Delivering a Highly Available Citrix® Provisioning Server™ using Leading Edge Shared Storage Technologies

By Andrew Melmed, Integration Services Advisor, Citrix Systems, Inc.

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Introduction

The purpose of this report is to present various options for delivering a highly available Citrix Provisioning Server (PVS) using the latest storage technologies currently on the market. When implemented in conjunction with Provisioning Server, the respective benefits associated with each of these technologies offer Administrators the ability to realize the true value afforded by Provisioning Server – maximum user productivity through minimal system downtime.

By comparing technologies based on cost, ease of use, performance, reliability and scalability – the aspects most often scrutinized during the decision-making process prior to any significant investment, this report aims to provide the information necessary to assist the reader in making an astute decision regarding which of the storage technologies found in today's enterprise networks would best meet their needs as well as the demands imposed by their mission and/or business-critical applications.

It is important to understand that this report does *not* explain how storage technologies work, nor does it provide any information concerning the installation, configuration, administration or maintenance of such technologies. It is also assumed that the reader has prior experience installing, configuring, managing and maintaining a highly available Citrix Provisioning Server.

Notice: The storage technologies described on the following pages have undergone extensive testing in Citrix labs. As a result, at the time of this publication, *no* interoperability issues between Provisioning Server and any of the technologies presented in this report were known to exist.

About Citrix Provisioning Server

Citrix Provisioning Server offers IT Administrators the ability to deliver server and desktop workloads (operating systems, core applications and configuration information) on-demand via a centralized management platform, reduce total cost of ownership, and improve manageability and business agility.

Some of the key benefits include:

- Simplifying and streamlining server and desktop workload management

By simplifying the delivery and maintenance of server and desktop workloads throughout the enterprise, IT staff can focus their time and attention on the myriad of other tasks presented to them on a daily basis.

- Reducing software rollout risk

The risk of user downtime due to incompatibility or failed upgrades as a result of OS and/or software updates can be mitigated or eliminated as changes to workloads are made using one system, while all other servers and desktops continue to operate using the previous “last-known working” workload.

- Rapid repurposing of servers with minimal effort

Using the following steps, servers can be repurposed at any time, quickly and easily, ensuring minimal system downtime and maximum user productivity:

1. Shut down
2. Reassigned a different workload
3. Booted up

- Extending Citrix Presentation Server™ application delivery and Citrix XenServer™ server virtualization capabilities

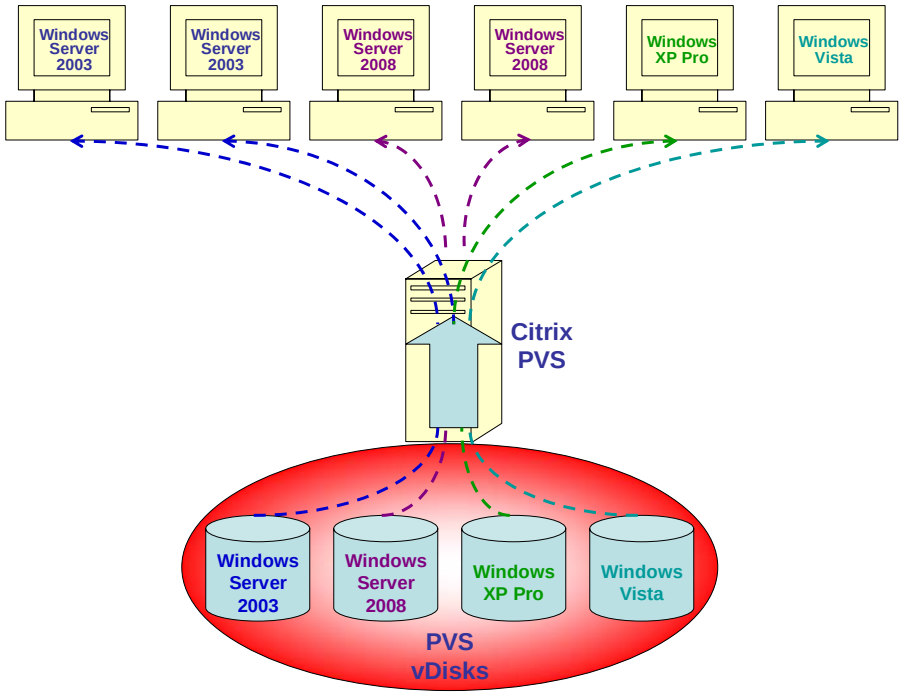
With its centralized management platform, Citrix Provisioning Server can be used to efficiently and effectively provision Citrix Presentation Servers and XenServer virtual machines, complementing and extending Citrix application delivery and server virtualization infrastructure capabilities.

By introducing Citrix Provisioning Server into an organization’s enterprise Datacenter, the above benefits can be realized immediately, ensuring a high ROI within a very short period of time.

How Citrix Provisioning Server Works

Using Citrix Provisioning Server, target devices (server and/or desktop systems) are configured to boot off the network via PXE (Pre-boot eXecution Environment, part of Intel’s Wired for Management (WfM) specification). During the initial stages of the boot process, a target device requests its IP address and boot information, including the name or IP address of the boot server and the name of the bootstrap file, from a DHCP server on the LAN. Upon receipt of this information, the device initiates a TFTP download request for

the bootstrap file from the boot server, which instructs the device to connect to the Provisioning Server for the purpose of registration. During the registration process, the Provisioning Server determines which vDisk (workload) is assigned to the target device and instructs the device to download its vDisk to complete the boot process. Once the target device has obtained its workload, it is able to operate as a fully-functional server or desktop system, *taking full advantage of its local processing capabilities*. (See figure below.)



Delivering a Highly Available Citrix Provisioning Server

With the ability to simplify server/desktop workload delivery, reduce software rollout risk, reprovision servers quickly and easily and extend Citrix Presentation Server application delivery and XenServer server virtualization capabilities, Citrix Provisioning Server makes for a very flexible and powerful solution.

