VMware® Horizon View™
Large-Scale Reference Architecture

REFERENCE ARCHITECTURE
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Executive Summary

This reference architecture is based on real-world test scenarios, user workloads, and infrastructure system configurations. It uses the VCE Vblock Specialized System for Extreme Applications, composed of Cisco UCS server blades and EMC XtremIO flash storage, to support a 7,000-user VMware® Horizon View™ 5.2 deployment.

Extensive user-experience and operations testing, including Login VSI desktop performance benchmark testing on over 80,000 desktops, revealed world-class operational performance. A simple design architecture and efficient use of storage preserved ease of use at an attractive price point. The results are summarized here and further described later in this paper.

### Outstanding Desktop Performance
- Desktops exhibited performance characteristics similar to Ultrabook and high-end physical PCs
- Excellent user-experience characteristics even with diverse use cases and burst-heavy workloads

### Simple Architecture
- Desktops and associated management servers deployed on a single shared storage platform
- Efficient use of storage capacity through built-in SAN overprovisioning and inline deduplication

### Extremely Fast Desktop Operations
- User desktop pools provisioned quickly
- Enterprise use cases up and running the same day as requested
- New desktops, applications, and hot fixes rolled out within a single maintenance window

<table>
<thead>
<tr>
<th>1 Hour 15 Minutes</th>
<th>1,000 Linked Clones Deployed</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Hour 45 Minutes</td>
<td>1,000 Linked Clones Recomposed</td>
</tr>
<tr>
<td>15 Minutes</td>
<td>1,000 Linked Clones Start-Up</td>
</tr>
<tr>
<td>6,432</td>
<td>Login VSI Max - 7,000 Active Sessions - Represents 100% Session Concurrency</td>
</tr>
<tr>
<td>0.9 ms</td>
<td>Front-End Datastore Latency</td>
</tr>
<tr>
<td>3.5 TB</td>
<td>Total Storage Footprint</td>
</tr>
</tbody>
</table>

Figure 1: Highlights
Overview

All VMware Horizon View desktops were hosted on the VCE Vblock Specialized System for Extreme Applications, which incorporates Cisco UCS server blades and EMC XtremIO flash-based arrays to ensure the performance and responsiveness needed to support massively scalable solutions.

VCE Vblock Specialized System for Extreme Applications

This Vblock System is specifically designed for solutions such as virtual desktop infrastructure (VDI). Currently targeted for general availability in the fourth quarter of 2013, it enables a lower price per desktop, rich user experience, flexible VDI deployment, and simplified administration.

It consists of a dedicated 6-chassis, 48-blade UCS blade environment. Infrastructure and management servers are isolated on four Cisco UCS C220 rack-mount servers, with storage for all virtual desktops and infrastructure servers hosted on the same EMC X-Brick storage (two X-Bricks) environment. User data and Horizon View persona data are directed to Isilon S-series NAS.

Adding an EMC Isilon for user data provides a simple, low-cost, file-based solution with good scale-out design. Putting user data in Isilon NAS and virtual desktops on XtremIO SAN increases desktop footprint capacity and value per desktop, and it also improves user experience by separating storage I/O workloads and directing them to different storage platforms. The configuration has the ability to grow in a linear fashion along with the environment.

Note: Testing was performed on a pre-release version of the Vblock Specialized System for Extreme Applications. Contact VCE directly for availability.

Figure 2: Infrastructure Overview
VMware Horizon View

VMware Horizon View provides unified access to virtual desktops and applications that run in a secure, centralized datacenter and are accessible from a wide variety of devices. Horizon View allows IT to manage desktops, applications, and data centrally while increasing flexibility and customization at the endpoint for the user. It enables levels of availability and agility of desktop services unmatched by traditional PCs at about half the total cost of ownership (TCO) per desktop.

Unlike other desktop virtualization products, Horizon View is a tightly integrated, end-to-end solution built on the industry-leading virtualization platform, VMware vSphere®. Horizon View allows customers to extend business continuity and disaster recovery features to their desktops and to standardize on a common platform, from the desktop through the datacenter to the cloud.

Storage Components

The VCE Vblock Specialized System for Extreme Applications uses EMC XtremIO storage arrays as primary storage for Horizon View virtual desktops and EMC Isilon NAS to store user data and Horizon View persona data.

EMC XtremIO

XtremIO is a highly scalable, all-flash storage array that combines multi-level cell (MLC) flash with sophisticated wear leveling, data reduction, and write abatement technology to deliver extended flash endurance that makes the system both enterprise-reliable and reasonably priced.

The smallest unit of an XtremIO system is an X-Brick, and additional uniformly sized X-Bricks can be added for scalability in an XtremIO design. A simple user interface reduces the time required to design and provision storage. Enterprise resiliency is delivered through Fibre Channel connectivity, flash-specific dual-parity data protection, and storage presentation over the iSCSI protocol.

EMC Isilon NAS

This reference architecture leverages an EMC Isilon as an optional add-on scale-out NAS component to the Vblock System. Isilon delivers increased performance for file-based data applications and workflows from a single file system. It can reduce, or even eliminate, the need to overprovision storage capacity or performance. As an additional component, EMC Isilon is sold separately.

