# Technical white paper

## HP 3PAR StoreServ Storage and VMware vSphere 5 best practices

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Executive summary

When supported with the correct underlying storage platform, server virtualization delivers greater consolidation, administrative efficiency, business continuity and cost savings. As a result, server virtualization is not only transforming the data center, but also the businesses that those data centers fuel. However, these transformative results depend on enterprise class storage to deliver the performance, availability, and flexibility to keep up with the dynamic and consolidated nature of virtualized server environments.

HP 3PAR StoreServ Storage is the next generation of federated Tier 1 storage and was built from the ground up to exceed the economic and operational requirements of virtual data centers and cloud computing environments by providing the SAN performance, scalability, availability and simplified management that clients need. It does this through an innovative system architecture that offers storage federation, secure multi-tenancy, built-in thin processing capabilities, and autonomic management and storage tiering features that are unique in the industry.

When deployed together, VMware vSphere and HP 3PAR StoreServ Storage deliver a compelling virtual data center solution that increases overall resource utilization, provisioning agility, application availability, administrative efficiency, and reduces both capital and operating costs.

Implementing HP 3PAR StoreServ Storage systems with VMware vSphere 5 enables its users the unique ability to:

• Increase consolidation savings by doubling virtual machine density\(^1\)
• Maximize savings through lower storage costs by up to 50%
• Simplify storage provisioning and management time by up to 90%

Figure 1. HP 3PAR StoreServ Storage for VMware vSphere Environments

These benefits in VMware environments are delivered through a combination of HP 3PAR StoreServ advanced features and integration with VMware storage technologies (Figure 1).

**Increase Consolidation:** Integrating HP 3PAR StoreServ Storage systems with VMware vSphere 5 enables its users to double virtual machine density on physical servers through wide striping, mesh-active clustered architecture, mixed workload support, and hardware assisted support of VMware vSphere Storage APIs for Array Integration (VAAI).

**Simplify Administration:** Managing storage in VMware environments is simplified through unique HP 3PAR StoreServ capabilities such as Autonomic Groups, Recovery Manager for VMware software, and integrated management through VMware vCenter Server with the HP Insight Control Storage Module for vCenter.

**Maximize Savings:** HP 3PAR StoreServ leading edge thin technologies, including Thin Provisioning, Thin Conversion, and Thin Persistence with in-line zero detect capability of the HP 3PAR StoreServ hardware ASIC, deliver the ultimate in storage efficiency in VMware environments.

This white paper outlines best practices on how to set up HP 3PAR StoreServ Storage with VMware vSphere 5 as well as how to take advantage of HP 3PAR StoreServ’s unique features such as vSphere integration, HP 3PAR Thin Provisioning technologies, Dynamic and Adaptive Optimization, Priority Optimization, and HP 3PAR Recovery Manager for VMware to

\(^1\) The HP Get Virtual Guarantee program guarantees that you’ll achieve 2x the VM density on the physical servers in your existing VMware vSphere environment when you migrate from your traditional, legacy storage to HP 3PAR StoreServ Storage.
create a world class virtualized IT and application infrastructure. The information contained in this document should be used along with the documentation set provided by HP for the HP 3PAR StoreServ Storage system, HP 3PAR Operating System, and the documentation provided by VMware for vCenter, Site Recovery Manager (SRM), and other related products.

**Target audience:** IT Administrators and Solution Architects planning to leverage HP 3PAR StoreServ Storage within a VMware vSphere 5 environment.

This white paper is based on testing performed in February 2014 with HP 3PAR OS 3.1.3 and VMware vSphere 5.5. Recommendations in this document also apply to prior versions of HP 3PAR OS 3.1.x and VMware vSphere 5.x unless specifically noted.

