

# Dell Virtual Remote Desktop Reference Architecture

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## Executive Summary

Maintaining traditional physical desktops typically requires time-consuming desk-side visits, reduces user productivity, delays support response, exposes data to increased risk and reduces mobility. While some organizations have the resources to address these concerns, doing so is often at the expense of more strategic initiatives.

Many businesses are interested in implementing some form of desktop virtualization to realize the benefit of centralized deployment and management of their desktop environment. Centralized deployments at enterprise scale are not without their challenges, often requiring significant investment of both time and money to plan and size the infrastructure appropriately. User Experiences often play into the decision, where an appropriately sized infrastructure can mean the difference between a successful deployment and a failed deployment.

Dell, Citrix, and Microsoft provide an end-to-end optimized solution for remote, server-hosted desktop virtualization called Dell Virtual Remote Desktop (VRD). This solution combines Dell's client, server, storage, networking hardware, and services with Citrix XenDesktop desktop virtualization technology and Microsoft's server virtualization and management infrastructure. Dell VRD provides a desktop replacement that is better than a standard desktop in many ways by centralizing management, making IT resources more efficient, improving data security and control, reducing support times, improving staff mobility, and improving the end-user experience.

This Dell VRD Reference Architecture describes three validated configurations of a virtual infrastructure hosting desktop workloads. The Reference Architecture enables customers to consider, evaluate, and select the most suitable Dell virtualization solution configuration according to their requirements by providing selection criteria and discussing relevant performance issues.

This end-to-end optimized reference architecture leverages our strong partnership with Citrix and Microsoft to deliver the following benefits:

- Easier deployment, update, and maintenance - by abstracting the OS, applications, customizations, and data from the physical hardware, IT maintains fewer base images and can customize them dynamically, reducing desktop management complexity
- Faster, cheaper support - centralized maintenance of virtual desktops and the ability to instantly swap out a failed image means the end of the desk-side visit, faster resolution for problems, and lower support costs
- Better security and compliance - without a local installation, no corporate data ever needs to leave the data center, ensuring centralized audit and control to maintain data security and regulatory compliance
- Improved efficiency & productivity - users can access more powerful environments or new applications at the click of a mouse, to take advantage of faster processing and new business solutions at the drop of a hat

- Better availability, disaster recovery, and business continuity - virtual desktops can be migrated in seconds to bypass failing endpoint devices (or even entire locations), maintaining business continuity in the case of minor mechanical problems or even major disasters.
- Improved workforce flexibility and mobility - workers can access their personal desktop from any department or location, even on the road (without carrying a laptop) or from PDAs and wireless devices, and if they change roles can access a new standard virtual desktop in minutes.

## Introduction and Scope

Dell's Flexible Computing Solutions integrate with your existing IT infrastructure to centralize end user resources in protected data centers and boost workforce productivity and security. The Virtual Remote Desktop (VRD) model enables the hosting of your desktop on a remote server where all the compute takes place. You get access to your virtual desktop from a local device, such as a Latitude 13 laptop or an Optiplex FX160.

This whitepaper is targeted towards IT organizations and System Integrators to provide a general sizing guide and configuration recommendations for the Dell Virtual Remote Desktop solution powered by Citrix XenDesktop and Microsoft Windows Server 2008 R2. The goal of this white paper is to:

- Introduce you to the architecture of Citrix XenDesktop with Microsoft Windows Server 2008 R2 on Dell hardware configurations.
- Help you understand the issues related to desktop virtualization across various usage scenarios.
- Clarify, aid, and simplify the selection of configurations for you.

The exact configuration of your hardware, software, and services ingredients can vary depending on your unique business requirements, the intensity of your workload and/or your feature preferences. This white paper outlines three validated VRD configurations that reflect the optimum tradeoffs between system performance, complexity and cost for each virtual desktop.

- The smallest configuration is the 250 user configuration. It requires a fairly minimal hardware footprint and is designed with simplicity in mind and focuses on demonstrating basic functionality. No Shared storage is included in this configuration to minimize complexity.
- The 500 user configuration provides a high degree to design flexibility and is designed to meet the production level deployment requirements of small and medium businesses.
- The 1000 user configuration is a full-feature virtualization solution for larger deployments. It is intended as a scalable configuration that can be deployed in increments of 1000 users. The scale out to configuration beyond 1000 users does require minor changes e.g. configuration of the Citrix Provisioning servers for superior image management, but these changes are outside the scope of this document.

This paper describes the features, benefits, and performance implications of each configuration.

The scope of this document is limited to Dell|Citrix|Microsoft VRD solutions only. It defines the configurations using Dell servers, storage, and networking components. Custom virtual infrastructure configurations using workstations/desktops and/or other products are possible, but not described here. Custom configurations for specific customer engagements may have third party hardware and hence are out of scope, as are software components from other vendors.

Dell, Microsoft, and Citrix provide several resources for designing and deploying virtualization solutions. For further information please see links given below:

- Dell Virtualization Solutions:  
<http://content.dell.com/us/en/enterprise/virtualization.aspx>
- Dell Flexible Computing Solutions:  
<http://dell.com/virtualclient>
- Dell Support and Services:  
<http://www.dell.com/content/topics/global.aspx/services/adi/virtualization?c=us&l=en&s=gen>
- Dell Virtualization Readiness Service:  
<http://www1.euro.dell.com/content/topics/global.aspx/services/adi/virtualization?c>
- Dell|Equallogic Storage Solutions:  
<http://www.dell.com/equallogic>
- Microsoft Windows Server 2008 R2 Hyper-V for Dell PowerEdge Systems:  
<http://content.dell.com/us/en/enterprise/d/virtualization/Windows-Server-2008-Hyper-V.aspx>
- Citrix XenDesktop with Microsoft Windows Server 2008 R2 Hyper-V Design Guide:  
<http://support.citrix.com/article/CTX124687>
- Dell EqualLogic Integrates with Citrix XenDesktop for Robust, Scalable Virtual Remote Desktop Solutions:  
[http://content.dell.com/us/en/enterprise/d/business-solutions-brochures-en/Documents-SB126\\_XenDesktop.pdf.aspx](http://content.dell.com/us/en/enterprise/d/business-solutions-brochures-en/Documents-SB126_XenDesktop.pdf.aspx)

# Virtual Remote Desktop Reference Architecture Configurations

Three configurations, namely **250 User**, **500 User** and **1000 User** are listed here. These configurations are created to reflect the solution size and capability required for mainstream applications and workloads. The recommendations focus on hardware capacity and software features and they feature Dell PowerEdge servers, Dell Equallogic storage and Dell PowerConnect networking.

The following table describes the recommended components of each configuration. Each configuration is described in detail in the sections following the table. Refer to Testing Methodology Section for workload definitions.

