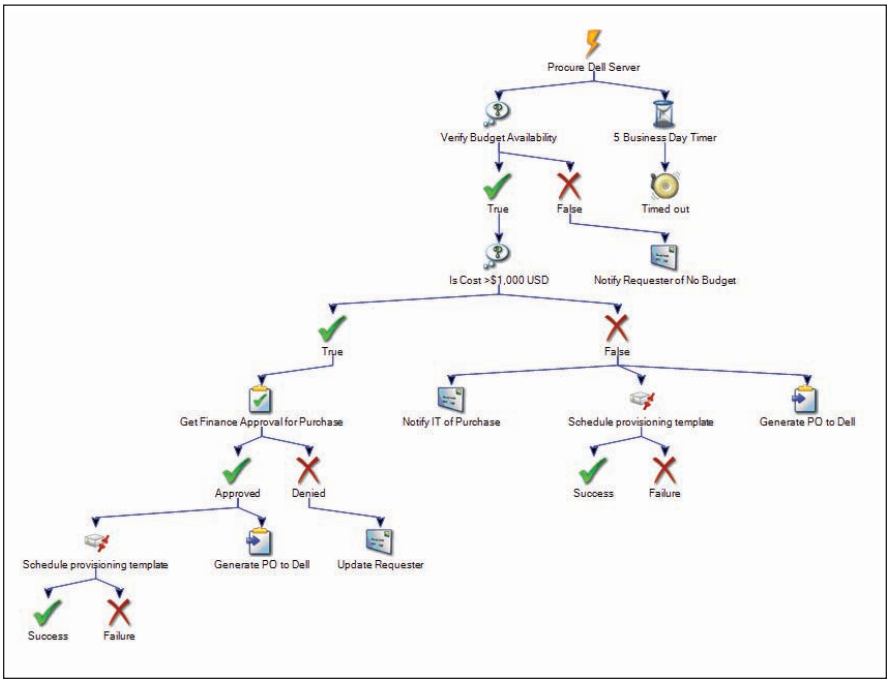

Figure 1. *Example workflow for procuring a Dell server shown in LANDesk Process Manager*

IT staff can use LANDesk Server Manager to schedule these provisioning tasks in advance—even before the hardware arrives—or they can run it dynamically as needed, such as when a system fails and needs to be restored.

Understanding provisioning templates

Provisioning with LANDesk Server Manager lets administrators define a template—a series of actions and attributes that are applied dynamically and contain the instructions necessary to bring a server to a known state. Templates can consist of actions as well as other sub-templates. Each template can therefore be executed as an independent unit or combined with other actions and templates in a master template, making it easy to create customized templates for specific hardware or application types.

Administrators can use these templates to provision servers more quickly, easily, and predictably than they could using multiple custom images or manual deployment processes. Because the templates are formatted as XML documents and their actions can be incorporated into other templates, administrators can easily review and edit individual templates for accuracy and consistency rather than rebuilding or recapturing multiple unique images. For example, in an environment with 30 unique server configurations, administrators could create an action that installs the virus scanner and updates definitions, then include this template within each of the 30 master templates. This approach helps avoid the need to rebuild each image 30 times when adding new information, and the need to add manual pieces to the provisioning process after applying a static image.

Because each system is unique, sharing a general image between systems can lead to compatibility or performance problems. Administrators can avoid these problems by using scripted installations and combining different templates to meet specific system requirements—for example, by changing a single driver version. LANDesk Server Manager also enables administrators to take advantage of an existing image library, and offers additional customizable and repeatable tasks to facilitate provisioning. For example, administrators can script one template to automatically wake and boot a server before image deployment, and another template to automatically install updated definitions files and OS updates after image deployment.

Creating and modifying provisioning templates

LANDesk Server Manager templates are divided into four provisioning sections: Pre-OS Installation, OS Installation, System Configuration, and Post-OS Installation. This division allows the LANDesk Server Manager interface to provide some guidance on where to place actions—for example, by helping prevent administrators from inadvertently initiating a low-level RAID configuration action after an OS installation action.

Pre-OS Installation. Actions in this section execute while the target server is running its preboot environment. They typically consist of low-level hardware configuration actions required for OS installation. Actions available when provisioning a Dell server, for example, include Map to the Dell DTK Utilities, Sets the BIOS to Boot from CD-ROM, Enable LAN Channel, Set BMC IP to DHCP, Install and Start the RACSVC Service, Enable DRAC NIC, Set DRAC DHCP IP Address, and Create a Virtual Disk.