Compute and Networking Components

The VCE Vblock Specialized System for Extreme Applications uses Cisco UCS blade enclosures, interconnects, and blade servers.

The Cisco UCS datacenter platform combines x86-architecture blade and rack servers with networking and storage access into a single system. Innovations in the platform include a standards-based, unified network fabric, Cisco Virtual Interface Card (VIC), and Cisco UCS Extended Memory Technology. A wire-once architecture with a self-aware, self-integrating, intelligent infrastructure eliminates the need for manual assembly of components into systems.

Cisco UCS B-Series two-socket blade servers deliver record-setting performance to a wide range of workloads. Based on Intel Xeon processor E7 and E5 product families, these servers are designed for virtualized applications and reduce CapEx and OpEx through converged network fabrics and integrated systems management.

Workload Generation and Measurement

Login VSI is an industry-standard tool designed to measure the maximum capacity of VDI infrastructures by simulating unique user workloads. The simulated users work with the same applications as typical employees, such as Microsoft Word, Excel, Outlook, and Internet Explorer. The results of several testing measurements are compiled in a metric known as VSI Max, which quantifies the maximum capacity of VDI workloads running on a given infrastructure while delivering an acceptable user experience.
Test Results

Test results are summarized in the following sections. For further details, see Appendixes A through C.

Login VSI

We used the Login VSI workload-generation and measurement tool to generate and measure rigorous, realistic desktop workloads. Of the several types of Login VSI tests, two produced the most revealing findings.

**VSI\text{max} and Horizon View Session Concurrency**

In Test 1 (7,000 desktops, 100 percent concurrency), examination of both sets of test results shows a VSI\text{max} of 6,432. At this level of session concurrency, host CPU resources are pushed to the point of CPU saturation, and user experience starts to break down. This is not a viable, sustained level of CPU utilization because little CPU headroom is available for burst capability or failover. The sustained upper CPU utilization threshold for most production implementations is 85 percent. Sustained CPU utilization above 85 percent ordinarily causes a high CPU usage alarm in VMware vSphere.

Test 2 (7,000 desktops, 80 percent concurrency) showed much better host CPU resource utilization. All 5,600 sessions demonstrated excellent performance, and host CPU resources remained under 85 percent. All 7,000 desktops were powered on and available while the Login VSI workload ran on 80 percent of the available desktops. Typical production VDI environments exhibit concurrent desktop usage of 80 percent of total available capacity.

**Login VSI Test 1: 7,000-Seat Test with 100 Percent Session Concurrency**

Highlights of Test 1 include:

- Desktop access using the PCoIP protocol and Medium Workload (with Flash enabled by default)
- Login VSI VSI\text{max} of 6,432
- Mixed host performance (CPU saturated but memory usage under 50 percent)
- Excellent desktop performance (all vDisk latency under 0.5ms for reads and writes)
- Peak of 65,000 IOPS on XtremIO Storage (75 percent writes, 25 percent reads)

![Login VSI Score – Test 1](image.png)
Figure 4: Desktop Performance – Test 1

Figure 5: Host Performance – Test 1

Figure 6: Storage Performance – Test 1
Login VSI Test 2: 7,000-Seat Test with 80 Percent Session Concurrency

Highlights of Test 2 include:

• 5,600 active sessions, with remaining desktops powered on but not in use
• Testing using the PCoIP protocol and Medium Workload (with Flash enabled by default)
• Login VSI VSImax not reached
• Excellent host performance (CPU and memory usage under 85 percent, no contention)
• Excellent desktop performance (all vDisk latency under 0.5ms for reads and writes)
• Peak of 50,000 IOPS on XtremIO storage (75 percent writes, 25 percent reads)
Average Host Resource Utilization

Front End Network Throughput Capacity
Front End Storage Throughput Capacity
Memory Consumed
CPU Usage

Average Host Resource Utilization

Figure 9: Host Performance – Test 2

X-Brick Performance

IOPS ms

Figure 10: Storage Performance – Test 2

Timing Tests

Measured in the Horizon View Manager™ console, 1,000 desktops powered on in 15 minutes, and 7,000 desktops powered on in just over two hours.

Number of Desktops Ready in Horizon View

Figure 11: Desktop Startup Testing
Linked-Clone Desktop Pool Deployment
We observed fast consistent, and reliable desktop pool deployments even with background workload on the compute and shared storage environment. With 5,000 desktops deployed and powered on, measurement of a 1,000-desktop linked-clone pool deployment produced the following results:

![1,000-Seat Linked Clone Pool Deployment](image)

Figure 12: Pool Deployment Measurements

Linked-Clone Desktop Pool Recompose
We observed similarly fast, consistent, and reliable desktop pool recompose operations. With 5,000 desktops deployed and powered on, we measured a 1,000-desktop linked-clone pool recompose and observed the following results:

![1,000-Seat Linked Clone Pool Recompose](image)

