Mixed Virtual Desktop Workloads with Hitachi Unified Compute Platform for VMware Horizon View on Hitachi Virtual Storage Platform G1000

Lab Validation Report

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April 15, 2014
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Mixed Virtual Desktop Workloads with Hitachi Unified Compute Platform for VMware Horizon View on Hitachi Virtual Storage Platform G1000

Lab Validation Report

Persistent desktops are becoming more prevalent in Virtual Desktop Infrastructure (VDI) environments within the corporate datacenter. Persistence provides the following benefits:

- Allows users to install custom applications
- Keeps user data locally on the desktop
- Guarantees that the end user receives the same desktop upon login every time
- Allows corporations to utilize traditional desktop management solutions

The ability to run mixed VDI workloads with no impact to user experience is important. This allows organizations to share a single hardware stack for all VDI workloads, from low utilization workloads such as Task Users up to software development-class workloads such as Heavy or Extreme Power Users.

This lab validation report shows how Hitachi Data Systems:

- Concurrently tested a Heavy Power User workload on linked clones and an Extreme Power User workload on dedicated persistent desktops
- Concurrently tested a Task User workload on linked clones and a Heavy Power User workload on dedicated persistent desktops

Testing was performed using Login VSI as a test harness to:

- Validate end user performance
- Ensure the underlying compute and storage hardware was sized adequately for the given workload
- Show the capability of the new Hitachi Virtual Storage Platform G1000 to easily handle mixed workloads
Table 1 lists the average IOPS profiles of the different workloads tested.

Table 1. Average IOPS Values of Workload Profiles Tested

<table>
<thead>
<tr>
<th>Workload Profile</th>
<th>Average IOPS Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extreme Power User</td>
<td>130-150</td>
</tr>
<tr>
<td>Heavy Power User</td>
<td>25-35</td>
</tr>
<tr>
<td>Task User</td>
<td>3-7</td>
</tr>
</tbody>
</table>

This paper is intended for vSphere and VDI engineers implementing Hitachi Unified Compute Platform for VMware Horizon View.

**Note** — Testing of this configuration was in a lab environment. Many things affect production environments beyond prediction or duplication in a lab environment. Follow the recommended practice of conducting proof-of-concept testing for acceptable results in a non-production, isolated test environment that otherwise matches your production environment before your production implementation of this solution.
Product Features

The following information describes the hardware and software features used in testing.

Hitachi Unified Compute Platform for VMware vSphere

Hitachi Unified Compute Platform for VMware vSphere offers the following:

- Full parity across the RESTful API
- Command line interface
- Graphical user interface

Director software on the Unified Compute Platform integrates directly into VMware vSphere. It provides unified end-to-end infrastructure orchestration within a single interface.

Unified Compute Platform (UCP) for VMware vSphere leverages your existing storage in one of two ways:

- Connect to your existing Hitachi Virtual Storage Platform family or Hitachi Unified Storage VM
- Virtualize other storage arrays that you have from other vendors using Virtual Storage Platform family or Unified Storage VM

UCP for VMware vSphere provides the following benefits:

- Centralization and automation of compute, storage, and networking components
- Significant reduction of time to value and operational costs across data centers
- Faster deployment of converged infrastructure with more efficient resource allocation
- Provides a foundation for the journey to the software defined datacenter using full support of the RESTful API

Hitachi Virtual Storage Platform G1000

Hitachi Virtual Storage Platform G1000 provides an always-available, agile, and automated foundation that you need for a continuous infrastructure cloud. This delivers enterprise-ready software-defined storage, advanced global storage virtualization, and powerful storage.

Supporting always-on operations, Virtual Storage Platform G1000 includes self-service, non-disruptive migration and active-active storage clustering for zero recovery time objectives. Automate your operations with self-optimizing, policy-driven management.
Virtual Storage Platform G1000 supports Oracle RAC and VMware Metro Storage Cluster.

Hitachi Dynamic Provisioning

On Hitachi storage systems, Hitachi Dynamic Provisioning provides wide striping and thin provisioning functionalities.

Using Dynamic Provisioning is like using a host-based logical volume manager (LVM), but without incurring host processing overhead. It provides one or more wide-striping pools across many RAID groups. Each pool has one or more dynamic provisioning virtual volumes (DP-VOLs) of a logical size you specify of up to 60 TB created against it without allocating any physical space initially.

Deploying Dynamic Provisioning avoids the routine issue of hot spots that occur on logical devices (LDEVs). These occur within individual RAID groups when the host workload exceeds the IOPS or throughput capacity of that RAID group. Dynamic provisioning distributes the host workload across many RAID groups, which provides a smoothing effect that dramatically reduces hot spots.

When used with Hitachi Virtual Storage Platform family, Hitachi Dynamic Provisioning has the benefit of thin provisioning. Physical space assignment from the pool to the dynamic provisioning volume happens as needed using 42 MB pages, up to the logical size specified for each dynamic provisioning volume. There can be a dynamic expansion or reduction of pool capacity without disruption or downtime. You can rebalance an expanded pool across the current and newly added RAID groups for an even striping of the data and the workload.

Hitachi Compute Blade 500

Hitachi Compute Blade 500 combines the high-end features with the high compute density and adaptable architecture you need to lower costs and protect investment. Safely mix a wide variety of application workloads on a highly reliable, scalable, and flexible platform. Add server management and system monitoring at no cost with Hitachi Compute Systems Manager, which can seamlessly integrate with Hitachi Command Suite in IT environments using Hitachi storage.

The Hitachi Compute Blade 500 chassis contains internal Fibre Channel and network switches for the high availability requirements of Hitachi Unified Compute Platform for VMware vSphere.

Brocade Storage Area Network and Ethernet Switches

Brocade and Hitachi Data Systems have collaborated to deliver storage networking and data center solutions. These solutions reduce complexity and cost, as well as enable virtualization and cloud computing to increase business agility.
This lab validation report uses the following Brocade products:

- **Brocade 6510 Switch**
- **Brocade VDX 6720 Data Center Switch**

**VMware vSphere 5**

*VMware vSphere 5* is a virtualization platform that provides a datacenter infrastructure. It features vSphere Distributed Resource Scheduler (DRS), High Availability, and Fault Tolerance.