OS Installation. In this section, administrators can choose between the Install by Image action and the Install by Script action. Although Install by Image (which uses an image to restore a snapshot of an existing server disk or partition) may be the more familiar of the two, Install by Script (which uses a response file and installation from the vendor's source media) may be a better approach for many servers. An OS installation script for the Microsoft® Windows Server® 2003 OS on a Dell server might include the following steps:

1. Delete all data from disk 0
2. Reset the RAID to the Dell default settings
3. Partition the entire logical disk into a single partition
4. Label the partition as drive C:\
5. Format the partition using NT File System (NTFS)
6. Install and configure Windows Server 2003 according to the settings and variables defined in the response file

System Configuration. Actions in this section modify the target OS before it boots for the first time—for example, by copying driver installation programs and then editing the sysprep.ini file (in Microsoft Windows® operating systems) or init scripts (in Linux® operating systems) to set those programs to run on first boot. When setting up this section, administrators can specify a server model, then add a patch action to the master template to scan the server and determine the appropriate driver updates. LANDesk Server Manager, in conjunction with Dell patch tools, can not only determine which driver and firmware versions are available, but also automatically install the appropriate drivers and firmware. Administrators can also search for other versions and override these automatic choices if they prefer.

Post-OS Installation. This section executes once the target OS has booted. The first action in this group is typically an agent configuration action that installs remote control, software distribution, and patch agents. Once these agents are installed, the action list can include complex actions such as scanning for vulnerabilities, repairing known vulnerabilities (for example, applying security updates from software vendors), and distributing software.

Other Post-OS Installation actions might include executing security templates configured from a base set of group security policies, such as ensuring that guest access is disabled on a specific share or that the firewall is on. In the past, administrators might have used a paper checklist to manually configure each of these security policies on each server. Using LANDesk Server Manager templates helps administrators ensure that these policies are applied automatically and correctly during each server provisioning.

Using pre-built and Dell-specific templates

To facilitate deployment, LANDesk Server Manager includes several pre-built templates that administrators can use as provided,

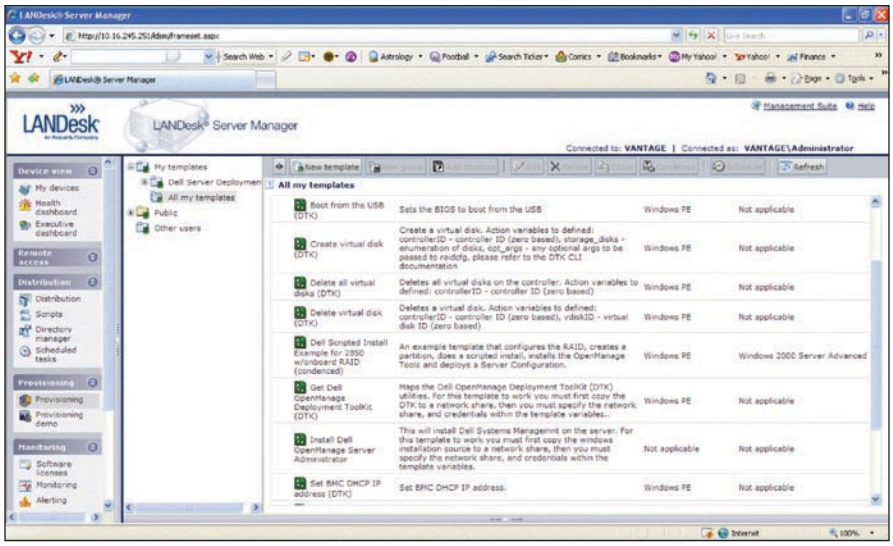

Figure 2. *Customized Dell-specific templates in LANDesk Server Manager*

customize to fit specific requirements, or use as patterns for additional templates. Some of these pre-built templates are optimized to work with particular hardware configurations, including Dell servers. Administrators can combine these templates with their own master templates or run them with minimal modification to provision specific Dell servers.

For each Dell server being provisioned, administrators can create a master template that contains all of the individual templates required to configure that specific server. This master template could include the provided Dell-specific templates customized to meet specific needs, as well as generic building-block templates used for various types of servers in the environment (see Figure 2).

