Managing traditional enterprise desktops has become increasingly difficult and costly, presenting challenges such as supporting rising numbers of remote and mobile users, controlling support and maintenance costs, performing time-consuming software management, and meeting stringent requirements for availability, stability, performance, and security. To help overcome these challenges, organizations are constantly looking for solutions that can provide a simplified, cost-effective approach to desktop management.

Given the success of server virtualization in supporting consolidation, helping simplify management, and helping reduce operating costs, organizations are beginning to look for ways to achieve similar benefits in desktop environments. VMware View—which includes VMware Virtual Desktop Infrastructure (VDI)—offers an end-to-end solution that enables organizations to provide end users with access to virtual desktops hosted in a central data center. This solution enables administrators to take advantage of the VMware Infrastructure 3 virtualization platform along with an enterprise-class desktop manager and connection broker to enhance manageability and control while still delivering a familiar desktop experience to end users. Virtual machine (VM) hardware independence, encapsulation, and isolation, combined with features such as VMware vMotion™ technology, VMware High Availability (VMware HA), VMware Distributed Resource Scheduler (VMware DRS), and VMware Consolidated Backup (VCB), help make virtual desktops substantially more agile than traditional physical desktop configurations.1

To help organizations implement this technology in their own environments, VMware and Dell have created a scalable reference design using a building-block approach based on VMware Infrastructure 3, Dell PowerEdge 2950 servers, and Dell EqualLogic PS5000XV Internet SCSI (iSCSI) storage area network (SAN) arrays. The building-block configuration has been designed, sized, and tested based on VMware and Dell best practices to support up to 64 virtual desktops, each handling a workload representative of a user running a common set of business applications. Organizations can use this architecture to help design and fine-tune a deployment that can meet the specific needs of their environments. By doing so, they can create a flexible, scalable environment that extends powerful VMware Infrastructure 3 capabilities such as business continuity and disaster recovery to the end users.


DESIGNING A SCALABLE ARCHITECTURE FOR VMWARE VIRTUAL DESKTOP INFRASTRUCTURE

By David Korsunsky
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desktop, streamlines desktop management, and increases administrator control while helping reduce ongoing operational costs.

**VMWARE VIEW REFERENCE SOLUTION**

Each building block of the reference architecture is designed to support up to 64 virtual desktops per VMware ESX host (8 per core) running a workload profile commonly referred to as a knowledge worker or information worker. This profile, based on VMware research on the most common type of desktop worker, is well suited to desktop virtualization. Specifically, the reference architecture was designed and tested with seven typical enterprise applications: Microsoft® Word, Microsoft Excel®, Microsoft PowerPoint®, Microsoft Internet Explorer®, Adobe® Acrobat, WinZip, and McAfee VirusScan software.

Figure 1 shows the building-block design for the target worker profile. The overall reference solution comprises four primary layers, each building on the layer below to provide a comprehensive platform for VMware View deployment in midsize enterprises.

**Layer 1: VMware Infrastructure 3**

VMware Infrastructure 3 provides the foundation of the reference architecture, abstracting processor, memory, storage, and networking resources into virtualized components that can support multiple VMs while also providing enhanced manageability, increased availability, simplified disaster recovery, and rapid provisioning and allocation of desktop and storage resources. In the reference architecture, this layer incorporates VMware ESX 3.5 Update 2 running on the Dell PowerEdge 2950 server as well as VMware vCenter Server (formerly VMware VirtualCenter) 2.5 software running on a Dell PowerEdge 1850 management server.

This layer can also include the VMware vMotion, VMware HA, VMware DRS, and VCB features. vMotion enables the live migration of VMs from one physical server to another without affecting running applications. VMware HA clusters are designed to provide continuous service availability during both planned and unplanned system downtime, while VMware DRS helps dynamically load balance VMs across the entire pool of available resources. VCB provides centralized, cost-effective backup to help efficiently protect VMs.

**Layer 2: Dell EqualLogic PS5000XV iSCSI SAN array**

iSCSI arrays are well suited for use with VMware View, offering cost-effective, high-performance storage for the virtualized environment. The Dell EqualLogic PS5000XV array is designed to provide a high-performance iSCSI SAN based on fully redundant, hot-swappable, enterprise-class hardware. Built-in EqualLogic PS Series software functionality includes automatic load balancing, snapshots and replication, multipath I/O, consistency sets, and more at no additional cost.