**Configuration**

There are several best practices when configuring an HP 3PAR StoreServ array with VMware vSphere 5 as well as in general with any Fibre Channel, FCoE or iSCSI implementation. HP 3PAR OS 3.1.2 MU2 added support for FCoE Target (or FCoE end to end) connectivity with HP 3PAR StoreServ 7000 and 10000 storage arrays. This section will describe the best practices when leveraging Fibre Channel, FCoE or iSCSI networking and an HP 3PAR StoreServ array to an ESXi host, configuring multi-pathing on an ESXi host, and describe the benefits of HP 3PAR Peer Persistence.

**Fibre Channel and iSCSI support**

**Target port limits and specifications**

To ensure an optimal configuration, observe the following limitations on ESXi host server ports and HP 3PAR StoreServ Storage target ports:

- Maximum of 128 host Fibre Channel initiators per HP 3PAR StoreServ Storage port
- Maximum of 64 iSCSI/FCoE host initiators per HP 3PAR StoreServ Storage port
- Maximum total host initiators per HP 3PAR StoreServ Storage system are:

<table>
<thead>
<tr>
<th>HP 3PAR StoreServ Storage model</th>
<th>Maximum host initiators</th>
</tr>
</thead>
<tbody>
<tr>
<td>7200</td>
<td>1024</td>
</tr>
<tr>
<td>7400 and 7450</td>
<td>2048</td>
</tr>
<tr>
<td>10400</td>
<td>4096</td>
</tr>
<tr>
<td>10800</td>
<td>8192</td>
</tr>
</tbody>
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On HP 3PAR StoreServ Storage, the Host Bus Adapters have multiple ports and the I/O queue depth limits are per port. The I/O queue depth for each HP 3PAR StoreServ Storage system HBA model is shown in Table 1. Note that the I/O queues are shared among the connected host server ports on a first-come, first-served basis. For recommendations on managing I/O queues for optimal performance, please see the Storage I/O Control and Adaptive queue depth throttling sections in this document.

**Table 1. I/O queue depth for HP 3PAR StoreServ Storage HBAs**

<table>
<thead>
<tr>
<th>HBA</th>
<th>Protocol</th>
<th>Array</th>
<th>Bus</th>
<th>Speed</th>
<th>Ports</th>
<th>Max. queue depth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Emulex LP11002</td>
<td>Fibre Channel</td>
<td>F200, F400, T400, T800</td>
<td>PCI-X</td>
<td>4 Gb/s</td>
<td>2</td>
<td>959</td>
</tr>
<tr>
<td>3PAR FC044X</td>
<td>Fibre Channel</td>
<td>F200, F400, T400, T800</td>
<td>PCI-X</td>
<td>4 Gb/s</td>
<td>4</td>
<td>1638</td>
</tr>
<tr>
<td>QLogic QLA4052C</td>
<td>iSCSI</td>
<td>F200, F400, T400, T800</td>
<td>PCI-X</td>
<td>1 Gb/s</td>
<td>2</td>
<td>512</td>
</tr>
<tr>
<td>Emulex LPe12002</td>
<td>Fibre Channel</td>
<td>StoreServ 7000</td>
<td>PCIe</td>
<td>8 Gb/s</td>
<td>2</td>
<td>3276</td>
</tr>
<tr>
<td>Emulex LPe12004</td>
<td>Fibre Channel</td>
<td>V400, V800, StoreServ 7000, StoreServ 10000</td>
<td>PCIe</td>
<td>8 Gb/s</td>
<td>4</td>
<td>3276</td>
</tr>
<tr>
<td>QLogic QLEB242</td>
<td>FCoE</td>
<td>V400, V800, StoreServ 7000, StoreServ 10000</td>
<td>PCIe</td>
<td>10 Gb/s</td>
<td>2</td>
<td>1748</td>
</tr>
<tr>
<td>QLogic QLEB242</td>
<td>iSCSI</td>
<td>V400, V800, StoreServ 7000, StoreServ 10000</td>
<td>PCIe</td>
<td>10 Gb/s</td>
<td>2</td>
<td>2048</td>
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</table>
Creating the host definition
Before exporting VLUNs from HP 3PAR StoreServ Storage to the ESXi host, you need to create a host definition that specifies a valid host OS for each system that is to be connected to the HP 3PAR StoreServ Storage. The host OS may be specified when creating the host definition, or the host definition may be edited as shown in Figure 2. Set the Host OS field to ESX 4.x/5.x. Host definitions may be created to use either Fibre Channel or iSCSI ports by choosing WWN or iSCSI names.