Included in the pre-built templates is the Dell Scripted Install Example template, which contains a wide variety of templates that administrators can use and modify as needed when deploying Dell servers. Like other pre-built templates, administrators can also use these templates as examples when creating their own customized templates.

To help administrators keep their templates up-to-date, LANDesk maintains and updates the contents of pre-built templates online. Administrators can download updated templates as needed from within LANDesk Server Manager.

Transparent change and release management

In addition to simplifying server provisioning, LANDesk Server Manager helps administrators handle the difficulties associated with change and release management. The integration between LANDesk Process Manager and LANDesk Server Manager also offers multiple advantages when creating and managing processes that deal with incident management, configuration management, release management, security management, and IT service continuity, helping administrators and other process owners do the following:

- Minimize the risk of failed or bad changes and potential service disruptions caused by changes, and prevent unauthorized changes
- Authorize and allocate resources to make changes, and ensure changes are implemented cost-effectively
- Implement enterprise-wide changes automatically and efficiently, without enterprise-wide impact
- Identify, record, and classify incidents and quickly restore affected service levels to maintain high levels of availability
- Automate the management, identification, control, and maintenance of existing configurations, replacing manual operations with rapid, efficient, and scalable automated processes—for example, by reusing a template to bring a particular server back to a known state

Efficient server procurement, provisioning, and change and release management

LANDesk Process Manager and LANDesk Server Manager enable administrators to efficiently perform server procurement, provisioning, and change and release management tasks while helping ensure that each step is carried out in a repeatable, reliable way. Administrators can easily customize each application to meet their particular needs, and can take advantage of pre-built Dell-specific templates in LANDesk Server Manager designed to further simplify these tasks for Dell servers. Integrating these two LANDesk management solutions provides an automated way to help ensure that servers are procured, provisioned, and deployed in a repeatable and reliable way, which can be essential in enterprise environments.

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ATI FireGL™ Accelerators from AMD Make Workstation Graphics a Snap to Manage

By Daniel Shapiro, Senior Marketing Manager, AMD

Workstation users are among the most demanding clients for IT administrators, pushing the limits of technology with compute- and graphics-intensive applications for 3D design, animation, CAD/CAM, and medical imaging. ATI FireGL™ workstation graphics accelerators from AMD help reduce TCO by streamlining configuration, boosting creativity, and ultimately enhancing user productivity. In addition, AMD's software engineering teams help ensure ATI FireGL accelerators are optimized and ISV certified for today's leading design and visualization applications.

It just works

"Install it, and then don't worry about it." That's the mantra for IT administrators and a goal AMD sets for customers using and managing graphics workstations. While the ATI FireGL™ family of workstation graphics accelerators from AMD can help boost user productivity with world-class features and highly tuned performance for leading computer-aided design (CAD) and content-creation applications, enterprise benefits reach far beyond raw graphics horsepower. By streamlining the installation, configuration, and upgrade process, ATI FireGL graphics accelerators can help cut down on the time it takes to deploy new systems, perform routine maintenance, and respond to support requests—helping reduce total cost of ownership (TCO) while freeing the IT team for more value-added tasks.

ATI FireGL accelerators can offer outstanding benefits for IT administrators, including independent software vendor (ISV) certification with comprehensive compliance, performance, and functionality verification, plus Auto Detect optimized configuration profiles.

Optimized and certified. AMD runs a rigorous tuning program to optimize ATI FireGL driver software for leading professional 3D applications, as well as to help ISVs optimize their software for ATI FireGL hardware. The exacting certification processes, conducted by the software vendors, puts ATI FireGL graphics accelerators up against a battery of simulations and real-world scenarios to help ensure the compatibility and stability workstation users require. In addition, AMD's quality assurance engineers conduct comprehensive compliance, performance, and functionality verification tests, and work closely with application and workstation vendors to refine ATI FireGL products—helping create top-flight reliability and performance in the field.

More than 40 graphics programs are tested with ATI FireGL accelerators, in categories including CAD, computer-aided engineering (CAE), as well as architecture, engineering, and construction (AEC); digital content creation (DCC) and digital media; geographical information systems (GIS) and visualization; life sciences; and oil and gas. Individual applications include Adobe Photoshop and Premiere Pro; Autodesk AutoCAD, 3ds Max, and Maya; Avid SOFTIMAGE|XSI; Dassault Systemes CATIA; ESRI ArcGIS; PTC Pro/ENGINEER; SolidWorks Corp. SolidWorks; and UGS Solid Edge. (For a complete list of certified applications, visit ati.amd.com/products/workstation/ISVCertsFireGL.pdf.)