The EqualLogic PS5000XV array used in the reference architecture is configured with EqualLogic PS Series firmware version 3.2.4 and sixteen 146 GB, 15,000 rpm Serial Attached SCSI (SAS) drives in a RAID-50 configuration with two hot-spare drives. Two 410 GB data volumes are provisioned on the array, each formatted as a VMware Virtual Machine File System (VMFS) volume and supporting 32 virtual desktops. To take advantage of advanced EqualLogic volume virtualization, the data volumes are distributed across all active drives and RAID sets in the array.

VMware ESX provides the software iSCSI initiator. The storage sizing was based on the use of full clones, with each virtual desktop having its own persistent virtual disk. Although this configuration provides a good starting point, organizations should take into account the needs of their specific environments before choosing a storage array, including the following criteria:

- **Performance:** Estimate performance requirements by collecting disk performance statistics on an end-user system during normal operation.
- **Capacity:** Estimate capacity requirements by determining the size of the hard drive to be allocated to each virtual desktop.
- **Drive type:** Choose an appropriate drive type based on performance, capacity, and interface requirements.
- **RAID level:** Choose an appropriate RAID level based on workload characteristics and how the application performs I/O.
**iSCSI initiator:** Choose an appropriate hardware or software iSCSI initiator.

The basic reference configuration is designed for simple sizing and deployment, but can result in increased costs as it scales up with additional building blocks. To help reduce storage costs as the solution scales up, organizations can take advantage of two additional options: EqualLogic PS Series snapshots and VMware View Composer.²

EqualLogic storage arrays include the ability to take one or more snapshots of a VMFS volume and provide these snapshots to VMware ESX as new writable data stores. This approach helps reduce storage requirements because virtual desktops share the desktop images hosted on the originating data volume, thus consuming additional storage only when new data is written by an individual virtual desktop.

VMware View Composer, a new component of VMware View, uses VMware linked clone technology to rapidly create desktop images that share virtual disks with a master image. User data and settings are separated from the desktop image, so they can be administered independently. Administrators can patch or update desktops that are linked to a master image simply by updating the master image, without affecting user settings, data, or applications. This feature helps reduce storage needs and costs while simplifying desktop management.

Administrators should deploy these options carefully, because they can potentially affect performance by increasing the load on a limited set of shared storage resources. A classic storage-sizing trade-off exists between optimizing cost and capacity and optimizing performance. The performance requirements as defined by the target workload for the reference solution indicate that the aggregate I/O workload for this type of environment is nontrivial and characterized by bursts of activity, requiring storage sizing to take into account both cost and I/Os per second (IOPS).

**Layer 3: Dell PowerEdge 2950 server**

Dell PowerEdge servers are designed to provide a simplified, cost-effective, high-performance platform for enterprise data centers, and can easily integrate with VMware Infrastructure 3. The Dell PowerEdge 2950 server used in the reference architecture is configured with two quad-core Intel® Xeon® processors at 2.67 GHz, 32 GB of RAM, and VMware ESX 3.5 Update 2, along with two Gigabit Ethernet network interface cards (NICs) for the VM network and two Gigabit Ethernet NICs for the iSCSI SAN. This configuration helps provide a good balance between overall server hardware cost and sufficient performance to support the 64 virtual desktops. As with the storage layer, organizations should take into account the needs of their specific environments before choosing a server, including the following criteria:

- **Cost per VM:** Choose a server that provides an appropriate balance between overall cost and the number of VMs it can run in a production environment.
- **Number of ESX servers:** Balance cost per VM with the number of ESX servers. Very large deployments may favor servers with increased processor and memory resources to support more VMs per ESX server, thereby requiring fewer ESX servers to manage.
- **ESX license costs:** Choose a server that provides an appropriate balance between license costs and performance; two-socket servers with quad-core processors are typically appropriate for VMware View environments.
- **PCI slots:** Ensure the server has a sufficient number of PCI slots for network and storage connectivity to provide both high availability and resiliency.
- **vMotion compatibility:** Ensure that all ESX hosts in the VMware View environment have compatible processors for vMotion, especially if the hosts will be part of an existing ESX cluster.