VMware vSphere 5 has the following components:

- **ESXi 5** — This is a hypervisor that loads directly on a physical server. It partitions one physical machine into many virtual machines that share hardware resources.

- **vCenter Server** — This allows management of the vSphere environment through a single user interface. With vCenter, there are features available such as vMotion, Storage vMotion, Storage Distributed Resource Scheduler, High Availability, and Fault Tolerance.

**VMware Horizon View 5.3**

*VMware Horizon View 5.3* provides virtual desktops as a managed service. Using Horizon View, you can create clones of approved desktops and deploy them automatically, as needed. Desktop users access their personalized desktop, including data, applications, and settings from anywhere with network connectivity to the server. PCoIP, a high performance display protocol, provides enhanced end-user experience compared to traditional remote display protocols.
Test Environment Configuration

Testing of the persistent desktops took place in the Hitachi Data Systems laboratory using the Hitachi Compute Blade 500, Hitachi VSP G1000, and Hitachi Unified Compute Platform Director.

Hardware Components

Table 2 describes the details of the hardware components used.

<table>
<thead>
<tr>
<th>Hardware</th>
<th>Description</th>
<th>Version</th>
<th>Quantity</th>
</tr>
</thead>
</table>
| Hitachi Virtual Storage Platform G1000 | ■ Dual controllers  
■ 64 × 8 Gb/sec Fibre Channel ports  
■ 1 TB cache memory  
■ 8 × 900 GB 10k RPM SAS disks, 2.5 inch SFF  
■ 28 x 800 GB SSD disks, 2.5 inch SFF | 80-01-01-00/00 | 1 |
| Hitachi Compute Blade 500 Chassis | ■ 8-blade chassis  
■ 2 Brocade 5460 Fibre Channel switch modules, each with 6 × 8 Gb/sec uplink ports  
■ 2 Brocade VDX 6746 Ethernet switch modules, each with 8 × 10 Gb/sec uplink ports  
■ 2 management modules  
■ 6 cooling fan modules  
■ 4 power supply modules | SVP: A0155-B-7850  
5460: FOS 7.0.2c  
VDX6746: NOS 3.0.0_dcb3 | 1 |
| 520HB2 Server Blade (Task Users) | ■ Half blade  
■ 2 × 12-core Intel Xeon E5-2697v2 processors, 2.70 GHz  
■ 256 GB RAM  
■ 16 × 16 GB DIMMs | Firmware: 04-08  
BMC/EFI: 04-06/10-12 | 2 |
Table 2. Infrastructure Hardware Components (Continued)

<table>
<thead>
<tr>
<th>Hardware</th>
<th>Description</th>
<th>Version</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>520HB2 Server Blade (Heavy Power Users and Extreme Power Users)</td>
<td>Half blade</td>
<td>Firmware: 04-08 BMC/EFI: 04-06/10-12</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>2 x 12 core Intel Xeon E5-2697v2 processors, 2.70 GHz</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>384 GB RAM</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>24 x 16 GB DIMMs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CR 210H Rack Server</td>
<td>2 x 6-core Intel Xeon E5-2620 processors, 2.00 GHz</td>
<td>BMC/EFI: 01-05</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>96 GB RAM</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>6 x 16 GB DIMMs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Brocade 6510</td>
<td>SAN switch with 48 x 8 Gb Fibre Channel ports</td>
<td>FOS 7.1.1</td>
<td>2</td>
</tr>
<tr>
<td>Brocade VDX 6720</td>
<td>Ethernet switch with 24 x 10 Gb/sec ports</td>
<td>NOS 3.0.1aa</td>
<td>2</td>
</tr>
<tr>
<td>Brocade FCX648</td>
<td>Ethernet switch with 48 x 1 Gb/sec ports</td>
<td>07.4.00cT7f3</td>
<td>2</td>
</tr>
</tbody>
</table>

Software Components

Table 3 describes the details of the software components used in this testing.

Table 3. Software Components

<table>
<thead>
<tr>
<th>Software</th>
<th>Version</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hitachi Storage Navigator Modular 2</td>
<td>Microcode Dependent</td>
</tr>
<tr>
<td>Hitachi Dynamic Provisioning</td>
<td>Microcode Dependent</td>
</tr>
<tr>
<td>Hitachi UCP Director</td>
<td>3.0.1</td>
</tr>
<tr>
<td>VMware vCenter server</td>
<td>5.5.0, Build 1476327</td>
</tr>
<tr>
<td>VMware Virtual Infrastructure Client</td>
<td>5.5.0, Build 1281650</td>
</tr>
<tr>
<td>VMware ESXi</td>
<td>5.5.0, Build 1331820</td>
</tr>
<tr>
<td>Microsoft® Windows Server® 2008</td>
<td>Enterprise edition, R2</td>
</tr>
<tr>
<td>VMware Horizon View</td>
<td>5.3.0, Build 1427931</td>
</tr>
<tr>
<td>Login VSI</td>
<td>4.0.4.2951</td>
</tr>
</tbody>
</table>
Network Infrastructure

The network infrastructure for Hitachi UCP for VMware vSphere is configured for management and automation through Hitachi UCP Director. For more information, please visit the Hitachi UCP for VMware vSphere product homepage.

Storage Infrastructure

The storage infrastructure for Hitachi UCP for VMware vSphere is configured for management and automation through Hitachi UCP Director. For more information, please visit the Hitachi UCP for VMware vSphere product homepage.

Solution Infrastructure

The VMware Horizon View connection server used for this solution was placed on the Hitachi Unified Compute Platform management cluster. Table 4 describes the details of the connection server virtual machine configuration used during this testing.

Table 4. VMware Horizon View Connection Server Virtual Machine Details

<table>
<thead>
<tr>
<th>Configuration Item</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating System</td>
<td>Microsoft Windows 2008 R2 Server, Enterprise Edition</td>
</tr>
<tr>
<td>Virtual CPUs</td>
<td>4</td>
</tr>
<tr>
<td>Memory</td>
<td>16 GB</td>
</tr>
<tr>
<td>Disk Size</td>
<td>40 GB</td>
</tr>
<tr>
<td>Disk Type</td>
<td>Eager Zeroed Thick</td>
</tr>
</tbody>
</table>

A Microsoft Windows 2008 R2 Active Directory® domain controller was deployed onto the Hitachi Unified Compute Platform management cluster to support user authentication and domain services for the VMware Horizon View solution infrastructure. Table 5 describes the details of the Active Directory virtual machine configuration used during this testing.