When an ATI FireGL accelerator is paired with a certified application, professional engineers, designers, and animators can expect a stable and high-performance workstation graphics environment on both Microsoft® Windows® and Linux® platforms. Moreover, IT administrators

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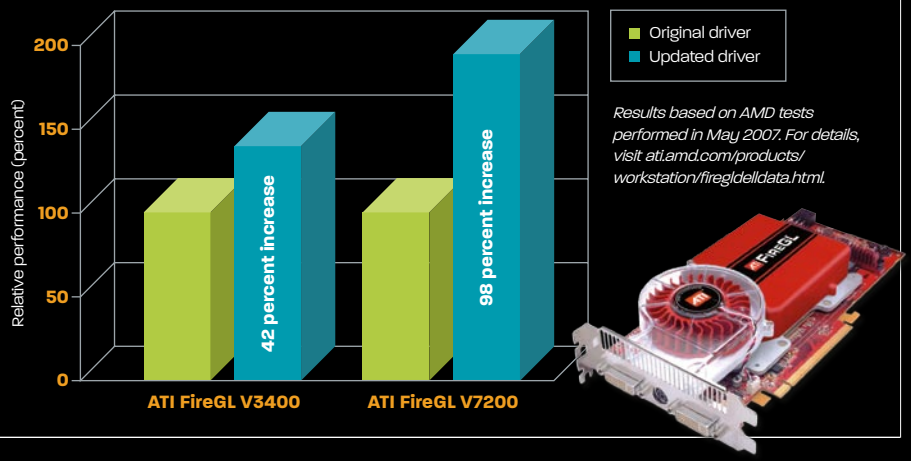
Ongoing driver optimization enhances ATI FireGL™ performance



don't have to worry about driver conflicts or the many other compatibility issues that can emerge when running powerful graphics programs.

Automatic performance tuning. A new feature recently integrated in the ATI FireGL driver is called Auto Detect. When a workstation equipped with an ATI FireGL accelerator launches a certified application, the accelerator automatically detects this action and loads the configuration profile optimized for that application. This relieves a big IT headache—assisting users who aren't sure how to load graphics drivers, configure control panels, or take other steps required to launch applications on workstations equipped with accelerators that don't offer Auto Detect. In addition, Auto Detect enables optimized driver performance when running multiple applications simultaneously as users switch between windows.

Eye-opening performance

Few applications demand more processing power than professional graphics software; incredible amounts of computation are required to transform, rotate, and scale large 3D data sets, then render images on the screen. Plus, users want big screens, pinpoint sharpness, and near-perfect color displays. And they want it now, without tapping their feet while new images are being rendered.

ATI FireGL accelerators are built on a scalable, ultra-threaded graphics architecture and innovative 512-bit ring bus memory system designed to handle the most complex 3D models, the largest data sets, and the highest-definition textures used today. With the 10-bit display pipeline and high dynamic range (HDR) 16-bit per RGB color component output, ATI FireGL accelerators are designed to produce over 1 billion colors on a 10-bit display. Multiple parallel geometry engines and pixel shader processors help reduce render time. The ATI FireGL graphics processing unit enables 128-bit full floating point precision and supports up to 1 GB of graphics double data rate 3 (GDDR3) memory.

This cutting-edge performance can also help sustain the IT department's workstation investment. For example, when ATI FireGL accelerators are first released, they often support features that are touted in upcoming ISV application releases. When these applications become available, the next-generation features can be enabled on the ATI FireGL accelerators through a software update. In addition, AMD's ongoing software development and driver tuning have demonstrated that users can boost application performance without having to spend a penny more on hardware. AMD tests have demonstrated that an updated version of the ATI FireGL driver increased ATI FireGL V3400 performance by up to 42 percent and ATI FireGL V7200 performance by up to 98 percent over a previous driver version (see figure). In this way, ATI FireGL accelerators also contribute to reduced TCO by extending the useful life of the workstations in which they are installed.

Graphics professionals can never get enough visual real estate; the more and bigger screens they have, the faster and more effectively they can work. To help meet these demands, ATI FireGL accelerators together with Dell Precision™ workstations continue to enhance productivity and overall user experience. For example, by tapping the two dual-link-enabled Digital Visual Interface (DVI) ports on the ATI FireGL V7200 accelerator, users can drive two 30-inch Dell UltraSharp™ wide-screen monitors at up to 2560 x 1600 resolution each, creating a massive desktop up to 5120 pixels wide.