**Table 1. Hardware and Software features of Configurations**

	250 User	500 User	1000 User
Description	Small configuration	Designed for small & medium businesses	Large Enterprise environments
License Alignment	250 licenses	500 licenses	1000 licenses
Number of VMs with Medium Knowledge Workload	Approximately 85 per server (1 vCPU allocated per VM)		
Hypervisor Server Configuration			
Hyper-V Servers	3 x R710	6 x R710	12 x M610
Operating System	Windows Server 2008 R2 Server Core		
Minimum Memory*	96GB RAM (1GB per VM required for support by Microsoft) <i>*Memory capacity may vary depending on workload intensity.</i>		
CPU	2 Sockets Intel Xeon Processor X5670		
Minimum NICS	4 x LAN on Motherboard	4 x LAN on Motherboard	2 x LAN on Motherboard + 1 dual port add-in 10GbE NIC
DRAC/iDRAC	Yes		
OS Storage Device	2 x 160GB 7.2K RPM (RAID1)		
Write Cache Volume	6 x 73GB 15K RAID5	6 x 73GB 15K RAID5	PS6510X
Controller/ RAID	PERC 6/i/e (RAID 1,5,10)	PERC 6/i/e (RAID 1,5,10)	PERC 6/i/e (RAID 1,5,10)

Provisioning Services (PVS) Server Storage Configuration			
Provisioning Server	2xR510	2xR510	2xM610
Operating System	Windows Server 2008 R2		
CPU	2 Sockets Intel Xeon Processor E5502		
Memory	8GB	8GB	8GB
Network	4x1GbE	4x1GbE	2x10GbE
Storage fabric	Local storage	Local storage	Network-based iSCSI
Storage Device	5 x 73GB 15K RAID5	5 x 73GB 15K RAID5	2 x 73GB 15K RAID1 PS6510X
Write Cache	Client Side		
File Server Configuration			
File Server	2xR510	2xR710	2xR710
Operating System	Windows Server 2008 R2		
CPU	2 Sockets Intel Xeon Processor E5502		
Memory	4GB	4GB	4GB
Network	2x1GbE	4x1GbE	2x10GbE
Storage fabric	Local storage	Network-based iSCSI	Network-based iSCSI
Storage Device	Depending on requirements (up to 24TB)	PS6000n (configuration of PS6000 varies - use Equallogic storage guidelines, SATA not recommended)	PS6010n (configuration of PS6010 varies - use Equallogic storage guidelines, SATA not recommended)
Infrastructure Server Configuration			
Infrastructure Server	2xR710	2xR710	2xM610
Operating System	Hyper-V Server 2008 R2 Hyper-V		
CPU	2 Sockets Intel Xeon Processor X5670		
Memory	32GB	32GB	32GB
Network	4x1GbE	4x1GbE	2x10GbE
Storage fabric	Local storage		
Storage Device	4 x 500GB Raid 5	4 x 500GB Raid 5	2 x 500GB Raid 1
XenDesktop Delivery Controller Server VM Configuration (2 clustered VMs)			
Operating System	Windows Server 2003		
CPU	2 Virtual CPUs		
Memory	4GB		



Disk Space	100GB		
Citrix License Server VM Configuration (1 clustered VM)			
Operating System	Windows Server 2008 R2		
CPU	2 Virtual CPUs		
Memory	4GB		
Disk Space	100GB		
Citrix Web Interface Server VM Configuration (1 clustered VM)			
Operating System	Windows Server 2008 R2		
CPU	2 Virtual CPUs		
Memory	4GB		
Disk Space	100GB		
XenApp Server Configuration (Optional)			
XenApp Server	2xR710	2xR710	4xR710
Operating System	Windows Server 2008 R2		
CPU	2 Sockets Intel Xeon Processor X5670		
Memory	48GB	48GB	48GB
Network	4x1GbE	4x1GbE	2x10GbE
Storage fabric	Local storage	Local storage	Local storage
Storage Device	2 x 300GB SAS	2 x 300GB SAS	2 x 300GB SAS
Management Infrastructure Configuration			
SCVMM	Required - Windows Server 2008 R2		

**Table 2. Citrix Software Versions**

Citrix XenDesktop Delivery Controller	XenDesktop 4.0
Citrix Provisioning Server	Provisioning Services 5.6
Citrix XenApp Server	XenApp 6.0

## 250 User Configuration

The 250 user configuration is designed to be a simple configuration. This smaller configuration consists of nine servers.

Three R710 servers, each running Windows Server 2008 R2 Hyper-V server core, are used to support up to 250 knowledge worker desktop workloads. 96 GB is the recommended memory configuration for all deployments, assuming ~85 VMs per server.

Two R510 servers with Windows Server 2008 R2 running provisioning services 5.6 are recommended for the virtual machine disk images. Provisioning services are expected in all configurations; however, in the 250 user configuration, shared storage isn't expected. The local disk in both provisioning services servers is used for the virtual machine image.

Two R710 servers running Windows Server 2008 R2 Hyper-V server core are used to host various infrastructure server VMs to include XenDesktop Delivery Controller 4.0, Citrix Web Interface, Citrix License server, SQL server 2008, and Microsoft Systems Center Virtual Machine Manager 2008 R2 (System Center Virtual Machine Manager 2008 R2).

Two file servers running Windows Server 2008 R2 are expected to be used to serve user data from local disk for the user shares.

Two optional servers with Windows Server 2008 R2 are tasked with running XenApp 6 to host additional applications for the virtual machines.

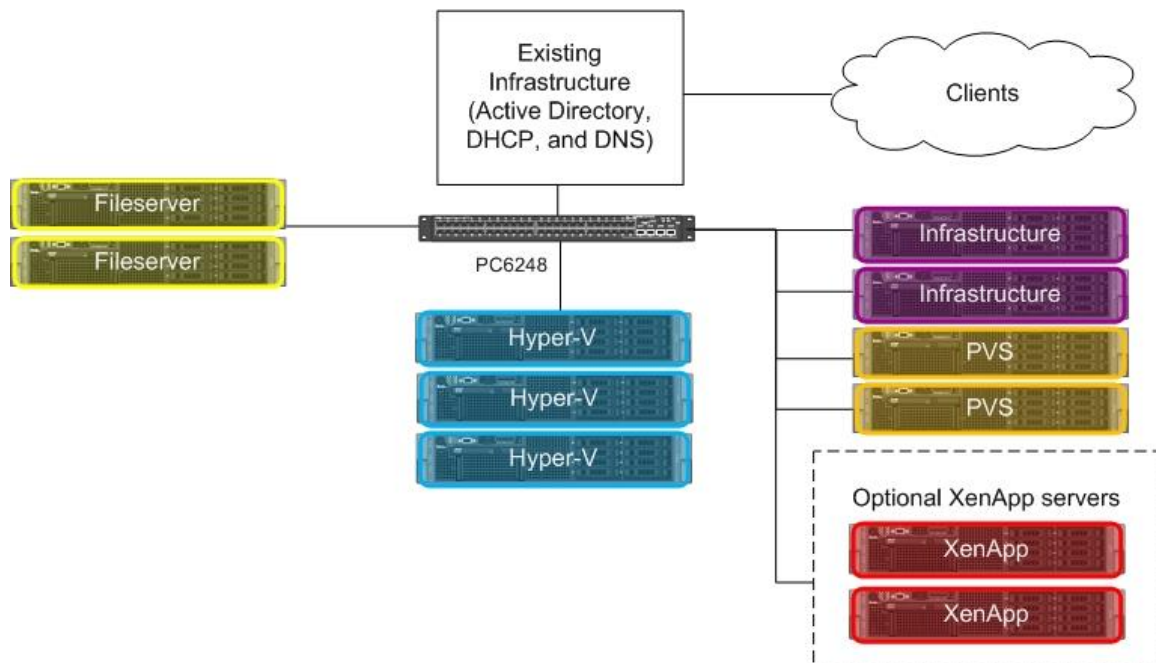


Figure 1. 250 user configuration

## Components:

**Hyper-V Servers:** Three R710 2U rack mount servers are recommended for this configuration. Each server is recommended to have two 160GB 7.2K RPM SAS drives in a RAID 1 configuration for the OS and pagefile. In addition, each server has six 72GB 15K RPM SAS drives in a RAID 5 configuration for the virtual machine configuration files, memory files, and client side write cache virtual disks. Three NICs are teamed and configured for virtual machine network(s) and the remaining NIC is configured for system management.