**Layer 4: VMware View Manager and clients**

The final layer in the reference solution is VMware View Manager and the client systems. VMware View Manager is an enterprise-class desktop management platform designed to securely connect end users.
users to virtual desktops in the data center, and includes a simplified Web browser-based interface to manage VMware View environments. It uses existing Microsoft Active Directory® infrastructures for authentication and user management, and integrates with VMware vCenter Server to manage virtual desktops on VMware ESX.

VMware View Manager includes the following primary components (see Figure 2):

- **View Client**: Locally installed application that communicates with View Connection Server to allow users to connect to their desktops using Remote Desktop Protocol (RDP)
- **View Portal**: Web browser–based version of View Client supported by multiple operating systems and browsers
- **View Administrator**: Web browser-based application that serves as the primary mechanism for configuring View Connection Server and managing users and desktops
- **View Connection Server**: Software that acts as a connection broker and provides management and user authentication for virtual desktops
- **View Agent**: Software that installs on virtual desktops and enables features such as RDP connection monitoring, remote USB support, and single sign-on

Each virtual desktop in the reference architecture is configured with one virtual processor, 512 MB of RAM, and 10 GB of disk space, and runs the Microsoft Windows® XP Professional OS with Service Pack 2, Microsoft Office 2003 suite, and VMware View Agent software.

**TEST ENVIRONMENT AND PERFORMANCE**

In November 2008, VMware carried out performance testing on the reference solution using the VMware View Performance test software along with VMware vCenter Server, esxtop, and the Dell EqualLogic performance monitoring tool. Figure 3 shows the test environment.

Figure 4 shows the VMware ESX memory utilization as measured by the esxtop tool when running 64 virtual desktops on a single Dell PowerEdge 2950 server. Actual memory usage and page sharing increased and decreased slightly during the four-hour test run as the virtual desktops opened and closed common applications, with utilization averaging approximately 19 GB. As the test progressed, additional common pages were found in memory for all the virtual desktops, enabling the server to reclaim approximately 13 GB of memory over the course of the test and helping demonstrate the efficient memory usage of the test environment.

Figures 5 and 6 show the storage IOPS and throughput measured by the EqualLogic performance monitoring tool on the EqualLogic PS5000XV array when running 64 virtual desktops. Performance averaged approximately 185 IOPS over the course of the test run, with a peak of approximately 650 IOPS; throughput averaged approximately 3,530 KB/sec, with a peak at 13,733 KB/sec. One of the advantages of the EqualLogic array is that the VMFS data store volumes are virtualized—that is, striped across all drives in the array—thus distributing the aggregate workload across the available storage resources. This approach enables...
organizations to add performance capacity simply by expanding the SAN with an additional storage array, which can be seamlessly added to the EqualLogic group. The EqualLogic storage can then automatically redistribute the data volume and disk I/O across the additional controller, network ports, memory cache, and disk spindles.

**DEPLOYMENT AND SCALING**

Designing and testing a server and storage building block for a typical worker profile enables organizations to use the VMware View reference configuration as a basis for their own deployments. Ideally, administrators should deploy the first building block as a proof-of-concept test with a group of pilot end users. This approach provides an opportunity to establish baseline performance measurements on the system to help ensure that the sizing estimates are in line with actual production use.

As organizations scale the environment and deploy additional building blocks, they should keep the following design considerations in mind:

- **VMware configuration maximums:** Always check the latest VMware configuration maximums before scaling up a deployment, particularly in large environments.
- **VMware ESX cluster design:** Determine whether the ESX hosts running the virtual desktop environment will form their own ESX cluster or be part of an existing ESX cluster containing other server workloads.
- **VMware vCenter Server instances:** Consider whether the virtual desktops will be managed by their own dedicated vCenter Server instance or by an existing vCenter Server instance that may already be managing other non-VMware View deployments.

**COMPREHENSIVE SOLUTION FOR DESKTOP VIRTUALIZATION**

Organizations today must support a wide variety of users on a range of equipment—including local, mobile, and remote users accessing sensitive information assets across desktops, laptops, and unmanaged PCs—making it difficult to support end users in a consistent and secure manner. By combining the advantages of VMware Infrastructure 3 and cost-effective, high-performance Dell servers and storage, the reference solution described in this article provides a robust basis for virtual desktop environments, one that can help both control ongoing costs and easily scale as business needs grow.

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**Figure 5.** Storage performance on a Dell EqualLogic PS5000XV array supporting 64 virtual desktops

**Figure 6.** Storage throughput on a Dell EqualLogic PS5000XV array supporting 64 virtual desktops