Deploying Dell iSCSI Storage with VMware Infrastructure 3

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.

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.

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 article 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 disk 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 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.

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

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*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 16 GB, 15,000 rpm SAS drives; the CX3-20c and CX3-40c include EMC Navisphere Departmental edition and five 146 GB, 10,000 rpm SAS drives, and the AX150i includes EMC Navisphere Express, one storage processor, and three 310 GB, 7,200 rpm SATA II drives.

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iSCSI and VMware Infrastructure 3

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

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,
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.

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 166 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 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

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1 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.

**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.

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![Figure 7. Orders per minute by number of driver threads for each iSCSI storage array in the test environment](image-url)