Figure 13: Pool Recompose Measurements
Storage Capacity

The volume capacity configured and presented to vSphere totaled 59.9TB. The actual storage footprint for 7,000 desktops and infrastructure servers was approximately 6.24TB. Due to the efficiency of the XtremIO inline data reduction capability, desktop and server virtual machines occupied a physical storage footprint of only 3.5TB. This represents:

• Overall efficiency ratio: 24:1
• Deduplication ratio: 2.6:1
• vSphere Thin Provisioning savings: 89%

This massive savings in storage capacity is a clear representation of how the EMC XtremIO storage platform can drive down the storage footprint and associated costs in a medium- to large-scale VDI deployment.
System Configurations

The following sections describe in detail how the components of this reference architecture were configured.

vSphere Cluster Configurations

For desktop virtual machines, we deployed two vSphere clusters with 24 nodes (with N+2 HA readiness). For management and infrastructure virtual machines, we deployed a single four-node cluster (with N+1 HA readiness).

![Cluster Configurations](image)

Figure 15: Cluster Configurations

Networking Configurations

Each fabric interconnect has multiple ports reserved for 10GbE ports. These connections are formed into a port channel to the Cisco Nexus switch and carry IP traffic destined for the desktop network 10GbE links. In a unified storage configuration, this port channel can also carry IP traffic to the X-Blades within the storage layer.

The Cisco Nexus 5548UP switches in the network layer provide 10GbE IP connectivity between the infrastructure and the outside world. In unified storage architecture, the switches connect the fabric interconnects in the compute layer to the XtremIO X-Bricks in the storage layer.
In segregated architecture, the Cisco Nexus 5548UP series switches in the network layer provide Fibre Channel (FC) links between the Cisco fabric interconnects and the EMC XtreemIO storage array. These FC connections provide block-level devices to blades in the compute layer.

![Diagram of network infrastructure]

**Figure 16: Cisco Networking Infrastructure**

**IP Network Components**
To support the Ethernet and SAN requirements in the traditional segregated network architecture, two Cisco Nexus 5548UP switches provide both 10GbE Ethernet and Fibre Channel (FC) connectivity.

The Cisco Nexus 5548UP switches have 32 integrated, low-latency unified ports, each providing line-rate 10GB Ethernet or FC connectivity. The Cisco Nexus 5548UP switches each have one expansion slot that can be populated with a 16-port unified port expansion module.

**Storage Configurations**
We used EMC XtreemIO X-Bricks for linked-clone system disk storage, and we redirected user data and user persona to an EMC Isilon NAS storage appliance to validate this reference architecture. This approach mirrors a real-world implementation. Separating the storage workloads between system disks and user data and persona allows a VDI architect to match the unique characteristics of the separate workloads to the storage array best suited to accommodate them.

We used two X-Bricks for this testing. The two systems were connected by InfiniBand switches and yielded 14TB raw capacity and approximately 70TB usable capacity, assuming 5:1 deduplication efficiency.

The following components made up the dual X-Brick deployment:
- Two X-Brick disk array enclosures
- Four X-Brick controllers
- Two battery backup units
- Two InfiniBand switches
X-Brick Storage Configurations in vSphere

Modest setting changes are required in vSphere to support EMC X-Brick storage systems:

• Adjust the number of outstanding storage target commands to 256.
• Change the number of consecutive storage commands to 64.
• Change the HBA queue depth settings to 256 for each host’s HBAs.
• Change the native storage multipath policy in vSphere to Round Robin.

Note: See Appendix B (Test Methodology) for details on changing these settings.

Each 24-node cluster was zoned and masked to allow access to 24 2TB datastores and a single 500GB datastore for pool masters.

The four-node management and infrastructure cluster was zoned and masked to allow access to a single 2TB datastore.
vSphere Configurations

We deployed separate virtual datacenters, one for management and monitoring servers and one for hosted desktops. This is the standard, recommended configuration for most production Horizon View deployments.

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**Infrastructure and Management Servers**

We deployed two VMware vCenter Server™ instances, one for desktops and one for infrastructure and management servers, in conformance with Horizon View 5.2 architecture planning guidelines.

**Note:** As of Horizon View version 5.2, VMware supports managing up to 10,000 desktops with a single vCenter 5.2 server instance. This is a significant revision from prior versions.

All additional vCenter™ roles (inventory, SSO, vCenter) for the desktop vCenter were divested to separate servers to avoid any resource contention that might have resulted from combining roles on a busy vCenter Server.