Figure 2. Set Host OS to ESX 4.x/5.x

Alternatively, the createhost or sethost command may be used to set or change the OS setting from the 3PAR CLI:

```
# createhost -persona 11 -os VMware [-iscsi] <hostname> [WWN or iSCSI Name...]
# sethost -persona 11 -os VMware <hostname>
```

Note
HP 3PAR OS version 3.1.2 introduced a new Host Persona (11) for VMware which enables asymmetric logical unit access (ALUA) functionality. Older implementations used Host Persona 6 for VMware hosts. HP 3PAR OS 3.1.3 will be the last release to support both Persona 6 and Persona 11 for VMware. When creating new host definitions using the 3PAR Management Console, selecting a Host OS type “ESX 4.x/5.x” will assign a persona of 11. When using the 3PAR CLI, it is necessary to specify the -persona option, and -persona 11 is recommended for HP 3PAR OS 3.12 and higher.
When changing an existing host persona from 6 to 11, a host reboot is required for the change to take effect. This is an offline process. In a VMware clustered environment, VM guests can be migrated to other cluster hosts using Live Migration to avoid any application down time. The host persona change should coincide with changing custom SATP rules on the host as well. See Automating Round Robin policy for all LUNs for details.

**Persistent Ports**

The Persistent Ports (or virtual ports) feature minimizes I/O disruption during an HP 3PAR Storage online upgrade or node-down event. Persistent Ports allows an HP 3PAR Storage port to assume the identity (port WWN for Fibre Channel or IP address for iSCSI ports) of a failed port while retaining its own identity. Persistent Ports for FCoE ports are also supported to the same extent as for iSCSI ports. The solution uses the NPIV feature for Fibre Channel and FCoE or IP address failover for iSCSI. This feature does not support direct-connect mode and is supported only on target ports that connect to the fabric where both the active and partner ports share the same fabric.

Each Fibre Channel port has a partner port automatically assigned by the system. Where a given physical port assumes the identity of its partner port, the assumed port is designated as a persistent port. Array port failover and failback with Persistent Ports is transparent to most host-based multipathing software which, in most cases, can keep all its I/O paths active.

The Persistent Ports feature is activated by default during node-down events (online upgrade or node reboot). Port shutdown or reset events do not trigger this feature. Persistent Ports is enabled by default for Fibre Channel ports starting with HP 3PAR OS 3.1.2. Persistent Port support for iSCSI and FCoE ports was added in the HP 3PAR OS 3.1.3 release. Note that no modifications are required on the ESXi hosts to take advantage of Persistent Ports, but VMware multipathing should also be configured on the host(s) for maximum availability.

**Multipathing considerations**

To maintain a constant connection between an ESXi host and its storage, vSphere supports multipathing. To take advantage of this support, virtual volumes should be exported to multiple paths to the host server. To do this, create a host definition on the HP 3PAR StoreServ Storage system that includes the World Wide Names (WWNs) of multiple HBA ports on the host server and then export the VLUNs to that host definition. For an ESXi cluster, the VLUNs must be exported to all of the host definitions for the cluster nodes, or a host set may be created containing all of the servers and the VLUNs can be exported to the host set.