Table 5. Microsoft Windows 2008 R2 Active Directory Domain Controller Virtual Machine Details

<table>
<thead>
<tr>
<th>Configuration Item</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating System</td>
<td>Microsoft Windows 2008 R2 Server, Enterprise Edition</td>
</tr>
<tr>
<td>Virtual CPUs</td>
<td>2</td>
</tr>
<tr>
<td>Memory</td>
<td>4 GB</td>
</tr>
<tr>
<td>Disk Size</td>
<td>40 GB</td>
</tr>
<tr>
<td>Disk Type</td>
<td>Eager Zeroed Thick</td>
</tr>
</tbody>
</table>
Hitachi Unified Compute Platform contains a dedicated management cluster, and a minimum of one compute cluster. For this testing, VMware Horizon View management/administration components were placed on the management cluster, and the virtual desktops were placed on the compute cluster. Figure 1 gives a high-level overview of the infrastructure and component placement.
Test Methodology

This section describes the solution configuration and testing methodology used. The purpose of the tests is to show acceptable levels of performance on the underlying hardware and to show that acceptable end user experience exists. All testing was completed in a high density configuration.

VMware Horizon View Configuration

Extreme Power Users - Persistent Full Clone Desktop Pool

A dedicated user assignment, full clone desktop pool of 180 desktops was configured in VMware Horizon View Administrator for use in the concurrent workload testing. The virtual machine template used for the full clones was configured for a Heavy Power User workload type as defined in the VMware whitepaper "Storage Considerations for VMware Horizon View". The virtual machines were then configured to run a total average load of 130-150 IOPS to simulate software development build and compile tasks. A 3 GB memory reservation was configured on the virtual machines in order to reduce the datastore space consumed by the vswap files. The virtual machine template was prepared for VDI use by following the guidelines in the VMware optimization guide "VMware Horizon View Optimization Guide for Windows 7 and Windows 8". The virtual machine template was also configured for use with Login VSI by following the guidelines established in the Login VSI 4.0 Documentation. Table 6 lists the configuration details of the virtual machine template used for the Extreme Power User full clone desktops.

<table>
<thead>
<tr>
<th>Operating System</th>
<th>Microsoft Windows 7, 64-bit</th>
</tr>
</thead>
<tbody>
<tr>
<td>vCPU Allocation</td>
<td>2</td>
</tr>
<tr>
<td>Memory Allocation</td>
<td>4 GB (3 GB Reserved)</td>
</tr>
<tr>
<td>Desktop Disk/Type</td>
<td>34 GB/Thick Provisioned</td>
</tr>
<tr>
<td>Average Steady State IOPS</td>
<td>130-150</td>
</tr>
<tr>
<td>High-Density vCPU per Core</td>
<td>7.5</td>
</tr>
</tbody>
</table>

The desktop pool was configured to use two datastores, which were presented to both hosts in the Hitachi UCP for VMware vSphere compute cluster used for the Extreme Power User workloads. Each datastore was presented to the cluster as a Hitachi Dynamic Provisioning (HDP) pool virtual volume, with the HDP pool containing 5 RAID-10 (2D+2D) parity groups of 800 GB SSD.
Figure 2 illustrates the storage configuration used for the VMware Horizon View full clone desktops.

After creating the desktop pool and allowing Horizon View to provision the desktops, each datastore contained 90 desktops (+/- 2 desktops). Each ESXi hypervisor in the compute cluster for Heavy Power User workloads was configured to host exactly 90 desktops in order to obtain accurate end user experience metrics during the testing.
Heavy Power Users - Persistent Linked Clone Desktop Pool

A dedicated user assignment, linked clone desktop pool of 180 desktops was configured in VMware Horizon View Administrator for use in the concurrent workload testing. The virtual machine template used for the linked clones was configured for a Heavy Power User workload type as defined in the VMware whitepaper "Storage Considerations for VMware Horizon View". A 3 GB memory reservation was configured on the virtual machines in order to reduce the datastore space consumed by the vswap files. The virtual machine template was prepared for VDI use by following the guidelines in the VMware optimization guide "VMware Horizon View Optimization Guide for Windows 7 and Windows 8". The virtual machine template was also configured for use with Login VSI by following the guidelines established in the Login VSI 4.0 Documentation. Table 7 lists the configuration details of the virtual machine template used for the Heavy Power User linked clone desktops.

Table 7. Configuration Details of Virtual Machine Template for Heavy Power User Linked Clones

<table>
<thead>
<tr>
<th></th>
<th>Microsoft Windows 7, 64-bit</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Operating System</strong></td>
<td></td>
</tr>
<tr>
<td><strong>vCPU Allocation</strong></td>
<td>2</td>
</tr>
<tr>
<td><strong>Memory Allocation</strong></td>
<td>4 GB (3 GB Reserved)</td>
</tr>
<tr>
<td><strong>Desktop Disk/Type</strong></td>
<td>34 GB/Thin Provisioned</td>
</tr>
<tr>
<td><strong>Average Steady State IOPS</strong></td>
<td>25-35</td>
</tr>
<tr>
<td><strong>High-Density vCPU per Core</strong></td>
<td>7.5</td>
</tr>
</tbody>
</table>

The desktop pool was configured to use eight datastores, which were presented to both hosts in the Hitachi UCP for VMware vSphere compute cluster used for Heavy Power User workloads. Each datastore was presented to the cluster as a Hitachi Dynamic Provisioning (HDP) pool virtual volume, with the HDP pool containing 2 RAID-10 (2D+2D) parity groups of 800 GB SSD.

The desktop pool was configured to use a single datastore for replica storage. The replica datastore was presented to the cluster as an HDP pool virtual volume, with the HDP pool containing a single RAID-10 (2D+2D) parity group of 800 GB SSD.
Figure 3 illustrates the storage configuration used for the VMware Horizon View linked clone desktops.