**Hyper-V Server CPU:** Six core CPUs are recommended in all Hyper-V desktop virtualization solutions for maximum virtual desktop scalability.

**Hyper-V Server Memory:** The 96GB RAM provides enough memory to deploy 84 1GB virtual machines running Microsoft Windows 7 with a knowledge worker workload.

**Hyper-V Operating System:** Windows Server 2008 R2 Hyper-V Server Core is recommended for scalability and stability.

**Hyper-V Server Networking:** The four onboard gigabit NICs provide enough bandwidth to support iSCSI target and network traffic, while leaving the remaining PCI-e slot(s) available for additional peripherals.

**Provisioning Servers:** Two R510 2U rack mount servers are recommended for provisioning services server configuration. Local storage consists of five 73GB 15K RPM in a RAID 5 configuration. Two LUNs are created, one used for the Windows Server 2008 R2 OS, and one for the vDisks. Two provisioning servers are required for redundancy, and each VM image has to be maintained separately between the two servers. Client side write cache is used to reduce the size of the storage requirements on the provisioning server and to reduce network traffic. The write cache is on a virtual hard drive for each VM located on the hard drive array local to the hypervisor.

**Provisioning Server CPU:** CPU utilization is relatively low on the provisioning server, so dual core CPUs are recommended.

**Provisioning Server Memory:** Memory usage is also low on the provisioning server, so 8GB is recommended.

**Provisioning Server Operating System:** Windows Server 2008 R2.

**Provisioning Server Networking:** An add-in PCI-e dual port 1GbE network card is required to provide enough network bandwidth in the R510 for provisioning services.

**Infrastructure Servers:** Two R710 Servers with 32GB of RAM and quad core CPUs are recommended for the Infrastructure servers. XenDesktop Delivery Controllers, Citrix Web Interface servers, and System Center Virtual Machine Manager 2008 R2 are deployed on these additional Hyper-V servers with Cluster Share Volumes for failover capabilities. XenDesktop Delivery Controller requires Windows Server 2003. The other infrastructure server VMs are recommended to be installed with Windows Server 2008 R2.

**Infrastructure Server CPU:** Six core CPUs are recommended in all Hyper-V desktop virtualization solutions for maximum scalability.

**Infrastructure Server Memory:** 32GB of RAM is recommended for the infrastructure servers.

**Infrastructure Server Operating System:** Windows Server 2008 R2 Hyper-V Server Core is recommended for scalability and stability.

**Infrastructure Server Networking:** The quad 1GbE NICs in the R710 meet the networking requirements on the infrastructure VMs.

**FILE Servers:** Two R510 2U rack mount servers are recommended for user home directory file servers. Local storage consists of two 73GB 10K RPM in a RAID 1 configuration for Windows Server 2008 R2. Local storage is also used for the user's data; the configurations are dependent on the amount of data space required and redundancy needed.

**FILE Server CPU:** CPU utilization is low on the file server, so dual core CPUs are recommended.

**FILE Server Memory:** Memory usage is low on the file server, so 4GB is recommended.

**FILE Server Operating System:** Windows Server 2008 R2.

**FILE Server Networking:** The existing dual 1GbE NICs in the R510 are teamed in this configuration.

**XenApp Servers:** Two R710 2U rack mount servers are recommended for XenApp. XenApp is optional in these configurations as the applications used (Microsoft Office, Internet Explorer, and command-line scripts) are all installed on the virtual machine vDisk hosted by the provisioning server. XenApp is expected to be used to deploy other programs that aren't installed on the vDisk. This reduces the amount of maintenance that is required on the vDisk and keeps applications with large memory or CPU requirements from overloading the hypervisors.

**XenApp Server CPU:** High CPU utilization is expected on XenApp servers, so six core CPUs are recommended.

**XenApp Server Memory:** Because memory usage is moderate on XenApp with Microsoft Office applications, 48GB is recommended. Different applications can change this requirement drastically.

**XenApp Operating System:** Windows Server 2008 R2.

**XenApp Server Networking:** The quad 1Gb NICs in the R710 meet the networking requirements of the XenApp server in this configuration.

## 500 User Configuration

The 500 user configuration is targeted towards use cases like small/medium business customers and remote offices for larger customers. It consists of twelve total servers.

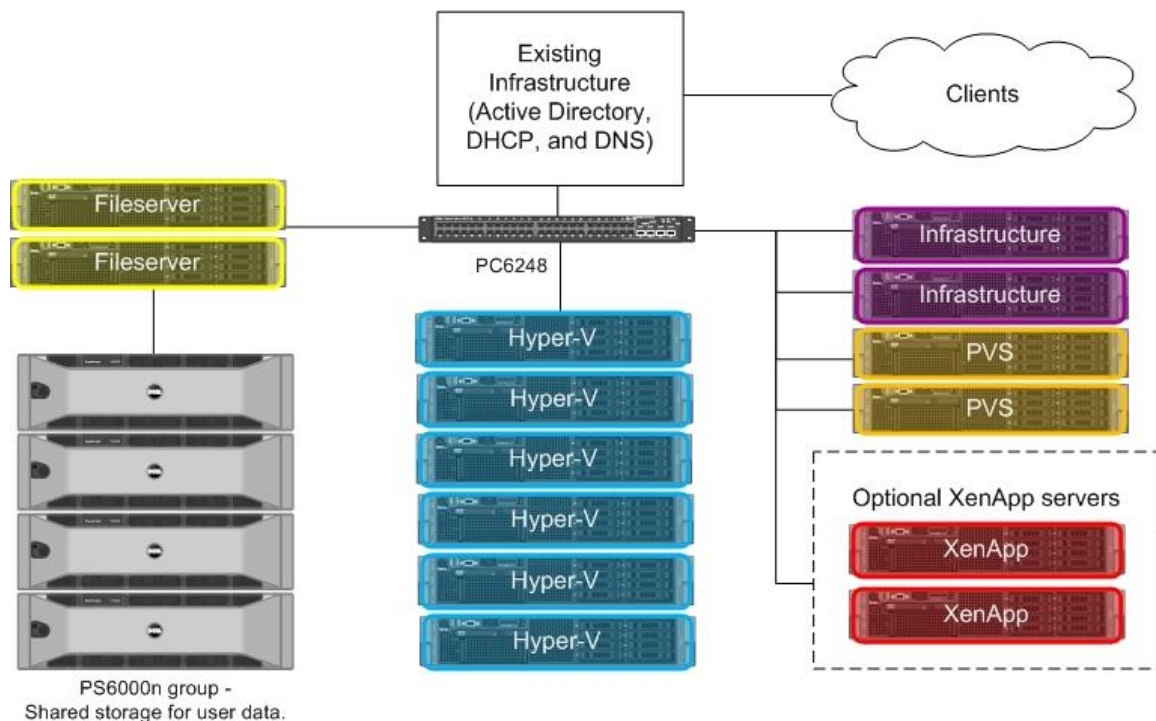
Six servers, each running Windows Server 2008 R2 Hyper-V server core, are required to support up to 500 knowledge worker desktop workloads. 96 GB is the recommended memory configuration for all deployments assuming ~85 VMs per server.