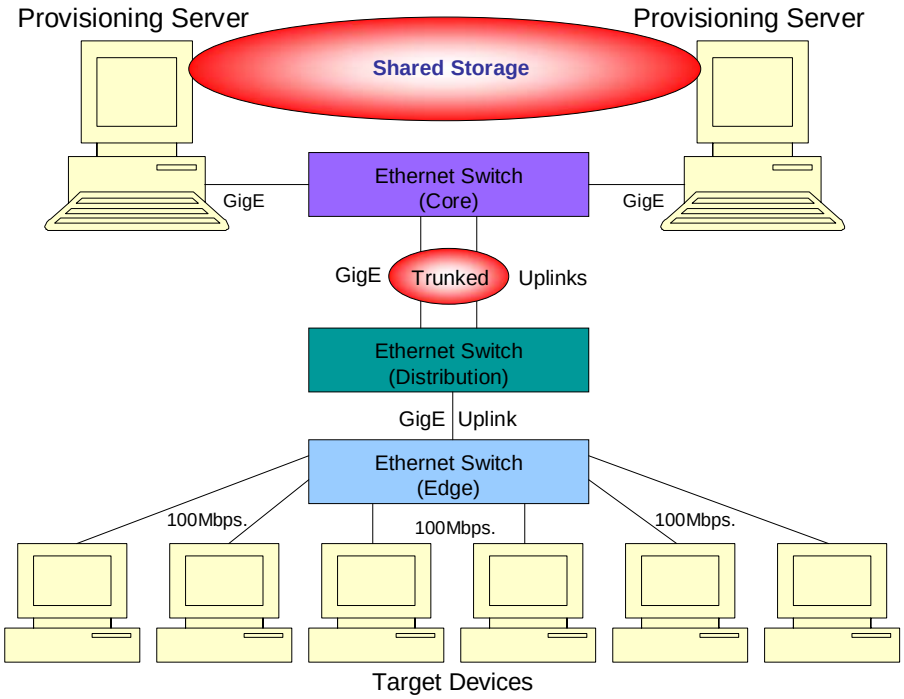
As organizations look to their IT Administrators to reduce costs and improve the overall user experience, the value-add provided by Citrix Provisioning server becomes evident. By deploying Citrix Provisioning Server in the Datacenter, the nucleus of the enterprise, both objectives can be achieved, ensuring lower costs and enhanced user productivity. With such a robust system proving invaluable to meeting and exceeding their objectives, IT Administrators are going to insist that such a vital resource be readily available at all times.

Acutely aware of the need to instill IT Administrators with the confidence afforded by a highly reliable system, Provisioning Server includes a high-availability feature. When this feature is enabled and properly configured, IT Administrators can be assured their Citrix Provisioning Server will be readily accessible at all times, thereby minimizing system downtime and maximizing user productivity.

Comprised of two or more Citrix Provisioning Servers sharing read/write access to the Provisioning Server (PVS) database, vDisks and target device write caches, a highly available Citrix Provisioning Server offers IT Administrators the following benefits:

- Facilitates load balancing of I/O (Input/Output) operations by effectively distributing I/O requests from target devices amongst all servers.
- Allows target devices to automatically re-establish connectivity (failover) to the vDisk containing their workload through another Provisioning Server in the event that connectivity to the vDisk through an initial Provisioning Server is lost unexpectedly, i.e. server hardware failure or loss of network connectivity.

The following diagram depicts a highly available Citrix Provisioning Server using shared storage.



Delivering a Highly Available Provisioning Server using a Windows Share

Pros:

- Minimal cost to purchase, implement and maintain.
- Easy to implement, manage and maintain:
  - Uses a network share created on a Windows server to store the PVS database and vDisks.
  - Uses IP over Ethernet to connect Provisioning Servers to the Windows server hosting the network share.
  - Uses Microsoft Windows security features to control access to the network share.
  - Uses CIFS (Common Internet File System) to ensure the integrity of the network share.

Cons:

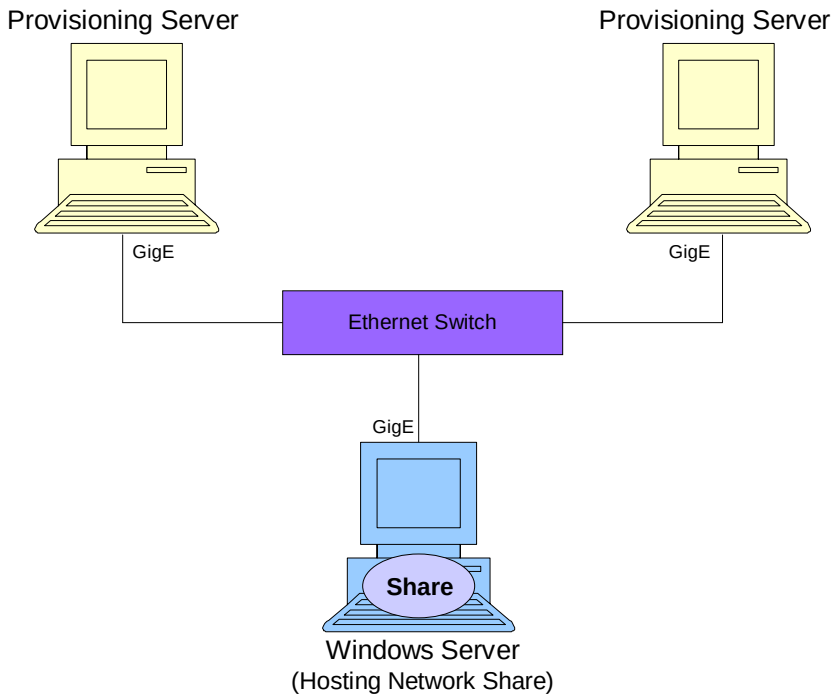
- I/O performance not as good as NAS, an iSCSI or Fibre Channel SAN.
- Fewest options for improving I/O performance:
  - Add network connections to the Windows server hosting the network share.
  - Use a Windows server with more processing power to host the network share.
- Minimal amount of reliability:
  - Most servers include redundant cooling fans and power supplies.
  - Most servers support multiple connections to the network.
  - If the Windows server hosting the network share loses network connectivity, all Provisioning Servers lose access to the database, resulting in the termination of all PVS Streaming services.
  - Some servers include a RAID Controller to combine and configure Disks in a RAID array for the purpose of recovering data during disk failures. If the server hosting the network share does not have a RAID Controller, one should be installed to ensure the recovery of data in the event of disk failure.
- No scalability to support Target Device base expansion:
  - Additional servers may be needed to support the increase in I/O demands, which introduces additional administration as well as network traffic, increasing the potential for slower performance resulting from network congestion.