After creating the desktop pool and allowing Horizon View to provision the desktops, each datastore contained 22 desktops (+/- 2 desktops). Each ESXi hypervisor in the compute cluster for Heavy Power User workloads was configured to host exactly 90 desktops in order to obtain accurate end user experience metrics during the testing.
Heavy Power Users - Persistent Full Clone Desktop Pool

A dedicated user assignment, full clone desktop pool of 180 desktops was configured in VMware Horizon View Administrator for use in the concurrent workload testing. The virtual machine template used for the full clones was configured for a Heavy Power User workload type as defined in the VMware whitepaper "Storage Considerations for VMware Horizon View". A 3 GB memory reservation was configured on the virtual machines in order to reduce the datastore space consumed by the vswap files. The virtual machine template was prepared for VDI use by following the guidelines in the VMware optimization guide "VMware Horizon View Optimization Guide for Windows 7 and Windows 8". The virtual machine template was also configured for use with Login VSI by following the guidelines established in the Login VSI 4.0 Documentation. Table 8 lists the configuration details of the virtual machine template used for the Heavy Power User full clone desktops.

<table>
<thead>
<tr>
<th>Operating System</th>
<th>Microsoft Windows 7, 64-bit</th>
</tr>
</thead>
<tbody>
<tr>
<td>vCPU Allocation</td>
<td>2</td>
</tr>
<tr>
<td>Memory Allocation</td>
<td>4 GB (3 GB Reserved)</td>
</tr>
<tr>
<td>Desktop Disk/Type</td>
<td>34 GB/Thick Provisioned</td>
</tr>
<tr>
<td>Average Steady State IOPS</td>
<td>25-35</td>
</tr>
<tr>
<td>High-Density vCPU per Core</td>
<td>7.5</td>
</tr>
</tbody>
</table>

The desktop pool was configured to use two datastores, which were presented to both hosts in the Hitachi UCP for VMware vSphere compute cluster used for Heavy Power User workloads. Each datastore was presented to the cluster as a Hitachi Dynamic Provisioning (HDP) pool virtual volume, with the HDP pool containing 5 RAID-10 (2D+2D) parity groups of 800 GB SSD.
Figure 4 illustrates the storage configuration used for the VMware Horizon View full clone desktops.

![Storage Configuration Diagram]

**Figure 4**

After creating the desktop pool and allowing Horizon View to provision the desktops, each datastore contained 90 desktops (+/- 2 desktops). Each ESXi hypervisor in the compute cluster for Heavy Power User workloads was configured to host exactly 90 desktops in order to obtain accurate end user experience metrics during the testing.

**Task Users - Linked Clone Desktop Pool**

A floating user assignment, linked clone desktop pool of 400 desktops was configured in VMware Horizon View Administrator for use in the concurrent workload testing. The virtual machine template used for the linked clones was configured for a Task User workload type as defined in the VMware whitepaper "Storage Considerations for VMware Horizon View". The virtual machine template was prepared for VDI use by following the guidelines in the VMware optimization guide "VMware Horizon View Optimization Guide for Windows 7 and Windows 8". The virtual machine template was also configured for use with Login VSI by following the guidelines established in the Login VSI 4.0 Documentation. Table 9 lists the configuration details of the virtual machine template used for the linked clone desktops.
The desktop pool was configured to use eight datastores for linked clone storage, which were presented to both hosts in the Hitachi UCP for VMware vSphere compute cluster used for Task User workloads. Each datastore was presented to the cluster as a Hitachi Dynamic Provisioning (HDP) pool virtual volume, with the HDP pool containing 2 RAID-10 (2D+2D) parity groups of 900 GB 10k SAS.

The desktop pool was configured to use a single datastore for replica storage. The replica datastore was presented to the cluster as an HDP pool virtual volume, with the HDP pool containing a single RAID-10 (2D+2D) parity group of 800 GB SSD.

Table 9. Configuration Details of Virtual Machine Template for Linked Clones

<table>
<thead>
<tr>
<th>Operating System</th>
<th>Microsoft Windows 7, 32-bit</th>
</tr>
</thead>
<tbody>
<tr>
<td>vCPU Allocation</td>
<td>1</td>
</tr>
<tr>
<td>Memory Allocation</td>
<td>1 GB</td>
</tr>
<tr>
<td>Desktop Disk/Type</td>
<td>24 GB/Thin Provisioned</td>
</tr>
<tr>
<td>Average Steady State IOPS</td>
<td>3-7</td>
</tr>
<tr>
<td>High-Density vCPU per Core</td>
<td>8.3</td>
</tr>
</tbody>
</table>
Figure 5 illustrates the storage configuration used for the VMware Horizon View linked clone desktops.

After creating the desktop pool and allowing Horizon View to provision the desktops, each linked clone datastore contained 50 desktops (+/- 2 desktops). Each ESXi hypervisor in the compute cluster for Task User workloads was configured to host exactly 200 desktops in order to obtain accurate end user experience metrics during the testing.
Login VSI Test Harness Configuration

Extreme and Heavy Power Users - Persistent and Linked Clone Desktop Pools

Login VSI was used to generate a heavy workload on the desktops. Login VSI launchers were each configured to initiate up to 15 PCoIP sessions to the VMware Horizon View Connection Server to simulate end-to-end execution of the entire VMware Horizon View infrastructure stack. The test harness infrastructure was hosted on hardware separate from the Hitachi UCP for VMware vSphere management and compute clusters in order to accurately measure desktop performance.

The standard "Heavy" Login VSI workload was modified to include running Vdbench in the background during all test phases in order to generate additional IOPS necessary to meet the 25-35 IOPS (Heavy) or 130-150 IOPS (Extreme) target for the necessary workload. In order to ensure the I/O profile used in Vdbench was applicable to desktop application usage, individual application I/O profiles were captured from previous testing and used as Vdbench workload definitions. Table 10 lists the applications and associated I/O profiles used to define the Vdbench workload definitions.