Completing the picture

AMD offers a range of ATI FireGL accelerators—from entry-level to ultra-high-end—because professional graphics is not a one-size-fits-all category. Dell matches this approach with its Dell Precision line of workstations, allowing each unit to be customized for the needs of an individual user. For IT administrators seeking to lower TCO, this combination makes it easy to avoid spending too much—or too little.

Dell Precision 390, 490, and 690 workstations can be ordered with ATI FireGL V7200 and ATI FireGL V3400 accelerators. In addition, other models of Dell workstations with PCI Express can incorporate ATI FireGL cards. Regardless of which ATI FireGL accelerator is installed, a unified driver supports all models, solving yet another problem for IT professionals by enabling them to easily and efficiently manage a variety of configurations deployed throughout the enterprise.

Get the details on ATI FireGL™ workstation graphic accelerators in Dell Precision workstations now!

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Parallel programming features supported by the Intel® C++ Compilers and Intel Fortran Compilers enable developers to increase application performance, accelerate the development of multi-threaded programs, and simplify the transformation of sequential programs into parallel programs.

The Intel C++ and Fortran Compilers support three major parallel programming features: parallelization with the OpenMP* application programming interface (API), auto-parallelization, and auto-vectorization. Each of these features contributes to application performance depending on the number of processors, the target architecture (Intel® IA-32 or Itanium® architecture), and the nature of the application. These parallel programming features can be combined to enhance application performance.

Parallel programming can be *explicit,* that is, defined by a programmer using OpenMP directives. Parallel programming can also be *implicit,* that is, detected automatically by the compiler. Implicit parallelism implements auto-parallelization of outermost loops and auto-vectorization of innermost loops (or both). See Figure 1.

Parallelism defined with OpenMP and auto-parallelization directives is based on thread-level parallelism (TLP). Parallelism defined with auto-vectorization techniques is based on instruction-level parallelism (ILP).

The Intel compilers support OpenMP and auto-parallelization on both IA-32 and Itanium architectures for multiprocessor systems as well as on single IA-32 processors with Intel® Hyper-Threading Technology. Auto-vectorization is supported on the families of the Intel® Pentium®, Pentium with MMX™ Technology, Pentium II, Pentium III, and Pentium 4 processors. To enhance the compilation of the code with auto-vectorization, programmers can also add vectorizer directives to their program. A closely related technique that is available on the Itanium-based systems is software pipelining.

Parallel program development

The Intel Fortran Compilers support the OpenMP FORTRAN version 2.0 API specification available from the www.openmp.org Web site. The OpenMP directives relieve the programmer from having to deal with the low-level details of iteration space partitioning, data sharing, and thread scheduling and synchronization.

The auto-parallelization feature of the Intel C++ and Fortran Compilers automatically translates serial portions of the input program into semantically equivalent multi-threaded code. Automatic parallelization determines the loops that are good work-sharing candidates, performs the data-flow analysis to verify correct parallel execution, and partitions the data for threaded code generation as is needed in programming with OpenMP directives. The OpenMP and auto-parallelization applications provide the performance gains from shared memory on multiprocessor systems and IA-32 processors with Hyper-Threading Technology.

Auto-vectorization detects low-level operations in the program that can be done in parallel, and then converts the sequential program to process 2, 4, 8, or up to 16 elements in one operation, depending on the data type. In some cases auto-parallelization and auto-vectorization can be combined to enhance performance. For example, TLP can sometimes be exploited in the outermost loop, while ILP can be exploited in the innermost loop.

Auto-vectorization can help increase the performance of an application that runs on systems based on Intel Pentium, Pentium with MMX Technology, Pentium II, Pentium III, and Pentium 4 processors.

Choosing effective options enables programmers to increase the performance of their application with minimal effort and use compiler features to accelerate the development of multi-threaded programs. Additionally, with the relatively small effort of adding OpenMP directives to their code, programmers can transform a sequential program into a parallel program.