**Setting Round Robin path policy**

VMware vSphere includes active/active multipath support to maintain a constant connection between the ESXi host and the HP 3PAR StoreServ Storage array. Three path policies are available, “Fixed”, “Most Recently Used” and “Round Robin”. For HP 3PAR StoreServ storage, Round Robin is the recommended policy for best performance and load balancing; however, it may not be enabled by default. The path policies can be viewed and modified from the vSphere Web Client on a per datastore basis as follows:

1. In the vSphere Web Client, select the datastore.
2. Select the Manage tab, then the Settings tab, and then click on Connectivity and Multipathing.
3. Select one of the ESXi hosts and then click the Edit Multipathing button (highlighted in red in Figure 3).
4. In the pop-up window, select Round Robin from the Path selection policy drop-down menu (as shown in Figure 4).
5. Click the OK button to save the new setting.
6. Repeat steps 3 through 5 for each ESXi host.
**Figure 3.** Edit multipathing policy

![Figure 3](image)

Figure 4 shows an example of an HP 3PAR StoreServ Fast Class VLUN that has the Round Robin path policy. Note that the status for all eight paths to the LUN is "Active (I/O)"

**Figure 4.** LUN set to Round Robin path policy

![Figure 4](image)

**Setting iops option for Round Robin policy**

Managing a Round Robin I/O path policy scheme through the vSphere Web Client on a per datastore basis does not allow setting important Round Robin policy details that can be specified when using the command line on the ESXi host. To achieve better load balancing across paths, the `--iops` option may be issued on the command line to specify that the path should be switched after performing the specified number of I/Os on the current path. By default, the `--iops` option is set to 1000. The recommended setting for HP 3PAR Storage is 1, and this setting may be changed as needed to suit the demands of various workloads.

To set the Round Robin policy for a specific device, use the following command:

```
# esxcli storage nmp device set --device <device-name> --psp VMW_PSP_RR
```
To set the device specified by --device to switch to the next path after 1 I/O operation has been performed on the current path, use the following command:

```
# esxcli storage nmp psp roundrobin deviceconfig set --type=iops --iops=1 --device <device-name>
```

### Automating Round Robin policy for all LUNs

Note that in Figure 3, the Storage Array Type Policy is VMW_SATP_ALUA (highlighted in green). VMware native multipathing has two key plugins: a storage array type plugin (SATP) that determines how path failover is handled, and a path–selection plugin (PSP) that decides which path is used to issue an I/O request to a storage device. The SATP VMW_SATP_ALUA is mapped to the PSP VMW_PSP_MRU, which is the Most Recently Used path policy. SATP rules can be edited or created using esxcli commands on the ESXi host to automatically achieve a Round Robin path policy for newly discovered LUNs.

Use the following command to create a custom SATP rule that will allow the ESXi host to configure the HP 3PAR LUNs to use Round Robin multipath policy. The command must be executed on each ESXi host that is connected to the HP 3PAR array.

```
# esxcli storage nmp satp rule add -s "VMW_SATP_ALUA" -P "VMW_PSP_RR" -O "iops=1" -c "tpgs_on" -V "3PARdata" -M "VV" -e "HP 3PAR Custom Rule"
```

Verify the new rule using the following command:

```
# esxcli storage nmp satp rule list | grep "3PARdata"
```

The new rule will be effective when adding new devices to the ESXi host, but not for existing devices. Existing devices continue to use VMW_SATP_ALUA with VMW_PSP_MRU by default. For existing LUNs, either a host reboot is required, or the path policy must be set for each LUN.

### HP 3PAR Peer Persistence

HP 3PAR Peer Persistence software enables HP 3PAR StoreServ systems located at metropolitan distances to act as peers to each other, presenting a nearly continuous storage system to hosts and servers connected to them. This capability allows you to configure a high-availability solution between two sites or data centers where failover and failback remains completely transparent to the hosts and applications running on those hosts.