Table 10. Vdbench Application I/O Profiles Used in Workload Definitions

<table>
<thead>
<tr>
<th>Application</th>
<th>% Read</th>
<th>% Write</th>
<th>% Random</th>
<th>% Sequential</th>
</tr>
</thead>
<tbody>
<tr>
<td>Microsoft PowerPoint®</td>
<td>19</td>
<td>81</td>
<td>75</td>
<td>25</td>
</tr>
<tr>
<td>Adobe Acrobat Reader</td>
<td>22</td>
<td>78</td>
<td>71</td>
<td>29</td>
</tr>
<tr>
<td>Microsoft Outlook®</td>
<td>17</td>
<td>83</td>
<td>81</td>
<td>19</td>
</tr>
<tr>
<td>Microsoft Excel®</td>
<td>18</td>
<td>82</td>
<td>74</td>
<td>26</td>
</tr>
<tr>
<td>Mozilla Firefox</td>
<td>36</td>
<td>64</td>
<td>55</td>
<td>45</td>
</tr>
<tr>
<td>Microsoft Internet Explorer®</td>
<td>17</td>
<td>83</td>
<td>80</td>
<td>20</td>
</tr>
<tr>
<td>Microsoft Web Album</td>
<td>27</td>
<td>73</td>
<td>68</td>
<td>32</td>
</tr>
<tr>
<td>Microsoft Media Player</td>
<td>23</td>
<td>77</td>
<td>61</td>
<td>39</td>
</tr>
<tr>
<td>Microsoft Word</td>
<td>26</td>
<td>74</td>
<td>62</td>
<td>38</td>
</tr>
</tbody>
</table>

Login VSI was configured to stagger logins of all 180 users with a single login occurring every 5.45 seconds. This ensured all 180 users logged into the desktops and began the steady state workload within a 17 minute period in order to ensure simulation of a moderate login storm.

Task Users - Linked Clone Desktop Pool

Login VSI was used to generate a light workload on the desktops. Login VSI launchers were each configured to initiate up to 20 PCoIP sessions to the VMware Horizon View Connection Server to simulate end-to-end execution of the entire VMware Horizon View infrastructure stack. The test harness infrastructure was hosted on hardware separate from the Hitachi UCP for VMware vSphere management and compute clusters in order to accurately measure desktop performance. The standard "Light" Login VSI workload was used to simulate a Task User workload.
Login VSI was configured to stagger logins of all 400 users with a single login occurring every 5.45 seconds. This ensured all 400 users logged into the desktops and began the steady state workload within a 36 minute period in order to ensure simulation of a moderate login storm.

Test Case 1: Concurrent Boot Storm

To simulate a power outage or other catastrophic failure of the supporting infrastructure, an immediate power on of 580 linked clone and full clone desktops was performed through the VMware Virtual Infrastructure Client. This boot storm test contained the following mix of desktop types:

- 400 linked clone desktops configured for Task User workloads
- 180 dedicated persistent desktops configured for Heavy Power User workloads

This test case was performed to ensure storage assigned to the desktop pools performed adequately under stress, and to determine the amount of time necessary for the desktops to be ready for login by the end user.

Test Case 2: Concurrent Login Storm and Steady State for Extreme Power Users and Heavy Power Users

Login VSI allows for staggering user logins within a desktop pool and then looping the configured workload for a specified amount of time before logging the session off. For this test case, both desktop pools started their login storm at the same time and each pool logged on a single user every 5.45 seconds. This means that a single login was performed every 2.73 seconds until all users in both pools were logged on. All sessions were configured to log off approximately three hours after logging on to ensure that each desktop ran a steady state workload loop at least twice.

This test case was performed to ensure that all 360 desktops ran the full steady state workload to show sustained concurrent performance, as well as show that the infrastructure can support a moderate login storm of all 360 desktops concurrently.

Test Case 3: Concurrent Login Storm and Steady State for Heavy Power Users and Task Users

For this test case, both desktop pools started their login storm at the same time. This means that a single login was performed every 2.73 seconds until all Heavy Power Users were logged on, then the remainder of the Task Users were logged on at a rate of one login every 5.45 seconds. All sessions were configured to log off approximately three hours after logging on to ensure that each desktop ran a steady state workload loop at least twice.

This test case was performed to ensure that all 580 desktops ran the full steady state workload to show sustained concurrent performance, as well as show that the infrastructure can support a moderate login storm of all 580 desktops concurrently.
Analysis

Test Case 1: Boot Storm

The immediate power on of 580 desktops took two minutes and 41 seconds. This was measured from the time that the desktops were concurrently powered on from vCenter until the time all 580 desktops showed as "Available" within VMware Horizon View Administrator. Six minutes of metrics are graphed to illustrate the periods prior to power-on and after the desktops were marked as available and ready to login.

Storage Infrastructure

Multiple performance metrics from the Hitachi Virtual Storage Platform G1000 were analyzed to ensure that the storage could support the stress of an immediate power on of all of the desktops.
**HDP Pool IOPS**

Figure 6 illustrates the total combined IOPS during the boot storm for the LDEVs used within the HDP pools used for the virtual desktops.

- **Write IOPS peak at approximately:**
  - 0 for the Replica HDP Pool
  - 9,000 for the Linked Clone HDP Pool
  - 3,800 for the Full Clone HDP Pool

- **Read IOPS peak at approximately:**
  - 14,200 for the Replica HDP Pool
  - 29,000 for the Linked Clone HDP Pool
  - 6,800 for the Full Clone HDP Pool

---

**Figure 6**
**Processor and Cache Write Pending**

Figure 7 and Figure 8 illustrate the management processor utilization and cache write pending rate observed during the boot storm.

- MPU utilization does not rise above 5%
- Cache write pending rate does not rise above 1%

![MPU Usage](chart1)

**Figure 7**

![Cache Write Pending](chart2)

**Figure 8**
Cache Hit Percentage

Figure 9 illustrates the read cache hit percentage observed during the boot storm.

- The read cache hit percentage of the Full Clone HDP Pool decreases throughout the boot storm as individual desktops power on.
- The read cache hit percentage of the Linked Clone HDP Pool and Replica HDP Pool is approximately 100% throughout the boot storm as individual desktops power on.

![Read Cache Hit Graph](image)

Figure 9
Physical Disk

Figure 10 illustrates the average physical disk busy rate for the LDEVs used within the HDP pools used for the virtual desktops.