Two servers with Windows Server 2008 R2 running Provisioning services 5.6 are recommended for the virtual machine disk images. Provisioning services are expected in all configurations; however, in the 500 user configuration shared storage isn't expected for the virtual machine disk images. Local disk in both Provisioning services servers is used for the virtual machine image. This does require that two separate vDisk images be maintained, one on each of the PVS servers.

Two R710 servers running Windows Server 2008 R2 Hyper-V server core are used to host various infrastructure server VMs to include XenDesktop Delivery Controller 4.0, Citrix Web Interface, Citrix License server, SQL server 2008, and System Center Virtual Machine Manager 2008 R2.

Two file servers running Windows Server 2008 R2 are expected to be used to serve user data from local disk for the user shares.

Two optional servers with Windows Server 2008 R2 are tasked with running XenApp 6 to host additional applications for the virtual machines.



**Figure 2.** 500 user configuration. Shared storage for user data shares.

## Components:

**Hyper-V Server:** Six R710 2U rack mount servers are recommended for this configuration. Each server is recommended to have two 160GB 7.2K RPM SAS drives in a RAID 1 configuration for the OS and pagefile. In addition, each server has six 72GB 15K RPM SAS drives in a RAID 5 configuration for the virtual machine configuration files, memory files, and client side write cache virtual disks. Three NICs are teamed and configured for virtual machine network(s) and the remaining NIC is configured for system management.

**Hyper-V Server CPU:** Six core CPUs are recommended in all Hyper-V desktop virtualization solutions for maximum virtual desktop scalability.

**Hyper-V Server Memory:** The 96GB RAM provides enough memory to deploy 84 1GB virtual machines running Windows 7 with a knowledge worker workload.

**Hyper-V Operating System:** Windows Server 2008 R2 Hyper-V Server Core is recommended for scalability and stability.

**Hyper-V Server Networking:** The four onboard gigabit NICs provide enough bandwidth to support iSCSI target and network traffic, while leaving the remaining PCI-e slot(s) available for additional peripherals.

**Provisioning Server:** Two R510 2U rack mount servers are recommended for provisioning services server configuration. Local storage consists of five 73GB 15K RPM in a RAID 5 configuration. Two LUNs are created, one used for the Windows Server 2008 R2 OS, and one for the vDisks. Two provisioning servers are required for redundancy, and each VM image has to be maintained separately between the two servers. Client side write cache is used to reduce the size of the storage requirements on the provisioning server and to reduce network traffic. The write cache is on a virtual hard drive for each VM located on the hard drive array local to the hypervisor.

**Provisioning Server CPU:** CPU utilization is relatively low on provisioning server, so dual core CPUs are recommended.

**Provisioning Server Memory:** Memory usage is also low on the provisioning server, so 8GB is recommended.

**Provisioning Server Operating System:** Windows Server 2008 R2.

**Provisioning Server Networking:** An add-in PCI-e dual port 1GbE network card is recommended along with the existing dual 1GbE NICs in the R510.

**Infrastructure Servers:** Two R710 Servers with 32GB of RAM and quad core CPUs are recommended for the infrastructure servers. XenDesktop Delivery Controllers, Citrix Web Interface servers, User share servers and System Center Virtual Machine Manager 2008 R2 are deployed on these additional Hyper-V servers with Cluster Share Volumes for failover capabilities. XenDesktop Delivery Controller requires Windows Server 2003. The other infrastructure servers are recommended to be Windows Server 2008 R2.

**Infrastructure Server CPU:** Six core CPUs are recommended in all Hyper-V desktop virtualization solutions for maximum scalability.

**Infrastructure Server Memory:** 32GB of RAM is recommended for the infrastructure servers.

**Infrastructure Server Operating System:** Windows Server 2008 R2 Hyper-V Server Core is recommended for scalability and stability.

**Infrastructure Server Networking:** The quad 1GbE NICs in the R710 meet the networking requirements on the infrastructure VMs.

**FILE Servers:** Two R710 2U rack mount servers are recommended for user home directory file servers. Local storage consists of two 73GB 10K RPM in a RAID 1 configuration for Windows Server 2008 R2. Shared storage with an Equallogic PS6000 is used for the user's data; the configurations are dependent on the amount of data space required and redundancy needed.

**FILE Server CPU:** CPU utilization is low on the file server, dual core CPUs are recommended.

**FILE Server Memory:** Memory usage is low on the file server, 4GB is recommended.

**FILE Server Operating System:** Windows Server 2008 R2.

**FILE Server Networking:** An add-in PCI-e dual port 1GbE network card is recommend along with the existing dual 1GbE NICs in the R510. Two 1GbE connections are teamed for networking to the PS6000 domain. The remaining 1GbE connections are teamed and networked with the virtual machines.

**Equallogic PS6000 Configuration:** As each deployment's storage configurations vary greatly, it is recommended that Equallogic storage guidelines are followed both for storage capacity and throughput.

**XenApp Servers:** Two R710 2U rack mount servers are recommended for XenApp. XenApp is optional in these configurations as the applications used (Microsoft Office, Internet Explorer, and command-line scripts) are all installed on the virtual machine vDisk hosted by the provisioning server. XenApp is expected to be used to deploy other programs that aren't installed on the vDisk. This reduces the amount of maintenance that is required on the vDisk and keep applications with large memory or CPU requirements from overloading the hypervisors.

**XenApp Server CPU:** High CPU utilization is expected on XenApp servers, so six core Westmere CPUs are recommended.

**XenApp Server Memory:** Because memory usage is moderate on XenApp with Microsoft Office applications, 48GB is recommended. Different applications can change this requirement drastically.

**XenApp Operating System:** Windows Server 2008 R2.

**XenApp Server Networking:** The quad 1GbE NICs in the R710 meet the networking requirements of the XenApp server in this configuration.

## 1000 User Configuration

The 1000 user configuration is a full feature virtualization solution targeted towards large enterprises. It consists of 18 total servers, each running Windows Server 2008 R2 Hyper-V Server Core. Shared storage via Dell|Equallogic arrays allow new features in Provisioning Server 5.6 to be used. These options enable features like read only stores which simplify image management.

Twelve servers, each running Windows Server 2008 R2 Hyper-V server core, are required to support up to 1000 knowledge worker desktop workloads. 96 GB is the recommended memory configuration for all deployments assuming ~85 VMs per server.