Compared to the traditional failover models where upon failover the hosts must be restarted, the Peer Persistence software allows hosts to remain online serving their business applications even when they switch from their original site to the second site, resulting in a much improved recovery time. The Peer Persistence software achieves this key enhancement by taking advantage of the Asymmetric Logical Unit Access (ALUA) capability that allows paths to a SCSI device to be marked as having different characteristics.

The Peer Persistence software allows you to use both primary and secondary sites in an “active–active mode” thereby putting your secondary site to active use rather than just using it as an expensive insurance policy against disaster. It enables you to move your VMs from one site to another based on your business and performance needs without impacting the applications running on those VMs.

An example would be the use of vMotion within a VMware vSphere Metro Storage Cluster (vMSC). vMSC allows a vSphere cluster to span across data centers (Figure 5). In the figure, a few virtual machines (VMs) are being serviced by an HP 3PAR storage system on site 1 while other VMs are being serviced by another HP 3PAR storage system at site 2 located within metropolitan distance from site 1. vMotion allows customers to move VMs across sites.

As seen in Figure 5 each host is connected to each HP 3PAR StoreServ on both sites via redundant fabric. Additionally, each volume maintains a synchronous copy of itself at the other site. While a primary volume on site 1 is exported in a read/write mode, its corresponding secondary volume on site 2 is exported in a read-only mode.

For example, in the figure, Volume A (source) and Volume A (target) are being exported to hosts at each site with a common WWN. However, volume paths for a given volume are “active” only on the HP 3PAR StoreServ where the “source” copy of the volume resides. In the figure, for Volume A (source), the path is active on HP 3PAR StoreServ A on Site 1 whereas for Volume B (source), the path is active on HP 3PAR StoreServ B on Site 2.

In a managed switchover scenario, when VMs from Site 1 failover to Site 2, the paths marked passive for their host’s target volumes become active and the hosts continue to access volumes with the same WWNs as they were accessing prior to the failover. This transparent failover capability enabled by the Peer Persistence software, with the help of the 3PAR StoreServ Quorum Witness (QW) software, protects customers from unplanned host and application outage. The Quorum Witness software should be installed at a third site, outside the cluster environment, and should not be on the 3PAR arrays used in the Peer Persistence deployment. It will act as an independent witness should one of the arrays or data centers become unavailable. For more information on configuring this environment and additional best practices, please see the technical white paper “Implementing vSphere Metro Storage Cluster using HP 3PAR Peer Persistence” at http://h20195.www2.hp.com/V2/GetDocument.aspx?docname=4AA4-7734ENW.
Figure 5. Transparent failover with HP 3PAR Peer Persistence

Note that under standard storage infrastructure, as the VMs move from site 1 to site 2, it forces presentation of new virtual volumes to those VMs, resulting in a forced reset of the VMs before continuing their operations.

The Peer Persistence software addresses this very limitation by presenting a host with the “same” virtual volume even when it moves across data centers. In other words, movement of VMs across data centers becomes completely transparent to the applications running on those VMs.

Please note the following details about the requirements and packaging for the Peer Persistence software:

- HP 3PAR Remote Copy is a prerequisite for Peer Persistence. The Peer Persistence software works with HP 3PAR Remote Copy synchronous mode only.
- The Peer Persistence license is required on both primary and secondary HP 3PAR StoreServ systems (just like HP 3PAR Remote Copy).
- For HP 3PAR StoreServ 10000, 7450 and 7000 systems, Peer Persistence is included in the Replication Suite while also being available as a separate title. For other supported HP 3PAR systems, Peer Persistence is available as a separate software title.
- The round trip latency between the two sites must be 2.6 milliseconds or less.
- The ESXi hosts must be configured using 3PAR host persona 11.
- Host HBA timeouts must not exceed 30 seconds.