- The disk busy rate on 900 GB 10K SAS drives for the Linked Clone HDP Pool does not rise above 73%
- The disk busy rate on 800 GB SSD drives for the Full Clone HDP Pool and Replica HDP Pool does not rise above 2%

![Average Disk Busy Rate](image)

Figure 10
**Front End Ports**

Figure 11 illustrates the throughput observed on the front end Fibre Channel ports of the Hitachi Virtual Storage Platform G1000 during the boot storm.

- Throughput on each port peaked at 106 MB/sec during the boot storm, for a total peak of 853 MB/sec

![Graph showing Storage Port Throughput](image)
Latency
Figure 12 illustrates the averaged storage latency observed on the Hitachi Virtual Storage Platform G1000 during the boot storm.

- Average latency peaked at 1.4 milliseconds during the boot storm

![Storage Port Latency](image)

**Figure 12**

Test Case 2: Login Storm and Steady State for Extreme Power Users and Heavy Power Users

Multiple performance metrics were collected and analyzed from the ESXi hypervisors, Hitachi Virtual Storage Platform G1000, and Login VSI test harnesses during the login storm and steady state operations. The desktop pools contained within this test were:

- 180 dedicated persistent desktops configured for an Extreme Power User workload
- 180 dedicated linked clone desktops configured for a Heavy Power User workload

Compute Infrastructure

Esxtop was used to capture performance metrics on all four hosts in the desktop cluster during the login storm and steady state operations. The following metrics illustrate the performance of the hypervisor and guest virtual machines.
**Hypervisor CPU Performance**

Figure 13 illustrates the CPU utilization representative of a host in the desktop cluster during the login storm and steady state operations.

- Percent core utilization does not rise above 93%
- Percent utilization time does not rise above 83%
- Percent processor time does not rise above 52%

*Figure 13*
Hypervisor System Load

Figure 14 illustrates the CPU load representative of a host in the desktop cluster during the login storm and steady state operations.

- The one minute load average does not rise above 1.95
Hypervisor Memory Performance

Figure 15 illustrates the memory performance representative of a host in the desktop cluster during the login storm and steady state operations.

- Shared VM memory stayed at 43 MB for the entirety of the testing due to the randomness of the workload generated by Login VSI and is not graphed

Figure 15
Hypervisor Network Performance

Figure 16 illustrates the network performance representative of a host in the desktop cluster during the login storm and steady state operations.

- MB/sec transmitted does not rise above 169 MB/sec
- MB/sec received does not rise above 71 MB/sec

Figure 16
Guest CPU Performance - Extreme Power User - Persistent Desktop Pool

Figure 17 and Figure 18 illustrate the in-guest CPU performance metrics obtained from esxtop during the login storm and steady state operations of the Extreme Power Users. The graphs show five representative virtual desktops from the 180 that ran the workloads. Percent ready should not average above 10% for every vCPU assigned to the virtual desktop (20% in the case of the tested infrastructure). Percent CoStop is an important metric to observe when deploying virtual machines with multiple vCPUs. A high CoStop percentage indicates that the underlying host's CPU resources are overloaded to the point where the virtual machine is ready to execute a command, but is waiting for the availability of multiple pCPUs from the ESXi CPU scheduler. Percent ready does not rise above 33%, and averages between 6 and 7%.

- Percent CoStop does not rise above 1.25%

Figure 17
Extreme User Guest CPU CoStop

Time in Minutes

Percent

Guest 1  Guest 2  Guest 3  Guest 4  Guest 5

Figure 18
Guest CPU Performance - Heavy Power User - Linked Clone Desktop Pool

Figure 19 and Figure 20 illustrate the in-guest CPU performance metrics obtained from esxtop during the login storm and steady state operations of the Heavy Power Users. The graphs show five representative virtual desktops from the 180 that ran the workloads. Percent ready should not average above 10% for every vCPU assigned to the virtual desktop (20% in the case of the tested infrastructure). Percent CoStop is an important metric to observe when deploying virtual machines with multiple vCPUs. A high CoStop percentage indicates that the underlying host’s CPU resources are overloaded to the point where the virtual machine is ready to execute a command, but is waiting for the availability of multiple pCPUs from the ESXi CPU scheduler.

- Percent ready does not rise above 39%, and averages between 9 and 11%
- Percent costop does not rise above 0.86%
Figure 21 illustrates the in-guest IOPS performance metrics during the login storm and steady state operations for the Extreme Power Users. The graphs show five representative virtual desktops from the 180 that ran the workloads.

- IOPS peak at 492 during the login storm
- IOPS peak at 235 and average 135 during steady state
Guest IOPS Performance - Heavy Power User - Linked Clone Pool

Figure 22 illustrates the in-guest IOPS performance metrics during the login storm and steady state operations for the Heavy Power Users. The graphs show five representative virtual desktops from the 180 that ran the workloads.

- IOPS peak at 216 during the login storm
- IOPS peak at 47 and average 27 during steady state

![Heavy Power User Guest IOPS](image)

**Figure 22**

Storage Infrastructure

Performance metrics were captured from the Hitachi Virtual Storage Platform G1000 during the login storm and steady state operations. The following metrics illustrate the performance of the storage array.
**HDP Pool IOPS**

Figure 23 illustrates the total combined IOPS during the login storm and steady state operations for the LDEVs used within the HDP pools used for the virtual desktops.

- Write IOPS peak at approximately:
  - 0 for the Replica HDP Pool
  - 12,600 for the Linked Clone HDP Pool
  - 35,400 for the Full Clone HDP Pool

- Read IOPS peak at approximately:
  - 290 for the Replica HDP Pool
  - 6,400 for the Linked Clone HDP Pool
  - 12,400 for the Full Clone HDP Pool

![HDP Pool IOPS Graph](image)

**Figure 23**
Processor and Cache Write Pending

Figure 24 and Figure 25 illustrate the management processor utilization and cache write pending rate observed during the login storm and steady state operations.

- MPU utilization does not rise above 48%
- Cache write pending rate does not rise above 25%

![ MPU Usage ]

**Figure 24**

![ Cache Write Pending ]

**Figure 25**
Cache Hit Percentage

Figure 26 illustrates the read cache hit percentage observed during the login storm and steady state operations.