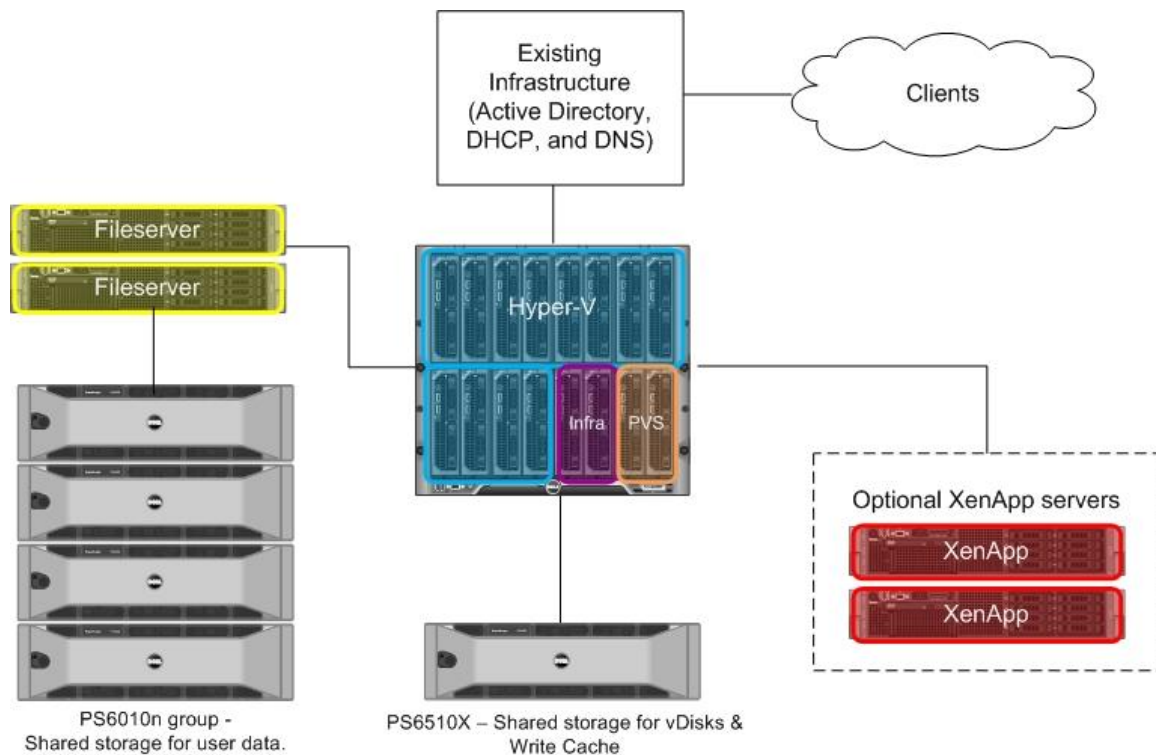
Two servers with Windows Server 2008 R2 running Provisioning Server 5.6 are recommended for the virtual machine disk images. Provisioning services are expected in all configurations; however, in the 1000 user configuration shared storage is expected to simplify image management and enable features like read-only stores. Shared storage for the virtual disk images also allows for additional scaling for even larger deployments. The Equallogic P6510X is recommended as it has both the throughput, in terms of IOPS, and storage capacity required for both the virtual machine disk images and the client side write caches.

Two R710 servers running Windows Server 2008 R2 Hyper-V server core are used to host various infrastructure server VMs to include XenDesktop Delivery Controller 4.0, Citrix Web Interface, Citrix License server, SQL server 2008, and System Center Virtual Machine Manager 2008 R2.

Two file servers running Windows Server 2008 R2 are expected to be used to serve user data from an Equallogic PS6010 storage group for user shares on a 10GbE network for bandwidth.

Two optional servers with Windows Server 2008 R2 are tasked with running XenApp 6 to host additional applications for the virtual machines.





**Figure 3. 1000 user configuration. Shared storage for both the Provisioning Server and user data shares.**

#### Components:

**M1000e chassis configuration:** Two Dell Ethernet pass-through network modules in slot A and two Dell M8024 10GbE switches in slot B are recommended. Two 10GE SFP+ modules are installed in each M8024 for a total of eight 10GbE network ports available in each M8024.

**Hyper-V Server:** Twelve M610 blade servers are recommended for this configuration. Each server is recommended to have two 500GB SAS drives in a RAID 1 configuration. Two LUNs are used on each Hyper-V server, one 200GB LUN for the OS image and one 300GB LUN for VM storage. Each Hyper-V server has a 400GB LUN shared to it from the PS6510X for client side write cache usage. Network connections expect to have one NIC configured for virtual machine network(s) and the other NIC for Hyper-V traffic. Networking is handled with one 10GbE add-in mezzanine card with two 10GbE connections.

**Hyper-V Server CPU:** Six core CPUs are recommended in all Hyper-V desktop virtualization solutions for maximum virtual desktop scalability.

**Hyper-V Server Memory:** The 96GB RAM provides enough memory to deploy 84 1GB virtual machines running Windows 7 with a knowledge worker workload.

**Hyper-V Server Networking:** The one add-in dual port 10 gigabit NIC provides enough bandwidth to support both virtual machine traffic and storage traffic.

**Provisioning Server:** Two M610 blade servers are recommended for provisioning server configuration. Local storage consists of two 73GB 10K RPM in a RAID 1 configuration for Windows Server 2008 R2. Shared iSCSI storage is provided by a Dell|Equallogic PS6510X array. Provisioning Server 5.6 adds a new feature called read-only stores. This feature, along with shared storage, allows for one vDisk to be shared between two or more provisioning servers. This helps reduce the management of the vDisks and eliminates the possibility of having differing vDisks between multiple provisioning servers. Client side write cache is used to reduce the size of the storage requirements on the provisioning server and to reduce network traffic. A second LUN is typically shared to the Provisioning Server for vDisk archival.

**Provisioning Server CPU:** CPU utilization is relatively low on provisioning server, so dual core CPUs are recommended.

**Provisioning Server Memory:** Because memory usage is also low on the provisioning server, 8GB is recommended.

**Provisioning Server Networking:** An add-in dual port 10GbE network mezzanine card is recommended. One 10GbE connection to the PS6510X storage domain and one 10GbE connection to the virtual machine network is used.

**Infrastructure Servers:** Two M610 Servers with 32GB of RAM and quad core CPUs are recommended for the Infrastructure servers. XenDesktop Delivery Controllers, Citrix Web Interface servers, SQL server 2008, and System Center Virtual Machine Manager 2008 R2 are deployed on these additional Hyper-V servers with Cluster Share Volumes for failover capabilities. XenDesktop Delivery Controller requires Windows Server 2003. The other infrastructure servers are recommended to be Windows Server 2008 R2.

**Infrastructure Server CPU:** Six core CPUs are recommended in all Hyper-V desktop virtualization solutions for maximum scalability.

**Infrastructure Server Memory:** 32GB of RAM is recommended for the infrastructure servers.

**Infrastructure Server Operating System:** Windows Server 2008 R2 Hyper-V Server Core is recommended for scalability and stability.

**Infrastructure Server Networking:** A dual port 10GbE mezzanine card is recommended.

**Equallogic PS6510X Configuration:** One 200GB LUN is created for the read only PVS store along with another 400GB LUN for vDisk archival. Each Hyper-V server is also allocated its own 400GB LUN for client side write cache.

**Equallogic PS6010 Configuration:** As each deployment's storage configurations vary greatly, it is recommended that Equallogic storage guidelines are followed both for storage capacity and throughput.

**FILE Servers:** Two R710 2U rack mount servers are recommended for user home directory file servers. Local storage consists of two 73GB 10K RPM in a RAID 1 configuration for Windows Server 2008 R2. Shared storage with an Equallogic PS6000 is used for the user's data; the configurations are dependent on the amount of data space required and redundancy needed.

**FILE Server CPU:** CPU utilization is low on the file server, dual core CPUs are recommended.

**FILE Server Memory:** Memory usage is low on the file server, 4GB is recommended.

**FILE Server Operating System:** Windows Server 2008 R2.

**FILE Server Networking:** An add-in PCI-e dual port 10GbE network card is recommended. One 10GbE connection is networked to the PS6010 domain. The remaining 10GbE connection is networked with the virtual machines.

**XenApp Servers:** Two R710 2U rack mount servers are recommended for XenApp. XenApp is optional in these configurations as the applications used (Microsoft Office, Internet Explorer, and command-line scripts) are all installed on the virtual machine vDisk hosted by the provisioning server. XenApp is expected to be used to deploy other programs that aren't installed on the vDisk. This reduces the amount of maintenance that is required on the vDisk and keep applications with large memory or CPU requirements from overloading the hypervisors.