Windows Share Sample Topologies:

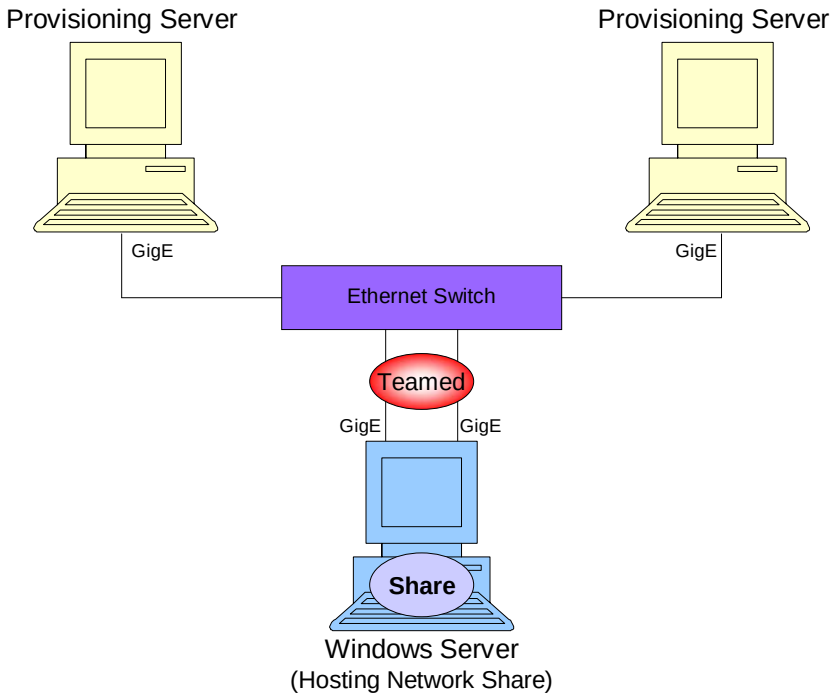
The following diagrams depict Provisioning Server deployments using a Windows Share to store the PVS database and vDisks. In all illustrations, Provisioning Servers consist of an HP ProLiant DL380 G4 and a Dell PowerEdge 2850.

Configuration A shows one GigE connection between the Windows Server and the network.

Configuration B shows two GigE connections between the Windows Server and the network, which may be utilized to improve I/O performance.



Configuration A



Configuration B

Delivering a Highly Available Provisioning Server using NAS

Pros:

- Moderate cost to purchase, implement and maintain.
- Fairly easy to implement, manage and maintain:
  - Uses IP over Ethernet to connect Provisioning Servers to the storage array hosting the network share.
  - Uses Windows or Unix security features to control access to the network share.
  - Uses CIFS or NFS (Network File System) to ensure the integrity of the network share.
- More options for improving I/O performance:
  - Add network connections to the storage array hosting the network share.
  - Install additional drives in the storage array hosting the network share.
  - Install higher-performance drives, i.e., SCSI or SAS.
  - Use a high-end storage array or NAS appliance with more processing power to host the network share.
- Enhanced reliability:
  - Most, if not all storage arrays contain redundant cooling fans and power supplies.
  - Most, if not all storage arrays support multiple connections to the network
    Drives can be grouped and configured to operate in a RAID array.
- Greater degree of scalability to support target device expansion:
  - Additional drives or higher-performance drives can be installed in the storage array to support the increase in I/O demands.
  - The combination of a NAS head/aggregator and additional storage arrays can be used to effectively load-balance the increase in I/O demands.

Cons:

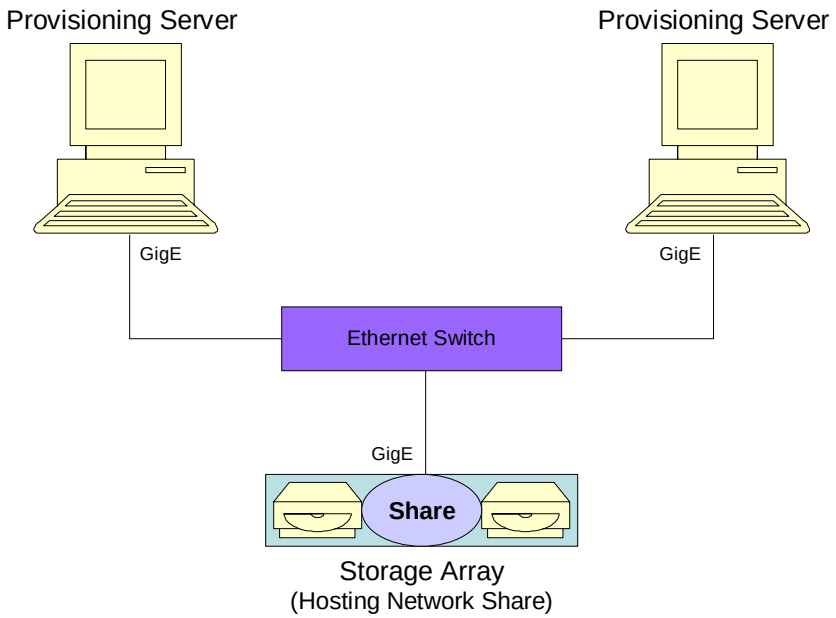
- More expensive than a Windows Share.
- Requires software to manage the storage array.
- RAID arrays must be configured on the storage array and assigned to each Provisioning Server.
- Designed for serving up files, not small or large scale block reads or writes – I/O performance not as good as an iSCSI or Fibre Channel SAN.
- Reliability not as high as an iSCSI or Fibre Channel SAN.
- Scalability not as great as an iSCSI or Fibre Channel SAN.