- The read cache hit percentage of the Full Clone HDP Pool decreases throughout the login storm as individual desktops begin their workload.
- The read cache hit percentage of the Linked Clone HDP Pool slightly decreases throughout the login storm as individual desktops begin their workload, and increases during steady state.
- The read cache hit percentage of the Replica HDP Pool decreases to zero at the beginning of the login storm as the replica is loaded into read cache on the Hitachi Virtual Storage Platform G1000.

![Read Cache Hit Graph]

Figure 26
Physical Disk

Figure 27 illustrates the average physical disk busy rate for the LDEVs used within the HDP pools used for the virtual desktops during the login storm and steady state operations.

- The disk busy rate:
  - Does not rise above 35% for the Full Clone HDP Pool 800 GB SSD drives
  - Does not rise above 23% for the Linked Clone HDP Pool 800 GB SSD drives
  - Does not rise above 4% for the Replica HDP Pool 800 GB SSD drives

![Average Disk Busy Rate Graph](image-url)

Figure 27
Front End Ports

Figure 28 illustrates the throughput observed on the front end Fibre Channel ports of the Hitachi Virtual Storage Platform G1000 during the login storm and steady state operations.

- Throughput on each port peaked at 222 MB/sec, for a total peak of 997 MB/sec

![Storage Port Throughput](image)

Figure 28
Latency

Figure 29 illustrates the averaged storage latency observed on the Hitachi Virtual Storage Platform G1000 during the login storm and steady state operations.

- Average latency peaked at 1.1 milliseconds during the login storm
- Average latency peaked at 0.3 milliseconds during steady state

![Storage Port Latency](image)

Figure 29

Application Experience

Login VSI was used to measure end user application response times and to determine the maximum number of desktops that could be supported on the tested infrastructure running the specified workload.

Application Response Times

Login VSI reported the time required for various operations to complete within the desktop during the test.

- All operations completed in less than 1.56 seconds

These performance metrics are extremely close to physical desktop performance. This proves that the tested infrastructure provides adequate user experience for 180 Extreme Power Users and 180 Heavy Power Users.
Table 11 lists the operation abbreviations used in Login VSI and a description of the action taken during the operation.

Table 11. Login VSI Operation Descriptions

<table>
<thead>
<tr>
<th>Login VSI Operation</th>
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<tbody>
<tr>
<td>FCDL</td>
<td>File Copy Document Local</td>
</tr>
<tr>
<td>FCDS</td>
<td>File Copy Document Share</td>
</tr>
<tr>
<td>FCTL</td>
<td>File Copy Text Local</td>
</tr>
<tr>
<td>FCTS</td>
<td>File Copy Text Share</td>
</tr>
<tr>
<td>NFP</td>
<td>Notepad File Print</td>
</tr>
<tr>
<td>NSLD</td>
<td>Notepad Start/Load File</td>
</tr>
<tr>
<td>WFO</td>
<td>Windows File Open</td>
</tr>
<tr>
<td>WSLD</td>
<td>Word Start/Load File</td>
</tr>
<tr>
<td>ZHC</td>
<td>Zip High Compression</td>
</tr>
<tr>
<td>ZNC</td>
<td>Zip No Compression</td>
</tr>
</tbody>
</table>
Figure 30 shows the application experience metrics as reported by Login VSI.
**VSI Max Metric**

VSI Max is a metric that indicates the number of desktop sessions the tested infrastructure can support running a specified workload.

Several metrics were monitored during the concurrent workload testing. While the "VSI Max" metric from Login VSI gives a good indicator of when the maximum user density has been reached due to infrastructure resource saturation, we chose to lower densities slightly below VSI Max while carefully monitoring guest CPU ready percentage, ESXi CPU load and utilization, and guest CPU CoStop values. This ensured that we can guarantee end user experience while still having enough overall resource headroom to support bursts of CPU or I/O usage by the underlying guest operating system.

**Test Case 3: Login Storm and Steady State for Heavy Power Users and Task Users**

Multiple performance metrics were collected and analyzed from the ESXi hypervisors, Hitachi Virtual Storage Platform G1000, and Login VSI test harnesses during the login storm and steady state operations. The desktop pools contained within this test were:

- 180 dedicated persistent desktops configured for a Heavy Power User workload
- 400 floating linked clone desktops configured for a Task User workload

**Compute Infrastructure**

Esxtop was used to capture performance metrics on all four hosts in the desktop cluster during the login storm and steady state operations. The following metrics illustrate the performance of the hypervisor and guest virtual machines.
Hypervisor CPU Performance

Figure 31 illustrates the CPU utilization representative of a host in the desktop cluster during the login storm and steady state operations.

- Percent core utilization does not rise above 91%
- Percent utilization time does not rise above 78%
- Percent processor time does not rise above 50%

Figure 31
Hypervisor System Load

Figure 32 illustrates the CPU load representative of a host in the desktop cluster during the login storm and steady state operations.

- The one minute load average does not rise above 1.89
Hypervisor Memory Performance

Figure 33 illustrates the memory performance representative of a host in the desktop cluster during the login storm and steady state operations.

- Shared VM memory stayed at 22 MB for the entirety of the testing due to the randomness of the workload generated by Login VSI and is not graphed.

Figure 33
Hypervisor Network Performance

Figure 34 illustrates the network performance representative of a host in the desktop cluster during the login storm and steady state operations.

- MB/sec transmitted does not rise above 153 MB/sec
- MB/sec received does not rise above 82 MB/sec

Figure 34
Guest CPU Performance - Heavy Power User - Persistent Desktop Pool

Figure 35 and Figure 36 illustrate the in-guest CPU performance metrics obtained from esxtop during the login storm and steady state operations of the Heavy Power Users. The graphs show five representative virtual desktops from the 180 that ran the workloads. Percent ready should not average above 10% for every vCPU assigned to the virtual desktop (20% in the case of the tested infrastructure). Percent CoStop is an important metric to observe when deploying virtual machines with multiple vCPUs. A high CoStop percentage indicates that the underlying host's CPU resources are overloaded to the point where the virtual machine is ready to execute a command, but is waiting for the availability of multiple pCPUs from the ESXi CPU scheduler.