**XenApp Server CPU:** High CPU utilization is expected on XenApp servers, so six core Westmere CPUs are recommended.

**XenApp Server Memory:** Because memory usage is moderate on XenApp with Microsoft Office applications, 48GB is recommended. Different applications can change this requirement drastically.

**XenApp Operating System:** Windows Server 2008 R2.

**XenApp Server Networking:** The quad 1GbE NICs in the R710 meet the networking requirements of the XenApp server in this configuration.

## Storage Configuration

Dell™ EqualLogic™ PS Series iSCSI storage arrays enable a flexible and scalable consolidation environment for desktop virtualization with Citrix XenDesktop 4. As the deployment of consolidated storage grows, PS Series arrays leverage purpose-designed hardware and firmware resources to evenly load-balance data requests, capacity, network activity, and cache, thus offering simple, low-cost operation. With PS Series arrays, IT organizations can consolidate storage for better organization, enhanced provisioning, and centralized control. Fully redundant, hot-serviceable components enable comprehensive data protection, while snapshots and auto-replication deliver online backups, instant restore, and straightforward disaster recovery.

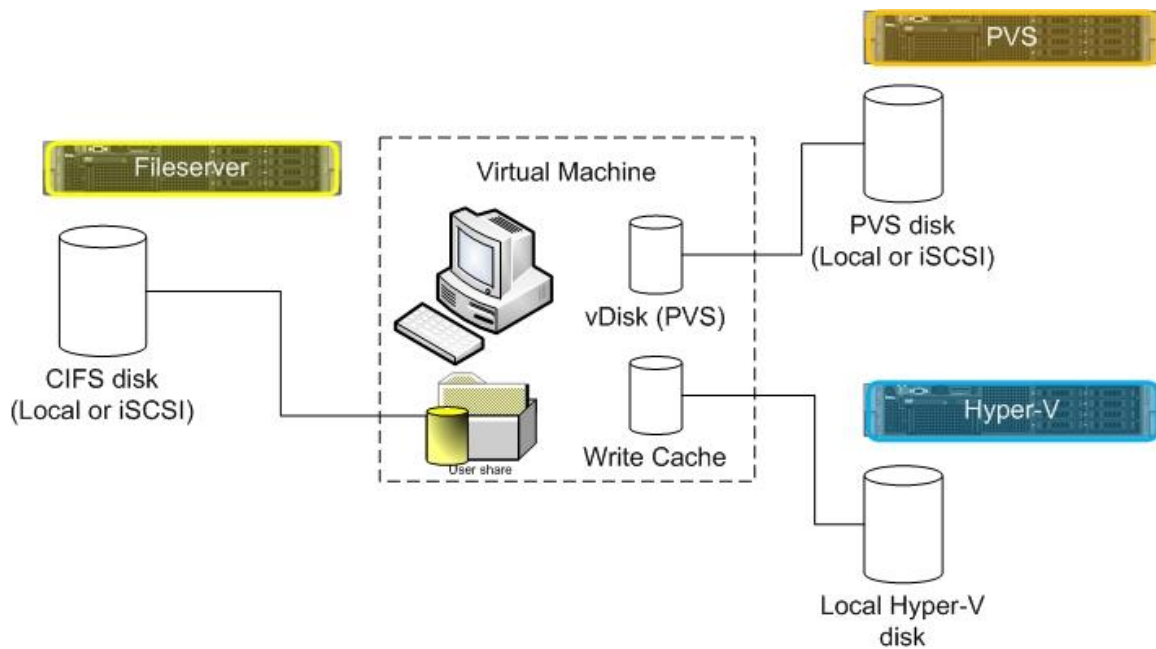
All of the configurations documented here support both local storage and shared storage options. The 250 user configuration is expected to be deployed with local storage, although PS Series iSCSI SAN storage provides exceptional flexibility and improved scalability at this size of deployment. The other configurations expect the user data to be available via network shares hosted on the user file servers located on the infrastructure servers.

The virtual machine configuration in each deployment is the same. The bootable volume is a vDisk that is presented from Citrix Provisioning services. This vDisk has a size of 20GB to provide enough storage for the Microsoft Windows 7 OS, Microsoft Office and some spare capacity for future growth of image size. The size of the image can vary greatly based on specific OS deployments, target applications and user requirements.

Provisioning server allows for two types of write cache to be used:

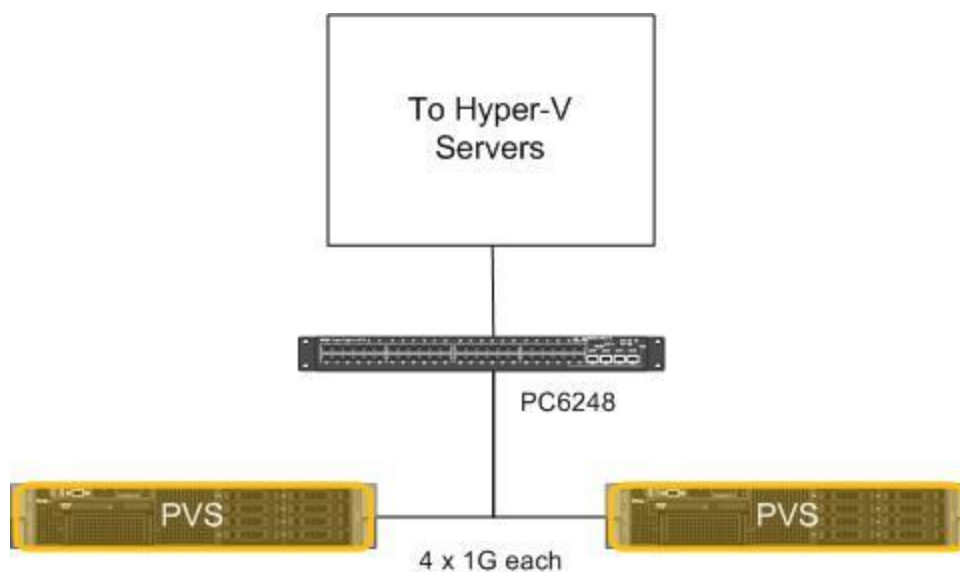
Server side write cache writes out the individual VM deltas from the vDisk source to a disk on the PVS server. Typically this isn't ideal as it generates additional network utilization and IOPS on the storage subsystems which can easily become bottlenecks.

Client side write cache writes out the VM deltas to local disk on the client device. Since the client device is a virtual machine, a virtual disk needs to be presented from the Hyper-V server. For testing in this configuration 2GB of disk space was sufficient, however actual implementations may vary depending on the workload and due to this 4GB is recommended. The recommendation is to target a larger disk space to utilize the largest write cache possible.



**Figure 4.** Configuration of the virtual machines with shared storage.

Both the 250 and 500 user configurations utilize Provisioning servers with server based SSD storage for the virtual machine vDisk. Four 1GbE network connections are utilized for vDisk network traffic. Provisioning server can utilize the network connections as four independent connections, or they can be teamed into a single 4GbE connection. If teamed, these network connections can no longer be used to boot bare metal systems with vDisks. This is not a concern in these configurations, but needs to be noted if the VRD Provisioning server infrastructure is utilized to stream images to physical client devices.