Parallelism	Description
Explicit	▪ Implements OpenMP* (TLP) parallelization ▪ Programmed by the developer ▪ Supported on Intel® IA-32 or Itanium® architecture–based multiprocessor systems and IA-32 Intel® Hyper-Threading Technology–enabled systems
Implicit	▪ Implements auto-parallelization (TLP) of outermost loops and auto-vectorization (ILP) of innermost loops ▪ Generated by the compiler and by developer-supplied hints ▪ Auto-parallelization supported on IA-32 or Itanium-based multiprocessor systems and IA-32 Hyper-Threading Technology–enabled systems ▪ Auto-vectorization supported on Intel® Pentium®, Pentium with MMX™ Technology, Pentium II, Pentium III, and Pentium 4 processors

Figure 1. Comparison of explicit and implicit parallelism

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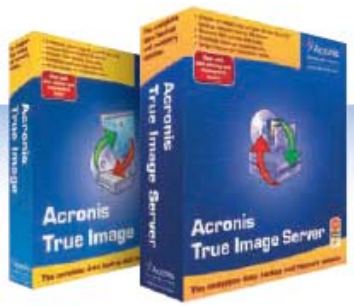

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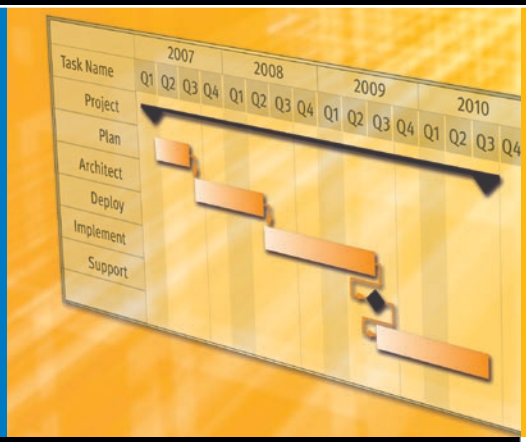

Streamlining Technology Management to Increase Workplace Productivity

BY MATT TREVORROW

Today's global business environment calls for complex, widely distributed technologies to drive a highly mobile workforce. Together, EDS and Dell look to deliver a comprehensive suite of life cycle services that support enterprise technology—from personalized configurations for far-flung end-user devices all the way to the enterprise data center.

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Gone are the days when most employees work from an assigned desk in a centralized location. To remain competitive, enterprises must find ways to cost-effectively manage customized technology provisioning and support for employees who routinely work from home or out in the field—and are often scattered around the globe. To stay productive, employees must have secure, reliable access to the enterprise network regardless of when and where they work.

Given mounting complexity in technology management and support requirements, many IT organizations are reaching their limit as they struggle to maintain service-level agreements. The example scenario in Figure 1 shows how various endpoints—including desktops, notebooks, and handheld devices—typically access a personalized workplace over a wide range of connectivity options. At the same time, enterprise data and applications are also continuing to increase in complexity and scope.

In addition, managing complex workplace technologies can be costly and time-consuming. For example, provisioning an end-user device such as a desktop or notebook computer requires that an organization not only purchase the device, but also configure it with the applications and network connectivity appropriate for the individual user. Administrators must then deploy the device to the user and migrate any preexisting user data to the new device. Finally, administrators must monitor and manage the health of the device throughout its lifetime, regardless of where it is deployed.

To help organizations improve cost efficiencies, EDS and Dell are working together to simplify technology management while taking advantage of emerging opportunities to refine and optimize current service offerings (see the "Intel vPro: Innovative model for desktop manageability and security" sidebar in this article). In particular, EDS and Dell have combined the extensive process and workplace infrastructure services expertise of EDS (see Figure 2) with the product and manufacturing technology of Dell. This initiative offers organizations best-in-class, custom-configured workplace technology delivered and managed with outstanding efficiency and effectiveness—enabling organizations to improve workplace productivity and reduce technology platform risk.

Delivering comprehensive life cycle management for end-user devices

Currently, the EDS and Dell relationship focuses primarily on streamlining the management of end-user devices, such as desktop and notebook computers. In particular, EDS and Dell offer a set of innovative services designed to increase the efficiency of end-user device management by reducing the time and effort required to complete management tasks at every stage of the device life cycle. These services include