All server resources were sized according to the current best practices from VMware. They are listed in the following table:

<table>
<thead>
<tr>
<th>SERVER ROLE</th>
<th>VCPU</th>
<th>RAM (GB)</th>
<th>STORAGE (GB)</th>
<th>OS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Domain Controller 1</td>
<td>2</td>
<td>4</td>
<td>40</td>
<td>Windows Server 2008 64-bit R2</td>
</tr>
<tr>
<td>Domain Controller 2</td>
<td>2</td>
<td>4</td>
<td>40</td>
<td>Windows Server 2008 64-bit R2</td>
</tr>
<tr>
<td>SQL Server 1</td>
<td>2</td>
<td>6</td>
<td>140</td>
<td>Windows Server 2008 64-bit R2</td>
</tr>
<tr>
<td>SERVER ROLE</td>
<td>VCPU</td>
<td>RAM (GB)</td>
<td>STORAGE (GB)</td>
<td>OS</td>
</tr>
<tr>
<td>------------------------------------------------</td>
<td>------</td>
<td>----------</td>
<td>--------------</td>
<td>-------------------------</td>
</tr>
<tr>
<td>SQL Server 2</td>
<td>2</td>
<td>6</td>
<td>140</td>
<td>Windows Server 2008 64-bit R2</td>
</tr>
<tr>
<td>Horizon View Composer™ Server</td>
<td>4</td>
<td>6</td>
<td>40</td>
<td>Windows Server 2008 64-bit R2</td>
</tr>
<tr>
<td>vCenter Server – Infrastructure</td>
<td>4</td>
<td>8</td>
<td>50</td>
<td>Windows Server 2008 64-bit R2</td>
</tr>
<tr>
<td>vCenter Server – Desktops</td>
<td>8</td>
<td>24</td>
<td>80</td>
<td>Windows Server 2008 64-bit R2</td>
</tr>
<tr>
<td>Horizon View Connection Server 1</td>
<td>4</td>
<td>10</td>
<td>60</td>
<td>Windows Server 2008 64-bit R2</td>
</tr>
<tr>
<td>Horizon View Connection Server 2</td>
<td>4</td>
<td>10</td>
<td>60</td>
<td>Windows Server 2008 64-bit R2</td>
</tr>
<tr>
<td>Horizon View Connection Server 3</td>
<td>4</td>
<td>10</td>
<td>60</td>
<td>Windows Server 2008 64-bit R2</td>
</tr>
<tr>
<td>Horizon View Connection Server 4</td>
<td>4</td>
<td>10</td>
<td>60</td>
<td>Windows Server 2008 64-bit R2</td>
</tr>
<tr>
<td>VMware vCenter Operations Manager™ for Horizon View Analytics Server</td>
<td>16</td>
<td>20</td>
<td>275</td>
<td>SLES 11 – 64-bit</td>
</tr>
<tr>
<td>VMware vCenter Operations Manager for Horizon View UI Server</td>
<td>8</td>
<td>12</td>
<td>145</td>
<td>SLES 11 – 64-bit</td>
</tr>
<tr>
<td>vCenter Log Insight</td>
<td>2</td>
<td>8</td>
<td>140</td>
<td>SLES 11 – 64-bit</td>
</tr>
<tr>
<td>DHCP Server 1</td>
<td>1</td>
<td>4</td>
<td>40</td>
<td>Windows Server 2008 64-bit R2</td>
</tr>
<tr>
<td>DHCP Server 2</td>
<td>1</td>
<td>4</td>
<td>40</td>
<td>Windows Server 2008 64-bit R2</td>
</tr>
<tr>
<td>vCenter Inventory Service – Desktops</td>
<td>4</td>
<td>8</td>
<td>55</td>
<td>Windows Server 2008 64-bit R2</td>
</tr>
<tr>
<td>vCenter SSO – Desktops</td>
<td>4</td>
<td>8</td>
<td>55</td>
<td>Windows Server 2008 64-bit R2</td>
</tr>
</tbody>
</table>

Table 1: Server Resource Sizing
**Horizon View Configuration**

The Horizon View installation included the following core systems:

- Four connection servers
- Dedicated vCenter with roles split to separate servers as follows:
  - vCenter
  - vCenter single sign-on (SSO)
  - vCenter Inventory Service
- View Composer running on a separate server from vCenter

![Horizon View Installation](image)

**Figure 20: Horizon View Installation**

**Note:** Security servers were not used during this testing.

**Basic Horizon View Settings**

The Horizon View global settings are summarized in Table 2.

<table>
<thead>
<tr>
<th>ATTRIBUTE</th>
<th>SPECIFICATION</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>GLOBAL POLICIES</strong></td>
<td></td>
</tr>
<tr>
<td>Multimedia redirection (MMR)</td>
<td>Allow</td>
</tr>
<tr>
<td>USB access</td>
<td>Allow</td>
</tr>
<tr>
<td>Remote mode</td>
<td>Allow</td>
</tr>
<tr>
<td>PCoIP hardware acceleration</td>
<td>Allow – medium priority</td>
</tr>
<tr>
<td><strong>GLOBAL SETTINGS</strong></td>
<td></td>
</tr>
<tr>
<td>Session timeout</td>
<td>600 (10 hours)</td>
</tr>
<tr>
<td>SSO</td>
<td>Always Enabled</td>
</tr>
<tr>
<td>ATTRIBUTE</td>
<td>SPECIFICATION</td>
</tr>
<tr>
<td>---------------------------------</td>
<td>---------------</td>
</tr>
<tr>
<td>View Administrator session timeout</td>
<td>120 minutes</td>
</tr>
<tr>
<td>Automatic status updates</td>
<td>Enabled</td>
</tr>
<tr>
<td>Pre-login message</td>
<td>None</td>
</tr>
<tr>
<td>Warning before forced logoff</td>
<td>None</td>
</tr>
</tbody>
</table>

**GLOBAL SECURITY SETTINGS**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Re-authenticate secure connections after network disrupt</td>
<td>Enabled</td>
</tr>
<tr>
<td>Message security mode</td>
<td>Enabled</td>
</tr>
<tr>
<td>Enable IPSec for Security Server pairing</td>
<td>Enabled</td>
</tr>
<tr>
<td>Disable SSO for Local Mode</td>
<td>Disabled</td>
</tr>
</tbody>
</table>

Table 2: Horizon View Settings

**Test Pool Configuration**

We deployed a total of eight linked-clone pools, as illustrated in Figure 21.