Summary

When configuring an HP 3PAR StoreServ Storage for use in a VMware vSphere environment, it is important to follow the recommendations for the maximum number of host server ports per HP 3PAR StoreServ Storage target ports, 128 Fibre Channel host initiators per 8Gb port and 64 iSCSI/FCoE host initiators per port. When configuring multipathing, the Round Robin path policy is recommended for best performance and load balancing. The 3PAR Peer Persistence software allows you to configure a high-availability solution between two sites or data centers, where failover and failback is transparent to the hosts and applications running on those hosts.
Overview and configuration of VMware vSphere Storage API Integration

HP and VMware deliver advanced integration between HP 3PAR StoreServ Storage and VMware vSphere 5 with vSphere Storage APIs for Array Integration (VAAI), HP Insight Control Storage Module (ICSM), and HP StoreFront Analytics for VMware vCenter Operations Manager (vCOps). This section will provide an overview of the APIs and HP plugins as well as how to configure and leverage them.

VAAI (vSphere Storage APIs for Array Integration)

The vSphere Storage APIs are a set of technologies and interfaces that enable vSphere to leverage storage resources to deliver the efficiency, control, and ease of customization that clients demand of their virtual environment. The vSphere Storage APIs for Array Integration (VAAI) is one of these technologies. Under the VAAI initiative, APIs have been introduced to improve performance, resource utilization, and scalability by leveraging more efficient array-based operations.

vSphere 5 provides enhanced support for the T10 SCSI standard without the need to install a plug-in, enabling vSphere to directly utilize more advanced features of the storage array. With other storage arrays, including HP 3PAR StoreServ Storage before the release of HP 3PAR OS version 3.1.1, that do not natively support the T10 SCSI standard, a VAAI plug-in is needed to use the VAAI capabilities VMware offers. To manage a VAAI capable device, your host attaches the VAAI filter and vendor-specific VAAI plug-in to the device. Because of the native T10 support built into HP 3PAR OS 3.1.1 and greater, this is not needed and as a result your ESXi host can communicate directly to HP 3PAR StoreServ Storage and does not require the VAAI plug-ins.

Some of the important hardware primitives that VAAI enables are documented below:

**Hardware Assisted Locking** eliminates SCSI reservation contention by providing a fast, fine-grained locking mechanism. The ATS (“Atomic Test and Set”) command verifies that a block of metadata is what is expected (test) and then replaces it with an updated block (set) in a single, atomic operation. Using this command, the ESXi host can lock a portion of a LUN related to a single VM instead of locking the whole LUN as seen in Figure 6, thereby allowing other VMs on the same LUN to continue operating normally. The implementation of ATS on HP 3PAR StoreServ Storage arrays uses the HP 3PAR StoreServ ASIC to further improve performance. The combination of ATS and the HP 3PAR StoreServ ASIC allows an increase in VM density per LUN and greater scalability for vSphere deployments.

**Fast Copy** uses the XCOPY command to improve the performance of common storage operations, such as VM cloning and Storage vMotion, by performing large data movement operations directly within the storage array. By not requiring each block to make a round-trip to the host, the time required for these operations is significantly reduced and storage network traffic minimized. When combined with HP 3PAR Thin Persistence Software, drive I/O and storage capacity can also be reduced since blocks of zeros are not written due to the array’s Zero Detect capability, which is integrated into the HP 3PAR StoreServ ASIC.

**Block Zeroing** uses the standard SCSI command WRITE_SAME to offload large, block-level write operations of zeros from the host to the storage array. Block zeroing improves host performance and efficiency when allocating or extending Eager Zeroed Thick (EZT) virtual disks, or on initial access to a block on a non-EZT virtual disk. When combined with built-in Zero Detect and EZT virtual disks, storage array bandwidth, disk I/O bandwidth, and disk consumption is minimized. Initializing
EZT virtual disks in seconds rather than minutes eliminates the tradeoff between fast VM creation and more predictable run-time performance.

Figure 7 shows the HP 3PAR storage system supports VAAI using the “esxcli storage core device list” command.