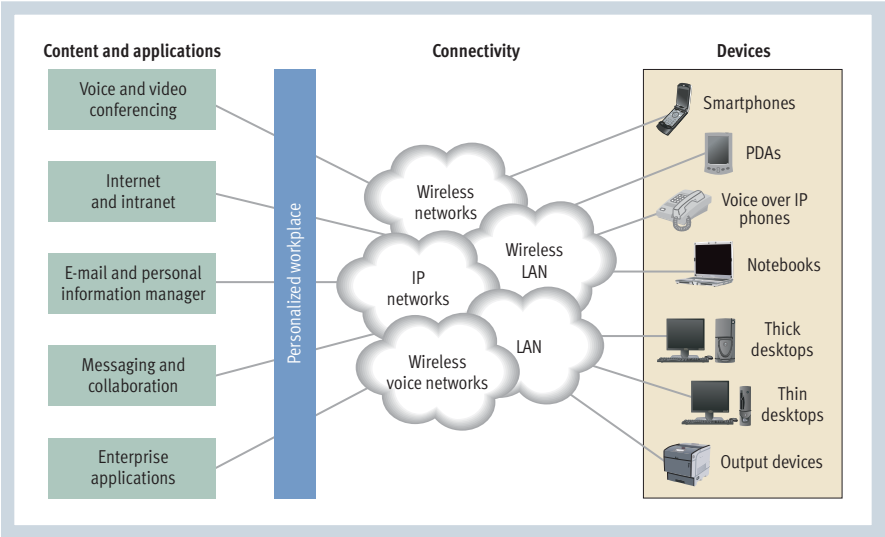

Figure 1. *Example personalized workplace spanning diverse applications, connectivity options, and device technologies*

custom-configured portals for procurement, factory-installed configuration, automated deployment, and integrated support systems.

Custom-configured portals for procurement. To make it easy for organizations to procure equipment, EDS and Dell have developed customized, client-specific Web portals that allow organizations to purchase products on an as-needed basis quickly and efficiently. To achieve this, the EDS team works with an organization to determine what products, configurations, and pricing are approved for different user profiles. Then, EDS and Dell create a custom Web portal that allows employees to purchase only those product configurations that have been preapproved by the organization. Once a product is purchased, the order goes directly to Dell manufacturing and is fulfilled automatically.

Factory-installed configuration. To simplify the configuration and imaging of new devices, EDS and Dell also offer custom factory-installed configurations, so organizations do not have to spend valuable IT time and resources manually configuring and imaging new devices. In particular, EDS works with an organization in advance to design a standard set of images appropriate for its user community. When a device is purchased, Dell preloads the appropriate image on to the device at the factory based on the role of the target user. In addition, Dell can include other customer-specific items such as preconfigured peripherals, welcome letters, T-shirts, and work manuals with the device (see the "Enterprise scenario: Personalized technology delivery" sidebar in this article).

Automated deployment. To help ensure that new devices are deployed quickly and appropriately, EDS takes advantage of Dell manufacturing data to automate the management of new devices. For example, once a new device has been configured and imaged and is ready to ship, Dell automatically sends a new device "birthing record" to EDS. This birthing record then automatically launches a set of EDS work orders to help avoid delays in deployment—for example, to pick up the device when it arrives, deliver it to the end user, and schedule a field technician if necessary to complete the transfer of user data.

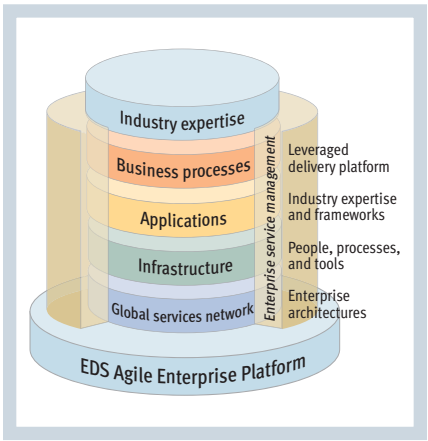

Figure 2. *EDS infrastructure services for the workplace*

Integrated support systems. To streamline the ongoing management of devices once they are deployed, EDS and Dell have also integrated their support and trouble-ticket systems, helping ensure that problems are diagnosed, routed to the appropriate organization, and resolved as quickly as possible. For example, if a problem with a device is identified as a warranty issue, the EDS service system is designed to automatically generate a trouble ticket in the Dell ticket system. Dell can then handle the problem directly, eliminating the need for time-consuming intermediary steps.