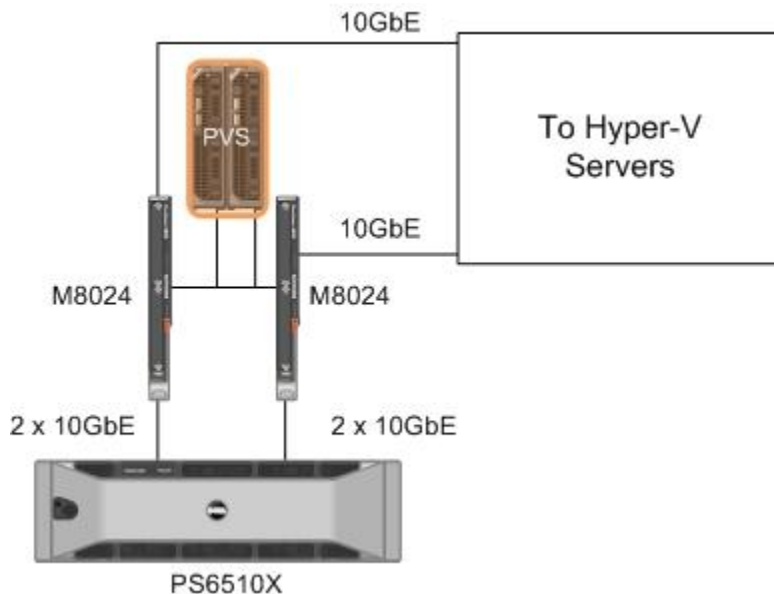
**Figure 5.** Citrix Provisioning Server network configuration for 250 and 500 user configurations.

The 1000 user configuration includes an Equallogic PS6510X array that provides shared iSCSI storage. All network traffic in this storage configuration is over 10GbE which provides exception network scalability.

In the 1000 user configuration there are four 10GbE connections from the PS6510X to the M8024 blade switch modules. Each SP is connected to both M8024s with a single 10GbE connection.

Each provisioning server is connected to both M8024s with a 10GbE link. Provisioning server traffic is allowed to the PS6510X and Hyper-V servers on both network connections for redundancy.

All Hyper-V blade servers have one 10GbE connection to each of the M8024 switches via their add-in 10GbE mezzanine NIC. Each Hyper-V blade server has a 400GB LUN shared to it by the PS6510X that hosts the write cache volumes for each virtual machine.



**Figure 6. Citrix Provisioning Server network configuration for 1000 user configuration.**

In all Equallogic configurations it is recommended that iSCSI traffic be isolated on its own VLAN.

## Virtual Machine Configuration

This section discusses the configuration and tuning of the virtual machines used in testing all of the deployments discussed in this document.

**Operating system:** Windows 7 Ultimate (Version 6.1.7600 32-bit)

**vCPUs:** 1

**Memory:** 1 Gigabyte

**vDisk drive space:** 20 Gigabytes OS and Application vDisk (may require more space if roaming profiles are not used - in that case profiles should be created on the vDisk image to keep PVS write cache reasonable)

**Write Cache drive space:** A 4 Gigabyte virtual disk is used for write cache. This volume is created on the hypervisor for each virtual machine. In the 250 and 500 user configuration it is created on local storage. In the 1000 user configuration the write cache virtual disks are created on LUNs being shared to the hypervisors from the Equallogic PS-6510X.

**Screen resolution:** 1024 x 768

**Performance tuning:** Windows search engine and Aero were disabled to reduce load on the hypervisors. Roaming user profiles are recommended as well as user home directories hosted on file servers. Citrix Provisioning Services Device Optimizer should be run when creating the vDisk image on provisioning server.

**Applications:** Microsoft Office 2007, Citrix Provisioning Services Target Device, Citrix Virtual Desktop Agent x86.

## FAQs

This section has most commonly asked questions by customers in setting up a Citrix XenDesktop with Windows Server 2008 R2 environment on Dell Servers.

### **Should I buy a quad core or six core systems?**

Six core CPUs are recommended for hypervisors in desktop virtualization deployments. As memory is typically the gating factor in these configurations a given workload may require more or less CPU resources. As detailed below, 1GB of memory is required for a supported Windows 7 virtual machine. Less memory can be assigned to each virtual machine to allow for more virtual machines and increase CPU utilization on the hypervisor.

Provisioning servers don't require much in the way of CPU, so dual core CPUs are recommended.

### **Should I buy a dual socket or quad socket servers?**

Based on server density and memory costs, dual socket servers were the best fit for this reference architecture in terms of both cost and performance.

### **Why do I want Provisioning Server?**

Provisioning server greatly reduces the amount time required to update virtual machine images as only one image needs to be updated.

### **What are the optimal RAID Configurations to use in my environment?**

RAID 1 is recommended for the Hyper-V boot volume. For SSD configurations greater than 2 drives, RAID 5 is recommended.

### **My virtual machines only use approximately 75% of their memory, why is 1GB recommended?**

One GB of RAM is required for Windows 7 to be supported. A VM could be configured with less and still function normally. However, if any issues are encountered the VM would have to be reconfigured with 1GB of RAM to ensure that the issue could be duplicated in the supported configuration. It should be noted that some memory should be reserved to make sure the virtual machines don't page memory as this will cause a large reduction in performance.

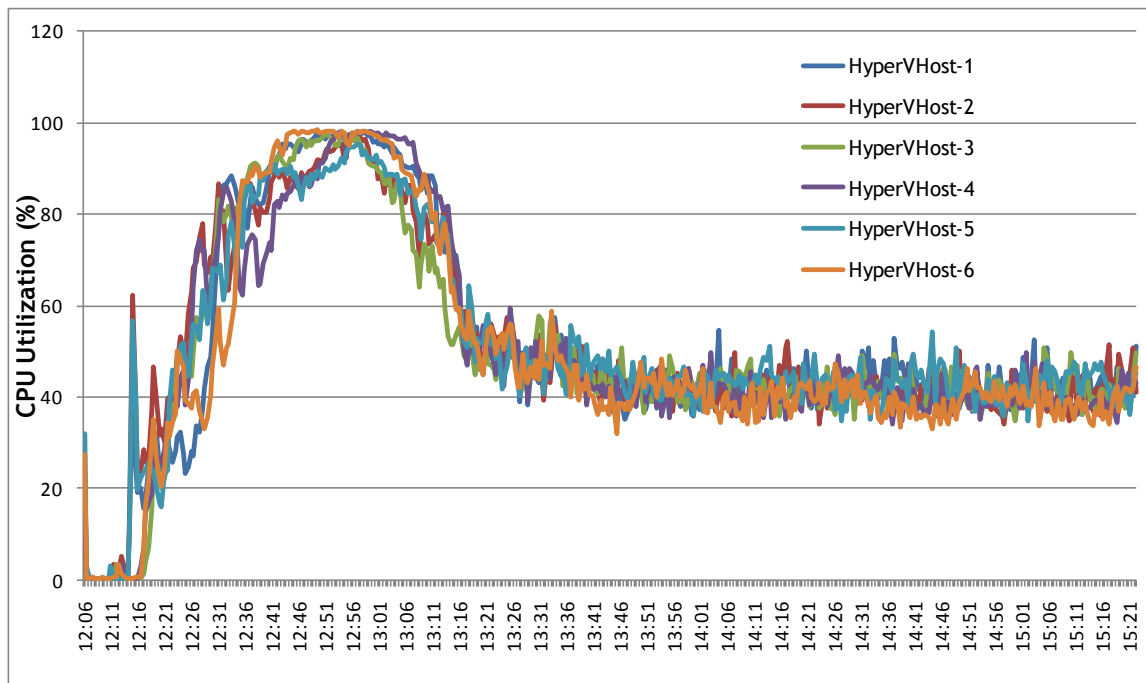


## Testing Methodology

An important part of designing a scalable desktop virtualization deployment is the accurate sizing of the infrastructure and proactively identifying any resource bottlenecks. The Dell VRD reference architecture was validated using two tools:

- VDI workload from Login Consultants (LoginVSI v 2.1.1) and 2)
- Auto-IT workload scripts developed by Dell Engineering to represent a knowledge worker workload.