NAS Sample Topologies:

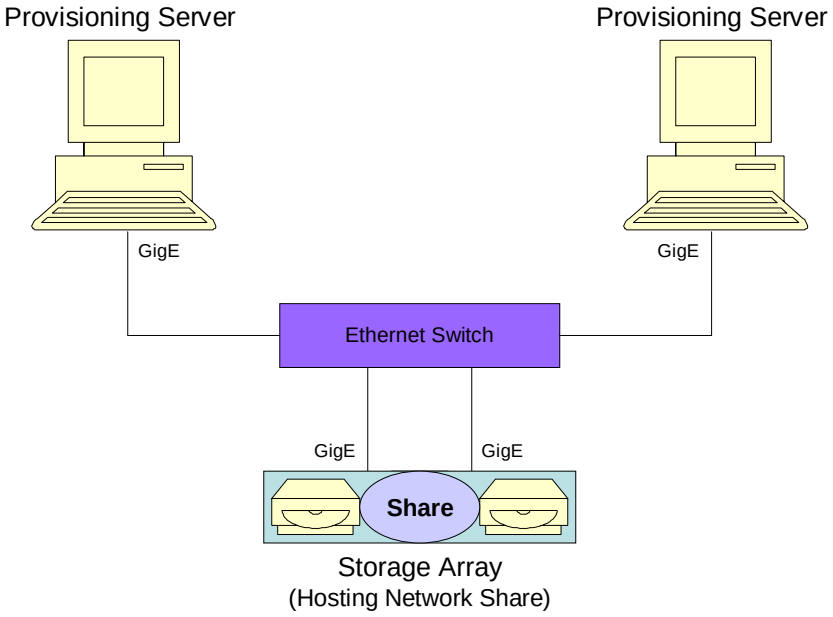
The following diagrams depict Provisioning Server deployments using NAS to store the PVS database and vDisks. In all illustrations, Provisioning Servers consist of an HP ProLiant DL380 G4 and a Dell PowerEdge 2850.

Configuration A shows one GigE connection between the storage array and the network.

Configuration B shows two GigE connections between the storage array and the network, which may be utilized to improve I/O performance.



Configuration A



Configuration B

Delivering a Highly Available Provisioning Server using an iSCSI SAN

Pros:

- Moderate cost to purchase, implement and maintain.
- Fairly easy to implement, manage and maintain:
  - Uses a partition or LUN created on a File Server or storage array, respectively, to store the PVS database and vDisks.
  - Uses IP over Ethernet to connect Provisioning Servers to the storage array.
  - Uses iSCSI (IP-based storage networking) to provide access to the storage array.
- More options for improving I/O performance:
  - Use multiple network connections between each Provisioning Server and the storage array.
  - Use iSCSI TOE cards/HBAs to connect each Provisioning Server to the storage array.
  - Install higher-performance drives such as SCSI or SAS.
  - Use a higher-end storage array with multiple I/O controllers.
- Highest levels of reliability via built-in redundant components and features:
  - The storage array includes redundant cooling fans and power supplies.
  - The storage array includes multiple interfaces for load-balancing and redundancy.
  - The storage array should include multiple I/O controllers for redundancy.
  - Drives can be grouped and configured to operate in a RAID array.
- Greatest degree of scalability to support Target Device base expansion:
  - Additional bandwidth can be provided using multiple network connections between each Provisioning Server and the storage array via a GigE switch.
  - Additional GigE switches can be installed to load-balance I/O demands amongst multiple I/O controllers (iSCSI Targets).
  - Additional drives or better-performing drives can be installed in the storage array to support the increase in I/O demands.
  - Multiple partitions/LUNs can be created on multiple RAID arrays and combined into a single stripe-set, utilizing the additional disk heads to support the increase in I/O demands.

Cons:

- More expensive to purchase, implement and maintain than a Windows Share or NAS.
- Requires software to manage the storage array.
- More software required to implement an iSCSI SAN:
  - iSCSI Initiator and multipath I/O software must be installed and configured on each Provisioning Server.
  - iSCSI Target software must be installed and configured on the File Server(s).
  - Uses authentication (CHAP) to control access to the iSCSI Target(s).
  - Uses a cluster or Parallel File System to ensure the integrity of the partition/LUN containing the PVS database and vDisks.
- RAID arrays and partitions/LUNs must be configured on the File Server(s) or storage array and assigned to each Provisioning Server.
- Not as much bandwidth (commonly GigE) as a Fibre Channel SAN (2Gbps. or 4Gbps.).

iSCSI SAN Sample Topologies:

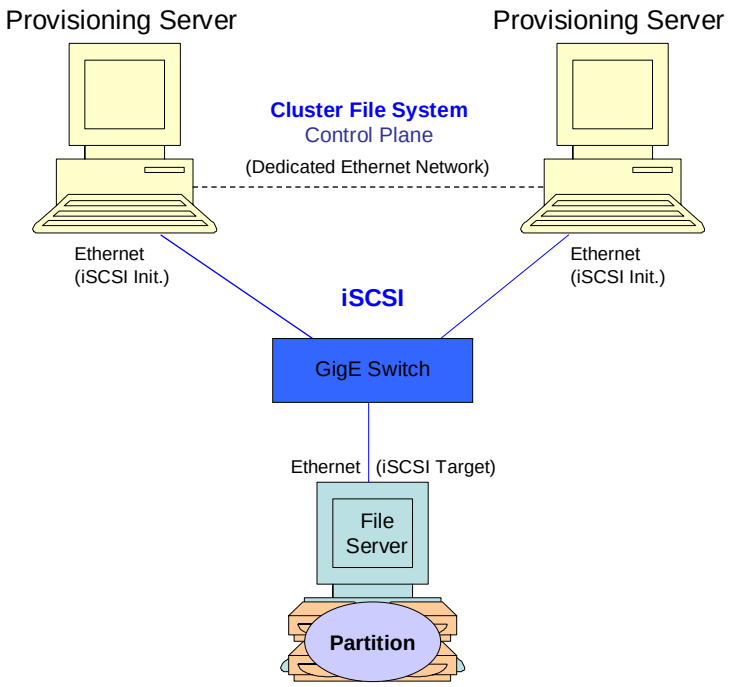
The following diagrams depict Provisioning Server deployments using an iSCSI SAN to store the PVS database and vDisks. In all illustrations, Provisioning Servers consist of an HP ProLiant DL380 G4 and a Dell PowerEdge 2850. In the first two diagrams, the iSCSI Targets are File Servers and in the last two diagrams, the iSCSI Target(s) is a storage array.

Configuration A shows one File Server with a single GigE connection to the network.

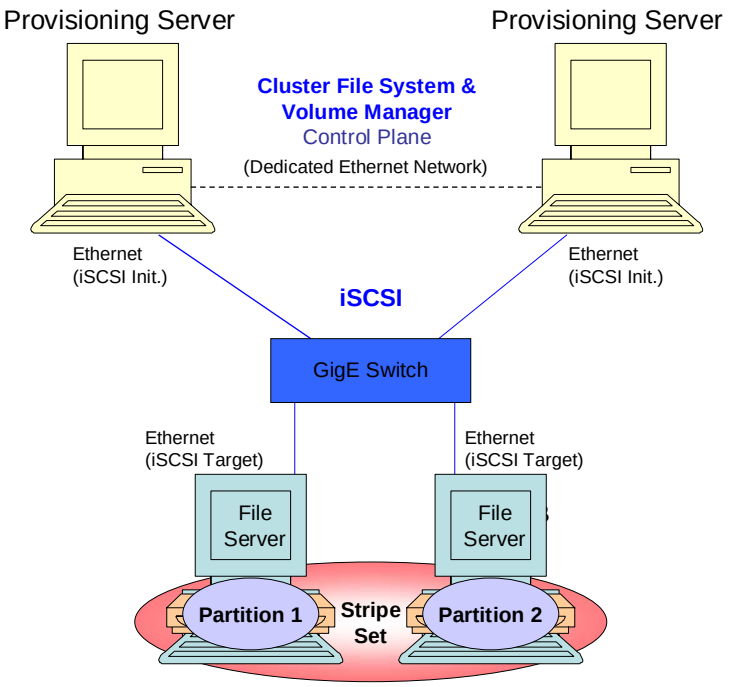
Configuration B shows two File Servers, each with a GigE connection to the network, serving two partitions combined into a single stripe-set to improve I/O performance.

Configuration C shows a single processor storage array with a GigE connection to the network.

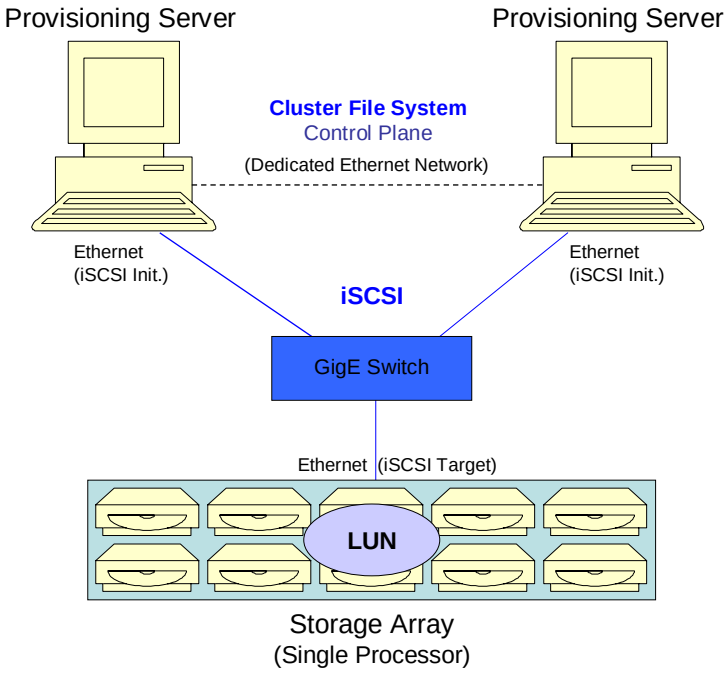
Configuration D shows a dual processor storage array with two GigE connections to the network, serving two LUNs combined into a single stripe-set to improve I/O performance.



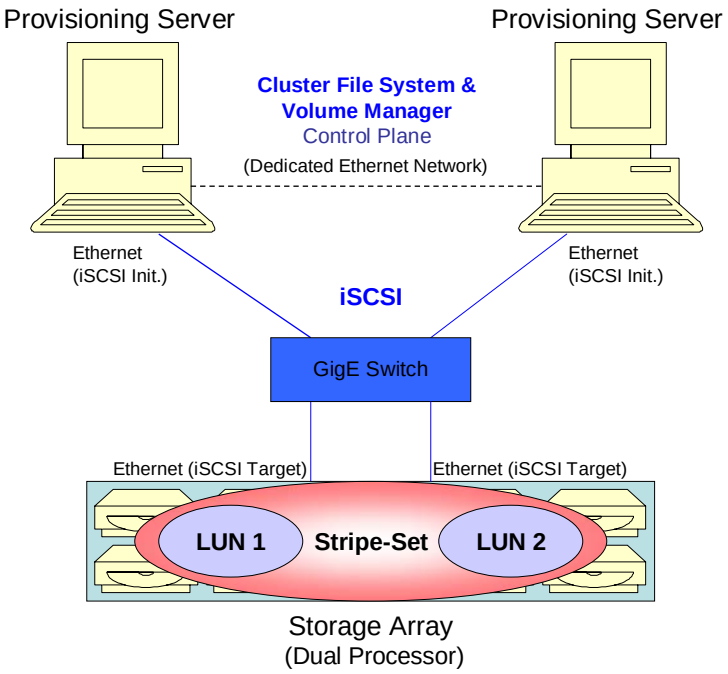
Configuration A



Configuration B



Configuration C



Configuration D

Delivering a Highly Available Provisioning Server using a Fibre Channel SAN

Pros:

- Highest levels of performance.
- Most options available for improving I/O performance:
  - Use multiple network connections between each Provisioning Server and the storage array.
  - Use 4Gbps. network connections between each Provisioning Server and the storage array.
  - Use one or more Fibre Channel (FC) switches to provide multiple point-to-point connections simultaneously between Provisioning Servers and the storage array.
  - Install higher-performance drives such as SCSI or SAS.
  - Use a higher-end storage array with multiple I/O controllers.
- Highest levels of reliability via built-in redundant components and features:
  - The storage array includes redundant cooling fans and power supplies.
  - The storage array includes multiple interfaces for load-balancing and redundancy.
  - The storage array should include multiple I/O controllers for redundancy.
  - Drives can be grouped and configured to operate in a RAID array.
- Greatest degree of scalability to support target device expansion:
  - Additional bandwidth can be provided using multiple network connections between each Provisioning Server and the storage array via a FC switch.
  - Additional FC switches can be installed to load-balance I/O demands amongst multiple I/O controllers.
  - Additional drives or better-performing drives can be installed in the storage array to support the increase in I/O demands.
  - Multiple LUNs can be created on multiple RAID arrays and combined into a single stripe-set, utilizing the additional disk heads to support the increase in I/O demands.

Cons:

- Most expensive to purchase, implement and maintain.
- Requires software to manage the storage array.
- Most amount of hardware and software required to implement a Fibre Channel SAN:
  - Fiber cables, FC HBAs, FC switches, FC storage array.
  - Fiber channel HBA drivers and multipath I/O software must be installed and configured on each Provisioning Server.
  - Uses a LUN created on a storage array to store the PVS database and vDisks.
  - Uses Fibre Channel to connect Provisioning Servers to the storage array.
  - Uses zones and LUN masking configured on the FC switches to control access to LUNs.
  - Uses a Cluster or Parallel File System to ensure the integrity of the LUNs containing the PVS database and vDisks.
- RAID arrays and LUNs must be configured on the storage array and assigned to each Provisioning Server.

Fibre Channel SAN Sample Topologies:

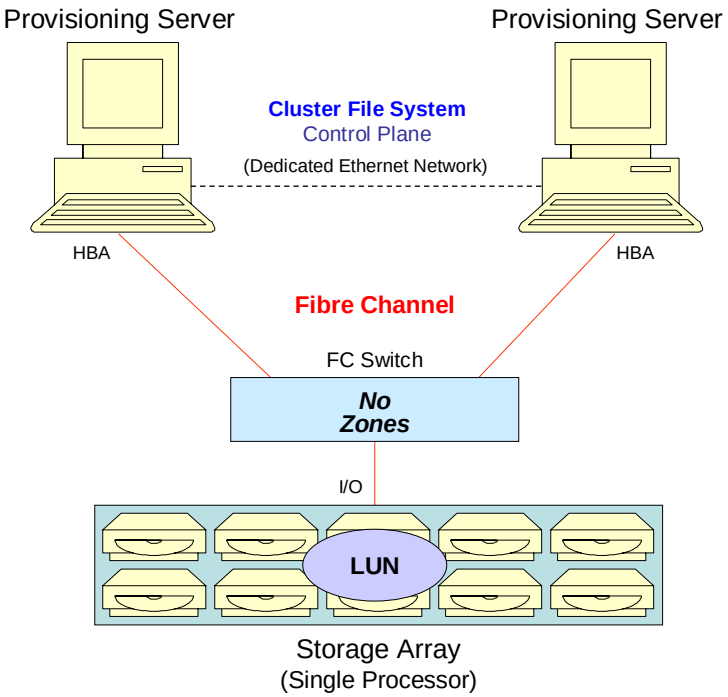
The following diagrams depict Provisioning Server deployments using a Fibre Channel SAN to store the PVS database and vDisks. In all illustrations, Provisioning Servers consist of an HP ProLiant DL380 G4 and a Dell PowerEdge 2850.

Configuration A shows a single processor storage array with a 2Gbps. connection to a FC switch.

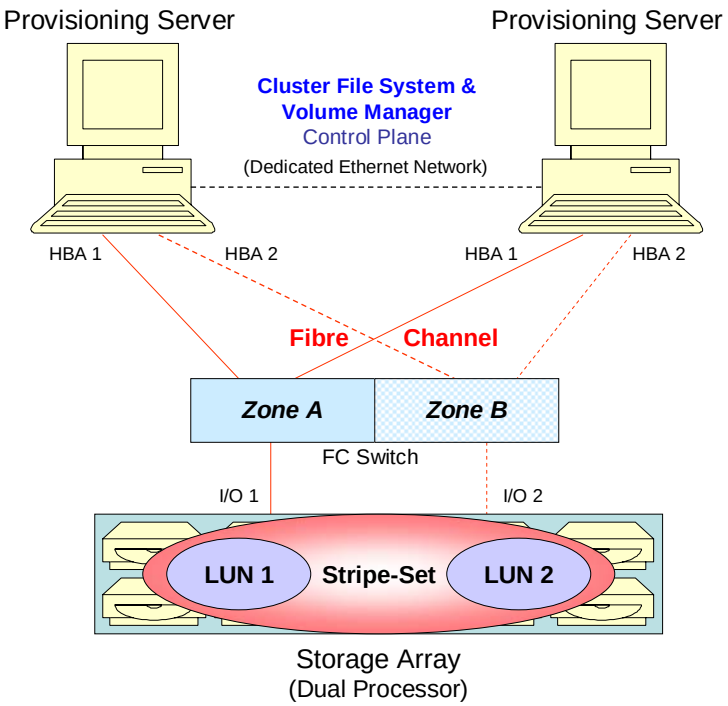
Configuration B shows a dual processor storage array with two 2Gbps. connections to a zoned FC switch, serving two LUNs combined into a single stripe-set to improve I/O performance.