- Percent ready does not rise above 34%, and averages between 9 and 10%
- Percent CoStop does not rise above 0.8%

Figure 35
Figure 36
Guest CPU Performance - Task User - Linked Clone Desktop Pool

Figure 37 illustrates the in-guest CPU performance metrics obtained from esxtop during the login storm and steady state operations for the Task Users. The graphs show five representative virtual desktops from the 400 that ran the workloads. Percent ready should not average above 10% for every vCPU assigned to the virtual desktop (10% in the case of the tested infrastructure). Percent CoStop is not graphed due to the Task User desktops only containing a single vCPU.

- Percent ready does not rise above 17%, and averages between 5 and 6%
Guest IOPS Performance - Heavy Power User - Persistent Desktop Pool

Figure 38 illustrates the in-guest IOPS performance metrics during the login storm and steady state operations for the Heavy Power Users. The graphs show five representative virtual desktops from the 180 that ran the workloads.

- IOPS peak at 124 during the login storm
- IOPS peak at 50 and average 28 during steady state

![Heavy Power User Guest IOPS](image-url)

Figure 38
Guest IOPS Performance - Task User - Linked Clone Pool

Figure 39 illustrates the in-guest IOPS performance metrics during the login storm and steady state operations for the Task Users. The graphs show five representative virtual desktops from the 400 that ran the workloads.

- IOPS peak at 129 during the login storm
- IOPS peak at 9 and average 4 during steady state

**Figure 39**

Storage Infrastructure

Performance metrics were captured from the Hitachi Virtual Storage Platform G1000 during the login storm and steady state operations. The following metrics illustrate the performance of the storage array.
**HDP Pool IOPS**

Figure 40 illustrates the total combined IOPS during the login storm and steady state operations for the LDEVs used within the HDP pools used for the virtual desktops.

- Write IOPS peak at approximately:
  - 0 for the Replica HDP Pool
  - 2,600 for the Linked Clone HDP Pool
  - 6,100 for the Full Clone HDP Pool

- Read IOPS peak at approximately:
  - 300 for the Replica HDP Pool
  - 500 for the Linked Clone HDP Pool
  - 3,700 for the Full Clone HDP Pool

![HDP Pool IOPS Chart](chart.png)

**Figure 40**
Processor and Cache Write Pending

Figure 41 and Figure 42 illustrate the management processor utilization and cache write pending rate observed during the login storm and steady state operations.

- MPU utilization does not rise above 15%
- Cache write pending rate does not rise above 5%

![Figure 41](image1)

![Figure 42](image2)
Cache Hit Percentage

Figure 43 illustrates the read cache hit percentage observed during the login storm and steady state operations.

- The read cache hit percentage of the Full Clone HDP Pool decreases throughout the login storm as individual desktops begin their workload.
- The read cache hit percentage of the Linked Clone HDP Pool slightly decreases throughout the login storm as individual desktops begin their workload, and increases during steady state.
- The read cache hit percentage of the Replica HDP Pool decreases to zero at the beginning of the login storm as the replica is loaded into read cache on the Hitachi Virtual Storage Platform G1000.

![Read Cache Hit](image)

**Figure 43**
Physical Disk

Figure 44 illustrates the average physical disk busy rate for the LDEVs used within the HDP pools used for the virtual desktops during the login storm and steady state operations.

- The disk busy rate:
  - Does not rise above 68% for the Linked Clone HDP Pool 900 GB 10K SAS drives
  - Does not rise above 11% for the Full Clone HDP Pool 800 GB SSD drives
  - Does not rise above 1% for the Replica HDP Pool 800 GB SSD drives

![Average Disk Busy Rate](image)

*Figure 44*
Front End Ports

Figure 45 illustrates the throughput observed on the front end Fibre Channel ports of the Hitachi Virtual Storage Platform G1000 during the login storm and steady state operations.

- Throughput on each port peaked at 65 MB/sec, for a total peak of 515 MB/sec

![Storage Port Throughput](image)

**Figure 45**
Latency

Figure 46 illustrates the averaged storage latency observed on the Hitachi Virtual Storage Platform G1000 during the login storm and steady state operations.

- Average latency peaked at 1.7 milliseconds during the login storm
- Average latency peaked at 1.8 milliseconds during steady state

**Figure 46**

Application Experience

Login VSI was used to measure end user application response times and to determine the maximum number of desktops that can be supported on the tested infrastructure running the specified workload.

Application Response Times

Login VSI reported the time required for various operations to complete within the desktop during the test.

- All operations completed in less than 2.6 seconds
- If the "Zip High Compression" metrics from the 32-bit desktops are removed from the analyzed metrics, all operations completed in less than 1.3 seconds. This shows the benefit of a 64-bit operating system for CPU intensive tasks such as compression.

These performance metrics are extremely close to physical desktop performance. This proves that the tested infrastructure provides adequate user experience for 400 Task Users and 180 Heavy Power Users.
Table 12 lists the operation abbreviations used in Login VSI and a description of the action taken during the operation.

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<tr>
<td>FCTS</td>
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<td>Notepad File Print</td>
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<tr>
<td>NSLD</td>
<td>Notepad Start/Load File</td>
</tr>
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<td>WFO</td>
<td>Windows File Open</td>
</tr>
<tr>
<td>WSLD</td>
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Figure 47 shows the application experience metrics as reported by Login VSI.

**User Application Experience**

*VSI Max Metric*

VSI Max is a metric that indicates the number of desktop sessions the tested infrastructure can support running a specified workload.
Several metrics were monitored during the concurrent workload testing. While the “VSI Max” metric from Login VSI gives a good indicator of when the maximum user density has been reached due to infrastructure resource saturation, we chose to lower densities slightly below VSI Max while carefully monitoring guest CPU ready percentage, ESXi CPU load and utilization, and guest CPU CoStop values. This ensured that we can guarantee end user experience while still having enough overall resource headroom to support bursts of CPU or I/O usage by the underlying guest operating system.
Conclusion

All metrics analyzed supported that the underlying hardware contained within the Hitachi UCP for VMware vSphere converged stack supported:

- An immediate power on of 400 linked clone desktops and 180 persistent desktops
- Adequate end user experience for 440 Task Users running at 3-7 IOPS per desktop
- Adequate end user experience for 180 Heavy Power Users running at 25-35 IOPS per desktop
- Adequate end user experience for 180 Extreme Power Users running at 130-150 IOPS per desktop
For More Information

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