![Figure 21: Test Pool Deployment](image)
**Desktop Pool Configurations**

Linked-clone pool configurations conform to a typical knowledge worker profile, with the exception of the storage overcommit policy. The configurations are detailed in Table 3.

<table>
<thead>
<tr>
<th>ATTRIBUTE</th>
<th>SPECIFICATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pool type</td>
<td>Linked Clone</td>
</tr>
<tr>
<td>Persistence</td>
<td>Non Persistent</td>
</tr>
<tr>
<td>Pool ID</td>
<td>DesktopPool###</td>
</tr>
<tr>
<td>Display name</td>
<td>DesktopPool###</td>
</tr>
<tr>
<td>Folder ID</td>
<td>/</td>
</tr>
<tr>
<td>Separate datastores for replica and OS?</td>
<td>Not selected</td>
</tr>
<tr>
<td>State</td>
<td>Enabled</td>
</tr>
<tr>
<td>Connection Server restrictions</td>
<td>None</td>
</tr>
<tr>
<td>Remote desktop power policy</td>
<td>Take no power action</td>
</tr>
<tr>
<td>Auto logoff after disconnect</td>
<td>Never</td>
</tr>
<tr>
<td>User reset allowed</td>
<td>False</td>
</tr>
<tr>
<td>Multiple sessions per user allowed</td>
<td>False</td>
</tr>
<tr>
<td>Delete or refresh desktop on logoff</td>
<td>Never</td>
</tr>
<tr>
<td>Display protocol</td>
<td>PColP</td>
</tr>
<tr>
<td>Allow protocol override</td>
<td>False</td>
</tr>
<tr>
<td>Max number of monitors</td>
<td>2</td>
</tr>
<tr>
<td>Max resolution</td>
<td>1920 x 1200</td>
</tr>
<tr>
<td>HTML Access</td>
<td>Not selected</td>
</tr>
<tr>
<td>Flash quality level</td>
<td>Medium</td>
</tr>
<tr>
<td>Flash throttling level</td>
<td>Moderate</td>
</tr>
<tr>
<td>Enable provisioning</td>
<td>Yes</td>
</tr>
<tr>
<td>Stop provisioning on error</td>
<td>No</td>
</tr>
</tbody>
</table>
### Table 3: Desktop Pool Configurations

**Cluster to Datastore Assignments**

Each 1,000-seat pool was deployed across four datastores as summarized in Table 4.

<table>
<thead>
<tr>
<th>POOL NAME</th>
<th>DATASTORE NAME</th>
<th>DATASTORE SIZE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cluster1 - Pool1</td>
<td>Datastore 1</td>
<td>2TB</td>
</tr>
<tr>
<td>1,000 desktops</td>
<td>Datastore 2</td>
<td>2TB</td>
</tr>
<tr>
<td></td>
<td>Datastore 3</td>
<td>2TB</td>
</tr>
<tr>
<td></td>
<td>Datastore 4</td>
<td>2TB</td>
</tr>
<tr>
<td>Cluster1 - Pool2</td>
<td>Datastore 5</td>
<td>2TB</td>
</tr>
<tr>
<td>1,000 desktops</td>
<td>Datastore 6</td>
<td>2TB</td>
</tr>
<tr>
<td></td>
<td>Datastore 7</td>
<td>2TB</td>
</tr>
<tr>
<td></td>
<td>Datastore 8</td>
<td>2TB</td>
</tr>
<tr>
<td>Cluster1 - Pool3</td>
<td>Datastore 9</td>
<td>2TB</td>
</tr>
<tr>
<td>1,000 desktops</td>
<td>Datastore 10</td>
<td>2TB</td>
</tr>
<tr>
<td></td>
<td>Datastore 11</td>
<td>2TB</td>
</tr>
<tr>
<td></td>
<td>Datastore 12</td>
<td>2TB</td>
</tr>
<tr>
<td>Cluster1 - Pool4</td>
<td>Datastore 13</td>
<td>2TB</td>
</tr>
<tr>
<td>500 desktops</td>
<td>Datastore 14</td>
<td>2TB</td>
</tr>
</tbody>
</table>