The CPU utilization across six Hyper-V host servers when hosting 500 desktop instances is illustrated in Figure 7. The CPU utilization is close to 100% initially when VMs are powered on and users start logging in simultaneously. The high CPU utilization during VM boots and simultaneous login of users represents the worst case scenario. When all users are logged in, the CPU utilization reaches steady state at approximately 40% indicating there is additional room to scale desktop users if required.



**Figure 7.** CPU utilization across 6 Hyper-V servers while running 500 desktops

The CPU utilization on a single Hyper-V host when running 100 desktop users using the VSI Login benchmark tool is illustrated in Figure 8. This scenario is presented to highlight the boundary conditions of resource allocation. The average CPU utilization is higher in this scenario since it is running 100 desktops on a single host. In this test run, the VMs have already been powered on and in steady state before the benchmark run so there is no spike in CPU utilization at the beginning of the run. A steady increase of the CPU load is observed when 100 users log in to their desktop session at a 30 second interval. Once all users are logged in, a steady CPU

utilization of approximately 82% is maintained on the Hyper-V server. The design goal is not to exceed 80% CPU utilization when sizing a VRD environment.

The response time measured by the VSI Login benchmark tool is plotted in Figure 9. The response time reflects the latency experienced by the users while executing their workload. Figure 9 shows a gradual increase in the response time as users log in over time and the system load increases. The design goal is to keep the response time relatively stable while scaling to a higher number of users.

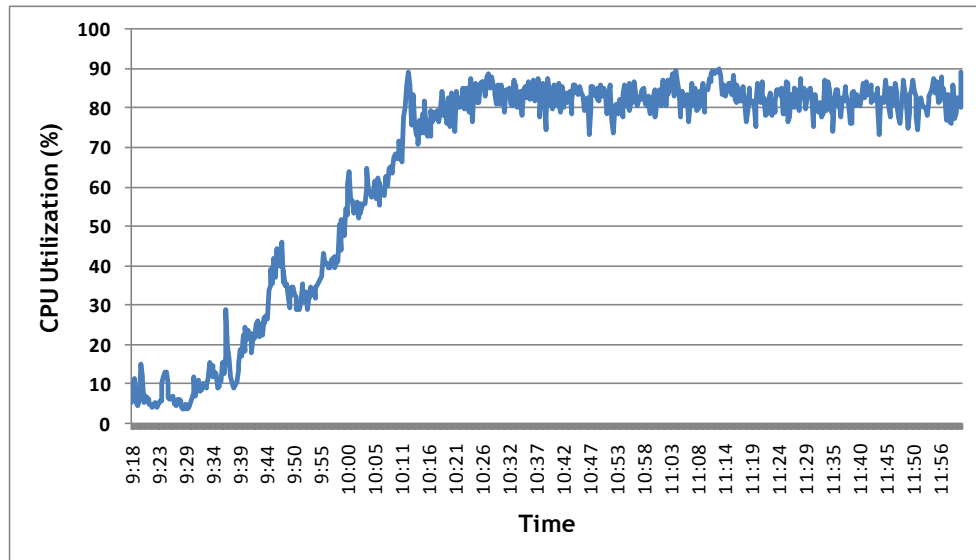


Figure 8. CPU utilization when running 100 desktops on a single HyperV Host

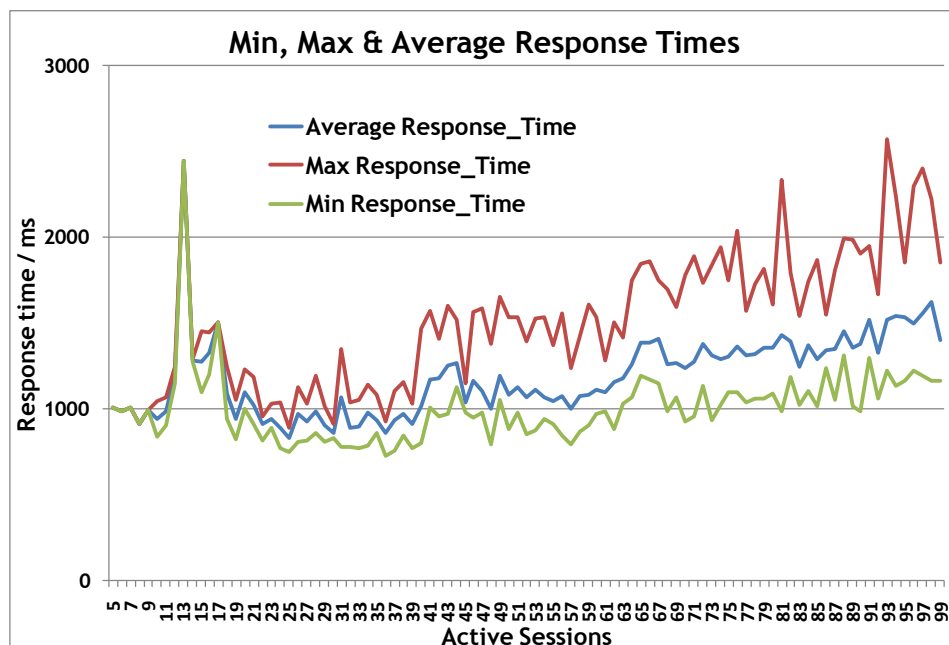


Figure 9. VSI Login benchmark response times

## Conclusion

By leveraging the Dell Virtual Remote Desktop reference architecture featuring Citrix and Microsoft technologies, IT leaders can easily and cost-effectively support their organization's business toward the delivery of a more secure and flexible desktop experience. By choosing Microsoft and Citrix with Dell, customers gain the advantage of over 10 years maturity in thin client computing experience along with best in class user experience and a choice of deployment options for both session virtualization with XenApp and desktop virtualization with XenDesktop for the best enterprise scale. The Dell Virtual Remote Desktop solution reference architecture has been designed with the end user in mind and features the fastest dynamic desktop provisioning management at scale with the quickest application deployment capabilities while helping eliminate the need for retraining and application sharing.

Choosing a Dell Virtual Remote Desktop solution means that customers can take advantage of a tested reference architecture, sized for specific user profiles and use cases, to deliver desktop virtualization and session virtualization capabilities to their end users without the time and money of validating the solution for themselves in their own business. This can effectively reduce the overall cost of deployment by a significant amount as planning and sizing the deployment can often cost just as much as the deployment itself.

The Dell Services team is ready to help assess, design, implement, and maintain desktop virtualization in specific organizational environments while offering a single point of contact for ongoing hardware and software support.

With its Flexible Computing initiative, Dell continues to pave the way for comprehensive, scalable solutions designed to satisfy diverse user profiles in a wide variety of enterprises and industries. Citrix and Microsoft are key partners in the Virtual Remote Desktop solution enabling enterprises to leverage exceptional hardware and software innovations resulting from the strong partnership with Dell.

This approach can help boost enterprise efficiency, reduce total cost of ownership for the desktop infrastructure, and enable organizations to respond quickly and flexibly to ever changing business needs.