Benefiting from streamlined technology management

Leveraging EDS process and workplace infrastructure services expertise together with Dell product and manufacturing technology can help organizations dramatically improve the efficiency of managing enterprise workplace

Intel vPro: Innovative model for manageability and security

By leveraging Intel® vPro™ processor technology available in Dell™ desktop and mobile systems, EDS Workplace Services can help improve the security and facilitate the management of computers across the enterprise. Intel vPro technology enables management capabilities to be built directly into client systems, allowing administrators to remotely perform inventory, security, management, and update tasks even when a system is powered down or disabled.

Dell offers Intel vPro technology in Dell OptiPlex™ and Latitude™ families. This capability allows administrators to monitor, manage, and secure enterprise clients without the need for desk-side visits—helping lower total cost of ownership and increase productivity.

For more information, visit www.dell.com/optiplex or www.dell.com/latitude.

ENTERPRISE SCENARIO: PERSONALIZED TECHNOLOGY DELIVERY

EDS and Dell enable organizations not only to simplify management, but also to deliver personalized technology to end users quickly and cost-effectively—wherever they may be (see Figure A):

1. **Place order:** Individual orders are placed through a customized Web portal that is specifically designed to offer only preconfigured and preapproved products and services.
2. **Transmit order:** When complete, each order is transmitted automatically to the Dell factory.
3. **Route order:** At the factory, a set of work orders for the products and services is automatically triggered across a broad range of suppliers that maintain inventories at the Dell assembly center.
4. **Assemble custom configuration:** Once a specific order is scheduled for assembly, the Dell factory creates a custom image on the end-user device; configures the device with tested, organization-specific peripherals; and bundles the completed order into one carton along with a manual, personal instructions, and other organization- and user-specific items.
5. **Ship package:** Finally, the personalized technology order is drop shipped to the individual straight from the factory.

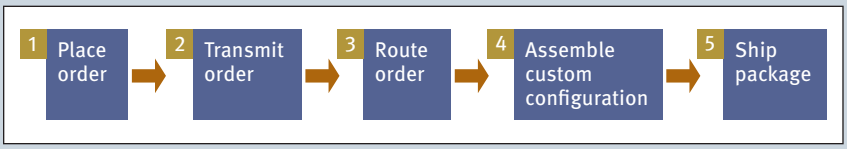

Figure A. *Personalized technology delivery from EDS and Dell*

technologies. This approach enables the following benefits:

- **Enhanced flexibility:** Custom-designed products and services give organizations the flexibility to tailor technology solutions to meet their specific needs. Furthermore, EDS and Dell can rapidly modify or augment custom product and service offerings, allowing organizations to rapidly adapt their technology infrastructures in response to changing business conditions.
- **Minimized technology risk:** EDS and Dell combine the extensive process and workplace infrastructure services expertise of EDS with industry-leading, standards-based technology from Dell to offer organizations best-in-class, low-risk workplace technology.
- **Increased productivity:** By streamlining technology management tasks such as procurement, configuration, deployment, and support, EDS and Dell help reduce administrative burdens, freeing IT staff to focus on strategic initiatives instead of day-to-day technology management. Furthermore, by minimizing end-user downtime through automated deployment and rapid problem resolution, EDS and Dell enable organizations to improve workplace productivity.
- **Low total cost of ownership:** The EDS and Dell relationship helps organizations lower total cost of ownership throughout the technology life cycle. For example, custom, on-demand procurement helps ensure that organizations buy only what they need, when they need it—avoiding expensive warehousing costs and unnecessary technology purchases. Also, custom factory integration services, direct shipment, and automated deployment help reduce IT staffing and equipment requirements, helping organizations lower IT costs and accelerate time to delivery. Furthermore, EDS and Dell solutions are based on cost-effective, industry-standard technology.

Extending technology management services into the data center

In addition to offering life cycle services for end-user devices, EDS and Dell are working toward offering a similar set of life cycle services for data center assets such as servers, storage devices, and printers. Although EDS and Dell plan for many of the services—such as customized, portal-based procurement and factory-installed configuration—to be the same for data centers as for end-user devices, data center assets also have unique needs that the two technology leaders plan to address. For example, EDS and Dell are working together to architect server images for standardized functions such as running Microsoft® Exchange or Microsoft Office SharePoint® software.

The relationship between EDS and Dell offers organizations best-in-class, personalized workplace solutions designed to improve cost efficiencies, increase workplace productivity, and lower total cost of ownership—enabling organizations to focus on their core competencies while using world-class technology to drive enterprise development to best competitive advantage.

Matt Trevorrow *is vice president of the EDS Infrastructure Service Line, Workplace Services.*

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