* Storage overcommit policy must be set to Aggressive with any storage platform that has an inline deduplication or data-reduction capability.
<table>
<thead>
<tr>
<th>POOL NAME</th>
<th>DATASTORE NAME</th>
<th>DATASTORE SIZE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cluster2 – Pool1</td>
<td>Datastore 15</td>
<td>2TB</td>
</tr>
<tr>
<td>1,000 desktops</td>
<td>Datastore 16</td>
<td>2TB</td>
</tr>
<tr>
<td></td>
<td>Datastore 17</td>
<td>2TB</td>
</tr>
<tr>
<td></td>
<td>Datastore 18</td>
<td>2TB</td>
</tr>
<tr>
<td>Cluster2 – Pool2</td>
<td>Datastore 19</td>
<td>2TB</td>
</tr>
<tr>
<td>1,000 desktops</td>
<td>Datastore 20</td>
<td>2TB</td>
</tr>
<tr>
<td></td>
<td>Datastore 21</td>
<td>2TB</td>
</tr>
<tr>
<td></td>
<td>Datastore 22</td>
<td>2TB</td>
</tr>
<tr>
<td>Cluster2 – Pool3</td>
<td>Datastore 23</td>
<td>2TB</td>
</tr>
<tr>
<td>1,000 desktops</td>
<td>Datastore 24</td>
<td>2TB</td>
</tr>
<tr>
<td></td>
<td>Datastore 25</td>
<td>2TB</td>
</tr>
<tr>
<td></td>
<td>Datastore 26</td>
<td>2TB</td>
</tr>
<tr>
<td>Cluster2 – Pool4</td>
<td>Datastore 27</td>
<td>2TB</td>
</tr>
<tr>
<td>500 desktops</td>
<td>Datastore 28</td>
<td>2TB</td>
</tr>
</tbody>
</table>

Table 4: Cluster to Datastore Assignments
**Test Image Configuration**

We configured the virtual hardware of the master desktop virtual machine according to standard Login VSI specifications. It is important to note that in production deployments, virtual machine configurations vary based on individual use-case requirements.

<table>
<thead>
<tr>
<th>ATTRIBUTE</th>
<th>SPECIFICATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Desktop OS</td>
<td>Microsoft Windows 7, 64-bit</td>
</tr>
<tr>
<td>VMware virtual hardware</td>
<td>Version 9</td>
</tr>
<tr>
<td>VMware Tools version</td>
<td>9.221 (up to date)</td>
</tr>
<tr>
<td>Virtual CPU</td>
<td>1</td>
</tr>
<tr>
<td>Virtual memory</td>
<td>2048MB</td>
</tr>
<tr>
<td>OS pagefile</td>
<td>1.5GB starting and maximum</td>
</tr>
<tr>
<td>vNICs</td>
<td>1</td>
</tr>
<tr>
<td>Virtual network adapter 1</td>
<td>VMXNet3 Adapter</td>
</tr>
<tr>
<td>Virtual SCSI controller 0</td>
<td>LSI Logic SAS</td>
</tr>
<tr>
<td>Virtual Disk – VMDK</td>
<td>40GB</td>
</tr>
<tr>
<td>Virtual Floppy Drive 1</td>
<td>Removed</td>
</tr>
<tr>
<td>Virtual CD/DVD Drive 1</td>
<td>Removed</td>
</tr>
<tr>
<td>VMware Horizon View Agent</td>
<td>VMware Horizon View Agent 5.2 build 987719</td>
</tr>
</tbody>
</table>
| Installed applications (per Login VSI standards) | Microsoft Office 2010  
Adobe Acrobat Reader 10  
Adobe Flash Player 10  
Adobe Shockwave Player 10  
Bullzip PDF Printer  
FreeMind  
Kid-Key-Lock |

*Table 5: Test Image Configuration*

The master image used in this test environment underwent VDI optimization as defined in the VMware Horizon View Optimization Guide for Windows 7. VMware strongly recommends that the Windows image be optimized when master images are prepared for use with VMware Horizon View.
EMC XtremIO Storage Configurations

As we would with any shared storage array, we followed VMware and storage vendor best practices for integration with vSphere. Execute the following VMware ESXi™ parameter adjustments to properly configure ESXi to work with EMC XtremIO X-Bricks:

1. Connect to the VMware ESX® host via the vSphere Client (directly or through the vCenter Server).
2. Click the Host icon in the left pane and click Advanced Settings.
3. Click the Disk section.
4. Find the Disk.SchedNumReqOutstanding parameter and change it to the Max value (256).
5. Find the Disk.SchedQuantum parameter and change it to the Max value (64).
6. Click OK to apply the changes.

Figure 22: ESXi Parameter Adjustments
vStorage API for Array Integration (VAAI) Settings
VAAI is a vSphere API that lowers desktop provisioning time from hours down to minutes by performing vSphere operations such as virtual machine provisioning and cloning within an array that supports VAAI. The XtremIO storage system fully supports VAAI. VAAI is enabled by default in vSphere version 5.x. No further action is required for VAAI to be used with XtremIO storage.