**Figure 7.** Storage VAAI capable support

```
# esxcli storage core device list -d \n\nDisplay Name: 3PARdata Fibre Channel Disk (\nDevice Type: Direct-Access
Multipath Plugin: NHP
Device Path: /dev/devices/disks/\nVendor: 3PARdata
Model: J:0
Revision: 3123
SCSI Level: 6
Is Pseudo: false
Status: on
Is R RX Capable: true
Is Local: false
Is Removed: false
Is Offline: false
Is Permanently Reserved: false
Queue Full Sample Size: 0
Queue Full Threshold: 0
Thin Provisioning Status: unmap
Attached Filters:
VAAI Status: supported
```

**VAAI UNMAP command**

One of the features that has been updated in vSphere 5.5 is VAAI Thin Provisioning Block Space Reclamation (UNMAP). UNMAP is a SCSI primitive that allows VMFS to communicate to the storage target that certain blocks are no longer used on a LUN backing a datastore. Using the UNMAP command, vSphere can issue a command to the storage array to un-allocate blocks of storage freed by vSphere, for example from a deletion of a VM, and return it to the storage array’s resource pool without the involvement of a storage administrator.

Figure 8 shows the UNMAP status using the “esxcli system settings advanced list” command, where a value of 1 indicates that UNMAP is enabled.

**Figure 8.** VAAI UNMAP status

```
# esxcli system settings advanced list --option /VMFS3/EnableBlockDelete
Type: int
100 Value: 1
Default Int Value: 0
Min Value: 0
Max Value: 1
String Value:
Default String Value:
Valid Characters:
Description: Enable VMFS block delete
```

vSphere 5.5 introduced a new simpler UNMAP command, as part of the overall thin provisioning primitive:

```
# esxcli storage vmfs unmap --volume-label=<label> | --volume_uuid=<uid> [-reclaim-unit=<blocks>]
```
The new UNMAP command replaces the deprecated vmkfstools command. It includes a --reclaim-unit option which specifies the number of VMFS blocks to UNMAP per iteration, which has a default value of 200 blocks (i.e. 200 MB for VMFS-5). Internal testing with an HP 3PAR StoreServ array has shown that specifying a large value for reclaim-unit can yield a substantial improvement in the amount of time required for the new UNMAP command to complete as compared to the vmkfstools command (note that results may vary depending upon the configuration and load on the storage array)²:

<table>
<thead>
<tr>
<th>Disk space reclaimed</th>
<th>Duration with vmkfstools --y 99% (min:sec)</th>
<th>Duration with unmap --reclaim-unit=12800 MB (min:sec)</th>
</tr>
</thead>
<tbody>
<tr>
<td>150 GB</td>
<td>8:37</td>
<td>2:48</td>
</tr>
<tr>
<td>720 GB</td>
<td>34:32</td>
<td>21:23</td>
</tr>
</tbody>
</table>

For more information on VMware vSphere VAAI and HP 3PAR storage, please see the VMware vSphere VAAI for HP 3PAR Storage performance benefits technical paper: http://h20195.www2.hp.com/V2/GetDocument.aspx?docname=4AA4-2864ENW

**HP Insight Control Storage Module (ICSM) for VMware vCenter**

**Note**
The HP 3PAR Management Software Plug-in for VMware vCenter is no longer needed as ICSM 7.3 includes VASA functionality and 3PAR Recovery Manager for VMware.

HP Insight Control for VMware vCenter Server seamlessly integrates the manageability features of HP ProLiant, HP BladeSystem, HP Virtual Connect, and HP Storage inside VMware vCenter Server. Administrators gain insight and control of their HP infrastructure supporting their VMware virtualized environment from a single pane of glass – reducing the time it takes to make important decisions, increase capacity, and manage planned and unplanned downtime. The single download includes three modules:

- Recovery Manager for VMware (RMV): Manages recovery sets of HP 3PAR StoreServ storage systems
- Server module: Licensed with HP Insight Control and manages HP ProLiant servers, HP BladeSystem, and HP Virtual Connect.
- Storage module: Free to use with HP Storage and leverages deep capabilities of HP's portfolio of storage arrays while providing a consistent view, regardless of the HP storage type.