Configuration C shows a dual processor storage array with four 2Gbps. connections to a zoned FC switch, serving two LUNs combined into a single stripe-set to improve I/O performance.

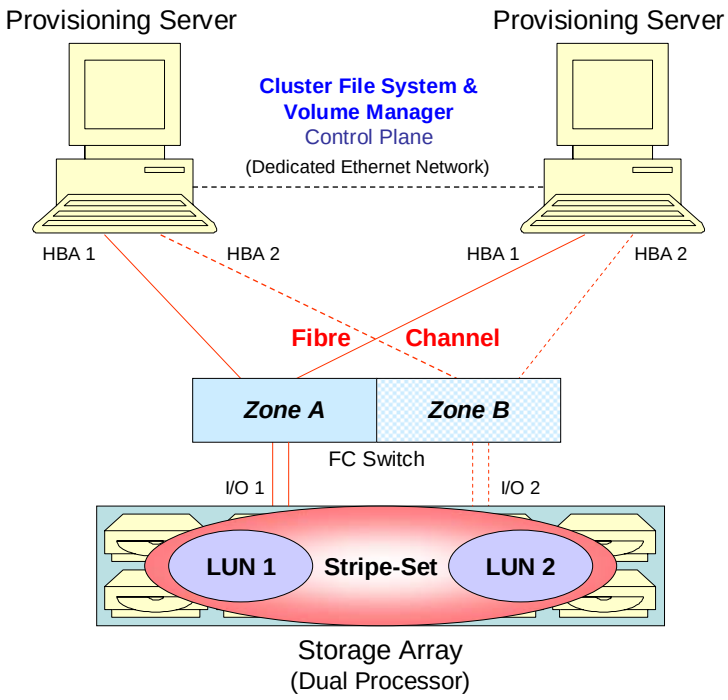
Configuration D shows a dual processor storage array with four 2Gbps. connections to two zoned FC switches, serving two LUNs combined into a single stripe-set to improve I/O performance.



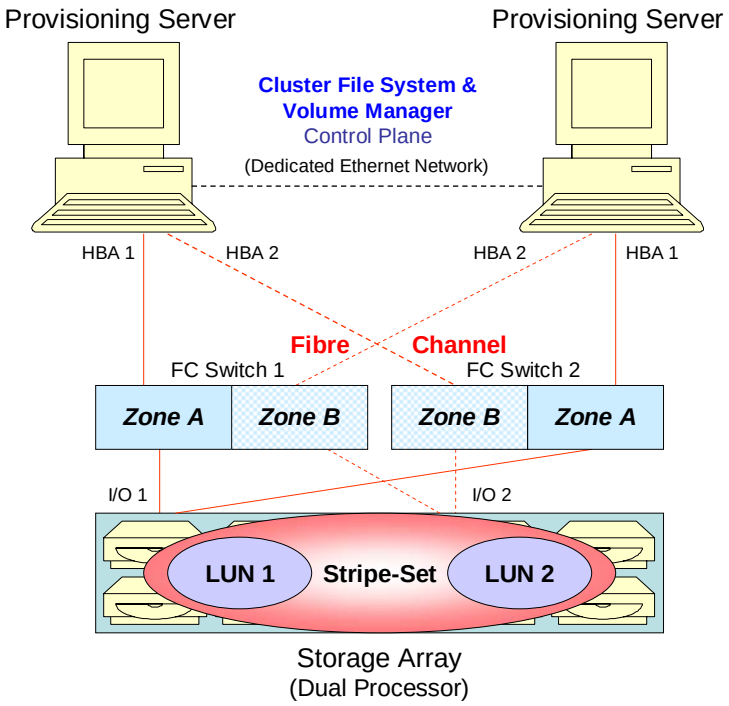
Configuration A



Configuration B



Configuration C



Configuration D

Shared Storage Technologies Benefits Comparison Chart

The following chart employs a scale from 1 to 5 (1 = the least benefit, 5 = the most benefit) to show which storage technologies offer the potential to realize the most benefit within each of the categories emphasized throughout this report.

	Cost	Ease of Use	Performance	Reliability	Scalability
Windows Share	**5**	**5**	**2**	**1**	**1**
NAS	**3**	**3**	**3**	**4**	**4**
iSCSI SAN	**3**	**3**	**4**	**5**	**5**
Fibre Channel SAN	**1**	**1**	**5**	**5**	**5**

Shared Storage Technologies Target Device Support Chart

The following chart shows the average number of target devices a highly available Provisioning Server can effectively support at optimal levels using the shared storage technologies presented in this report.

The data provided in this chart is based on tests conducted using a highly available Provisioning Server comprised of two Provisioning Servers streaming the OS, core applications, and configuration data using all options currently available for target device write caching. (See following page for test system details.)

While the information *should* be used as a guideline when planning the deployment of a highly available Provisioning Server, it is important to note that the numbers may vary depending on the make, model and performance capabilities of the components comprising the Provisioning Server, including the servers, target devices, storage systems and underlying network infrastructure.

	Windows Share	NAS	iSCSI SAN	Fibre Channel SAN
Private Image – Write to vDisk	25-50	50-75	75-100	100-125
Standard Image – Server Disk Caching	25-50	50-75	75-100	100-125
Standard Image – Target Device Disk Caching	50-100	100-200	200-300	300+
Standard Image – Target Device RAM Caching	50-100	100-200	200-300	300+

Note: The data provided above represents the number of target devices supported using non-optimized shared storage system configurations. It is strongly recommended that more advanced configurations, such as those portrayed in the diagrams depicted on the previous pages, be considered to support large scale target device deployments.