HBA Queue Depth Adjustment
To adjust the queue depth, use the following steps:

1. Connect to ESX host shell as root.
2. Verify which HBA module is currently loaded by entering one of the following commands:
   - For Qlogic: `esxcli system module list | grep qla`
   - For Emulex: `esxcli system module list | grep lpfc`
   For example, from a host with a Qlogic HBA:
     
     ```
     # esxcli system module list | grep qla qla2xxx true true
     ```
3. To adjust the HBA queue depth, run one of these two commands:
   - For Qlogic:
     ```
     esxcli system module parameters set -p ql2xmaxqdepth=256 -m qla2xxx
     ```
   - For Emulex:
     ```
     esxcli system module parameters set -p lpfc0_lun_queue_depth=256 -m lpfc820
     ```
4. Reboot the ESX host.
5. Connect to the ESX host shell as root.
6. Run the following command to confirm the queue depth adjustment:
   ```
   # esxcli system module parameters list -m <driver>
   ```
   For example, from a host with a Qlogic HBA with queue depth set to 256:
   ```
   # esxcli system module parameters list -m qla2xxx | grep ql2maxqdepth
   ql2maxqdepth int 256 Maximum queue depth to report for target devices
   ```

For further information about adjusting HBA queue depth with ESX, refer to VMware Knowledge Base article 1267.
Native vSphere Storage Multipathing

XtremIO supports the native multipathing technology that is part of the VMware vSphere suite.

For the best performance, set the native Round Robin path selection policy on XtremIO volumes presented to ESXi to ensure optimal distribution and availability of load among I/O paths to the XtremIO storage.

Figure 23 illustrates how to modify the path selection policy from the default Fixed path selection policy to the Round Robin policy.

![Figure 23: Path Selection Policy](image)

**Conclusion**

When designing and estimating capacity for this VMware Horizon View large-scale reference architecture, we adhered closely to published VMware sizing and estimation standards. Design and deployment were straightforward, time-efficient, and trouble-free, yielding rapid pool deployment and recompose times that showed desktop maintenance was feasible, even during the middle of a production workday, and even with extensive background workloads running simultaneously. The combination of simplicity and performance is without peer in the industry, and it surprised even those of us on the reference architecture team—in spite of having expected these results up front!

Our test results demonstrate that it is possible to deliver an Ultrabook-quality user experience at scale for every desktop, with headroom for any desktop to burst to thousands of IOPS as required to drive user productivity, thanks to the EMC XtremIO storage platform, which provides considerably higher levels of application performance and lower virtual desktop costs than alternative platforms. The high performance and simplicity of the EMC XtremIO array and the value-added systems integration work provided by VCE as part of the Vblock design contributed significantly to the overall success of the project.
About the Authors

Tristan Todd is an EUC Architect in the VMware End-User Computing Technical Enablement Group. He has extensive customer, field, and lab experience with VMware End-User Computing and ecosystem products.

Shree Das is a Solutions Architect at VCE responsible for design and development of cloud and virtualization reference architectures on Vblock platforms. His areas of expertise include datacenter design, VDI, multi-tenancy, VMware vCloud Director, and IaaS.

Shridhar Deuskar is a Solutions Architect with EMC XtremIO. He has over 15 years of experience in the industry, including virtualization and storage technologies.

Dennis Geerlings is Support Manager and Lead Consultant at Login VSI. In these roles, he brings to customers and partners years of experience in enterprise desktop and VDI design and deployment. In addition, he is an active developer on the Login VSI engineering team.

Acknowledgments

This reference architecture is the result of collaboration between VMware, EMC, VCE, and Login VSI. VMware recognizes its partners’ generosity in providing equipment, time, and expertise, without which this project would not have been possible.

EMC is a global leader in enabling businesses and service providers to transform their operations and deliver information technology as a service (ITaaS). Fundamental to this transformation is cloud computing. Through innovative products and services, EMC accelerates the journey to cloud computing, helping IT departments to store, manage, protect and analyze their most valuable asset, information, in a more agile, trusted, and cost-efficient way. For more information, visit http://www.emc.com.

VCE, formed by Cisco and EMC with investments from VMware and Intel, accelerates the adoption of converged infrastructure and cloud-based computing models that dramatically reduce the cost of IT while improving time to market for its customers. Through the Vblock Specialized System for Extreme Applications, VCE delivers the industry’s only fully integrated and fully virtualized cloud infrastructure system. For more information, visit http://www.vce.com.

Login VSI is an international software company focused on helping both end users and vendors of virtual desktop infrastructures to design, build, implement, and protect the best performing hosted desktop infrastructures possible. For more information, visit http://www.loginvsi.com.
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Cisco UCS SmartPlay Configurations for VMware Desktop Workloads

VCE
VCE Vblock Specialized System for Extreme Applications Product Overview
VCE End User Computing Solutions Portal

Login VSI
Login VSI Technical Documentation
Login VSI Workload Overview
Login VSI Deployment Guide
Login VSI Operations Guide
Cisco Login VSI Performance Study for Horizon View
Appendix A (Login VSI Detailed Scoring Methodology)

The Login VSI Medium Workload (with Flash) is a common industry-standard benchmark for VDI and SBC testing. The test involves the following considerations:

- This workload simulates a medium knowledge workload using Office, Internet Explorer, and PDF.
- Once a session has been started, the medium workload repeats every 12 minutes.
- During each loop the response time is measured every two minutes.
- The medium workload opens up to five applications simultaneously.
- The type rate is 160ms for each character.
- Approximately two minutes of idle time is included to simulate real-world users.