Highly Available Provisioning Server Test System Details

Provisioning Server specifications

- HP ProLiant DL380 G4
  - Intel Xeon CPU 3.40 GHz
  - 2GB RAM
  - HP NC7782 GigE integrated NIC (2), driver v10.24.0.0
  - Win2K3 Server Standard Edition with R2/SP1
  - Microsoft iSCSI Initiator software, driver v2.04.3273 (for iSCSI SAN tests)
  - QLogic 2340 Fibre Channel HBA, driver v9.1.4.15 (for Fibre Channel tests)
  - HP PolyServe Cluster File System v3.4 for Windows (for iSCSI and Fibre Channel SAN tests)
  - Sanbolic Melio FS 2008 Cluster File System (for iSCSI and Fibre Channel SAN tests)

- Dell PowerEdge 2850
  - Intel Xeon CPU 2.80 GHz
  - 3GB RAM
  - Intel Pro/1000MT GigE integrated NIC (2), driver v8.8.1.0
  - Win2K3 Server Standard Edition with R2/SP1
  - Microsoft iSCSI Initiator software, driver v2.04.3273 (for iSCSI SAN tests)
  - QLogic 2340 Fibre Channel HBA, driver v9.1.4.15 (for Fibre Channel tests)
  - HP PolyServe Cluster File System v3.4 for Windows (for iSCSI and Fibre Channel SAN tests)
  - Sanbolic Melio FS 2008 Cluster File System (for iSCSI and Fibre Channel SAN tests)

Target Device specifications

- Dell Optiplex GX520 (250)
  - Intel Pentium 4 CPU 2.80 GHz
  - 512MB RAM
  - Broadcom NetXtreme 57xx, GigE integrated NIC, driver v10.24.0.0
  - WinXP Professional Edition with SP2

Network specifications

- Extreme Networks Summit X450-24T 24-port GigE Core switch
- Extreme Networks Summit 400-48T 48-port GigE Distribution switches (2)
- NetGear GS524T 48-port GigE Edge switches (3)

Windows Share specifications

- Dell PowerEdge 2650 (hosting Windows Share)
  - Intel Xeon CPU 2.80 GHz
  - 2GB RAM
  - Broadcom NetXtreme 57xx GigE integrated NIC (2), driver v10.24.0.0
  - Win2K3 Server Standard Edition with R2/SP1

NAS specifications

- Adaptec Snap Server 4500 – GuardianOS v4.0.228

iSCSI SAN specifications

- Dell PowerEdge 2650 (hosting iSCSI SAN)
  - Intel Xeon CPU 2.80 GHz
  - 2GB RAM
  - Broadcom NetXtreme 57xx GigE integrated NIC (2), driver v10.24.0.0
  - Win2K3 Server, Standard edition R2/SP1
  - Microsoft iSCSI Target software, v3.0.1983

Fibre Channel SAN specifications

- Dell/EMC AX100 Clariion storage array (dual storage processor) – Flare OS v2.19.100.5.041
- Winchester Systems SA-3498R storage array (dual storage processor) – OS v3.47J
- Brocade SilkWorm 3250 8-port Fibre Channel switch

Storage Vendors List

The following list is presented exclusively for the convenience of our customers and does *not* constitute a recommendation by Citrix Systems on behalf of any of the vendors or their products.

Adaptec/SNAP- http://www.adaptec.com/ - NAS storage arrays

Agami Systems - http://www.agami.com/site/home - NAS storage arrays

BlueArc - http://www.bluearc.com/ - NAS storage arrays

Brocade/McData - http://www.brocade.com/index.jsp - Fibre Channel SAN switches

Cisco Systems - http://www.cisco.com/ - Fibre Channel switches, SAN storage arrays

Dell – http://www.dell.com/ - NAS storage arrays, Fibre Channel, iSCSI SAN storage arrays

EMC – http://www.emc.com/ - NAS storage arrays, Fibre Channel, iSCSI SAN storage arrays

EqualLogic - http://www.equallogic.com/ - iSCSI SAN storage arrays

Emulex - http://www.emulex.com/ - Fibre Channel Host Bus Adapters (HBAs), switches

Hitachi – http://www.hitachi.com/ - NAS storage arrays, hard drives

HP - http://www.hp.com/ - NAS storage arrays, Fibre Channel SAN storage arrays

IBM - http://www.ibm.com/us/ - Servers for NAS, hard drives

Ibrix - http://www.ibrix.com/ - Cluster File System

Lefthand Networks - http://lefthandnetworks.com/ - iSCSI SAN storage arrays

LSI Logic - http://www.lsi.com/ - Fibre Channel HBAs

Microsoft - http://www.microsoft.com/en/us/default.aspx - Servers for NAS and iSCSI SANs

Network Appliance - http://www.netapp.com/ - NAS storage arrays

Nexsan - http://www.nexsan.com/ - Fibre Channel SAN storage arrays

PolyServe (HP) - http://www.polyserve.com/ - NAS File Services, Parallel File System

QLogic - http://www.qlogic.com/ - Fibre Channel HBAs, Fibre Channel switches

Quantum – http://quantum.com/ - Cluster File System, Data Storage Management software

Sanbolic - http://www.sanbolic.com/ - Cluster File System

Sun Microsystems - http://www.sun.com/ - Servers for NAS

Winchester Systems - http://www.winsys.com/ - Fibre Channel, iSCSI SAN storage arrays

Conclusion

Delivering a highly available Citrix Provisioning Server as the foundation of application delivery and server virtualization infrastructures, IT Administrators are offered the peace of mind to focus on the numerous other tasks they are confronted with on a daily basis, confident that the system they rely on to meet the ever-increasing demands of their enterprise environments provides the dependability they require when server hardware or network connectivity issues arise.