Each Login VSI loop involves the following application operations:

- Internet Explorer – One instance is left open (BBC.co.uk), one instance is browsed to Wired.com and Lonelyplanet.com.
- Word 2007/2010 – One instance to measure response time; one instance to review and edit document.
- Bullzip PDF Printer and Adobe Acrobat Reader – The Word document is printed and reviewed to PDF.
- Excel 2007/2010 – A very large randomized sheet is opened.
- PowerPoint 2007/2010 – A presentation is reviewed and edited.
- 7Zip – Using the command line version, the output of the session is zipped.
Appendix B (Test Methodology)

This reference architecture used both deployment and recompose timing and Login VSI testing.

Deployment and Recompose Timing Tests

Deployment and recompose time measurements are often overlooked in Horizon View reference designs because they are considered infrequent events. Deploy and recompose times are critical beyond the initial setup for several reasons:

- Deployment and recompose events have a direct impact on the IT team’s agility and responsiveness. Consider the example of a large company that completes an acquisition and must roll out a corporate desktop and applications to all the newly acquired employees. Deployment times are directly correlated to the speed at which this can be accomplished.

- Linked-clone VDI images are recomposed and redeployed periodically to apply OS patches or application updates, which requires a maintenance window. The recompose operation must be completed, therefore, as rapidly as possible.

- Many customers employ a regular, automated recompose policy by setting desktops to Refresh on Logoff.

Note: All pool deployment and recompose timing tests in this reference architecture included not only the duration of the master image cloning process but virtual desktop customization, power on, domain registration, and View Agent registration. This is a more realistic test than simple creation of the image clones.

Login VSI Testing

Login Virtual Session Indexer (Login VSI) is the industry-standard benchmarking tool for measuring the performance and scalability of centralized desktop environments such as Virtual Desktop Infrastructure (VDI) and Server-Based Computing (SBC).

We used Login VSI to generate a reproducible, real-world test case that simulated the execution of various applications, including Microsoft Internet Explorer, Adobe Flash video, and Microsoft Office applications, to determine how many virtual desktop users, or sessions, each solution could support.

Login VSI was configured to run a medium workload against a Horizon View pool of virtual desktops, with the tests set up to log users in to virtual desktops incrementally every 30 seconds between session per physical host (blade).

Login VSI measured the total response time of all the applications from each session and calculated the VSI Index by taking the average response times and dropping the highest and lowest two percent.

The average response time of the first 15 sessions determined a baseline. As more sessions began to consume system resources, response time degraded, and the VSI index increased until it went above the VSI\text{max} (VSI\text{max} is baseline x 125\% + 3000ms). When this condition was met, the benchmark recorded a Login VSI\text{max}, which is the maximum number of sessions that the platform could support.

Once logged in, each session remained active for the duration of the test, and for at least 15 minutes. Not reaching VSI\text{max} is an indication of satisfactory user response at the predetermined user count.

During testing, Login VSI sessions were initiated by launchers (simulated user endpoints) that ran on separate compute and storage infrastructure. A total of 140 launchers were utilized, each running 50 sessions. Each launcher was configured with two vCPUs and 6GB of vRAM, following Login VSI sizing guidelines.
## Appendix C (Bill of Materials for Test Configuration)

The test configuration bill of materials is summarized in Table 6.

<table>
<thead>
<tr>
<th>AREA</th>
<th>COMPONENT</th>
<th>QUANTITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Host hardware</td>
<td>UCS 5108 Blade Chassis</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>Cisco UCS B200-M3 (2 x Intel E5-2680, 256GB RAM)</td>
<td>48</td>
</tr>
<tr>
<td></td>
<td>Cisco C220-M3 (2 x Intel E5-2680, 256GB RAM)</td>
<td>4</td>
</tr>
<tr>
<td>Storage hardware</td>
<td>EMC X-Bricks</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Isilon S200 NAS node (7.2TB capacity)</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>InfiniBand 36-port switch</td>
<td>2</td>
</tr>
<tr>
<td>Network hardware</td>
<td>Cisco Nexus 3048 Switch</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Cisco Nexus 5548P Switch</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Cisco Nexus 6248P Fabric Interconnect</td>
<td>2</td>
</tr>
<tr>
<td>Software inventory</td>
<td>VMware ESXi 5.1 Update 1, build 1117900</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>VMware vCenter</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>VMware Horizon View</td>
<td>7,000 users</td>
</tr>
<tr>
<td></td>
<td>VMware vCenter Operations Manager for Horizon View</td>
<td>8,000 virtual machines</td>
</tr>
<tr>
<td></td>
<td>VMware vCenter Log Insight</td>
<td>2 vCenter instances</td>
</tr>
<tr>
<td></td>
<td>Microsoft Server 2008</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>Microsoft SQL Server 2008</td>
<td>2</td>
</tr>
</tbody>
</table>

Table 6: Bill of Materials