Use the Storage module to:

- Monitor the status and health of HP storage systems
- View detailed storage configuration including thin-provisioning, replications, and paths data
- View relationships between the virtual and physical environment
- Change the direction of peer-persistent relationships (does not migrate VMs to active array in 7.3 release)
- Provision datastores and virtual machines easily:
  - Create, delete and expand datastores
  - Create new virtual machines onto new datastores in one easy step
  - Clone virtual machines using array-based snapshot and snap clone technologies
  - Delete orphan volumes

² VMworld US 2013 session STO4907 "Capacity Jail Break: vSphere 5 Space Reclamation Nuts and Bolts"
Figure 9. A Storage summary screen for a host provides quick, at a glance view of HP storage systems and datastores.
The Storage module enhances VMware functionality by detailing the relationships between the virtual and physical environment. For example, Figure 10 shows the mapping from the virtual machine to the array on which it resides. Understanding the physical infrastructure is crucial for making well-informed decisions when designing, deploying, maintaining, and troubleshooting a virtual environment.

**Figure 10.** The Storage Module of the plug-in provides mapping from the virtual to the physical environment. Notice the context menu option to open the *Switch Peer Persistence wizard.*

The Storage module also provides automated provisioning for datastores and virtual machines. After the storage administrator has configured the plug-in to support automated provisioning for specific disk groups, the VMware administrator can then perform storage provisioning operations quickly, without requiring the assistance of the storage administrator.

**New features in ICSM 7.3**
- Now includes HP 3PAR Recovery Manager for VMware
- New provisioning wizards accelerate provisioning datastores and virtual machines
- Simple provisioning of Peer Persistence
  - Include Peer Persistence when provisioning datastores and virtual machines
  - Easily switch Peer Persistence replication direction
- Graphical mapping of virtual machines to volumes
VASA (vSphere Storage APIs for Storage Awareness)

The ICSM 7.3 release has added built-in VASA functionality for 3PAR StoreServ arrays. Earlier ICSM releases included VASA functionality for other storage arrays and an additional plug-in had to be installed separately when VASA features on 3PAR StoreServ were required.

The vSphere Storage APIs for Storage Awareness (VASA) is a set of APIs introduced with vSphere 5 that enables VMware vCenter Server to detect the capabilities of the storage array LUNs and their datastores. This visibility into the array’s configuration of its datastores and their capabilities, simplifies vSphere administration with HP 3PAR StoreServ Storage. Capabilities such as RAID level, thin or thick provisioned, device type (SSD, Fast Class, or Nearline) and replication state can now be made visible from within vCenter Server’s disk management interface. This allows vSphere administrators to select the appropriate disk for virtual machine placement based on its needs. VASA eliminates the need for maintaining complex spreadsheets detailing the storage capabilities of each LUN previously required to guarantee the correct Service Level Agreement (SLA).

The concept of a storage profile, introduced in vSphere 5, extends the base VASA functionality. These profiles are used in conjunction with the capabilities of the LUN to determine which LUNs meet the needs of a VM. vSphere 5 can use this information to migrate virtual machines between LUNs for load balancing using Storage Distributed Resource Scheduler (DRS) while maintaining the storage performance and availability needs (RAID level, etc.) of the virtual machine. These profiles also allow vSphere to make placement decisions automatically based on the SLA requirements of the VM and the available datastores, further reducing the administration impact.

Figure 11. VASA features in Insight Control Storage Module

The latest version of the HP Insight Control Storage Module for vCenter may be downloaded from:

HP StoreFront Analytics for VMware vCenter Operations Manager

HP StoreFront Analytics for VMware vCenter Operations Manager (vCOps) is an adapter that extends vCOps functionality to support HP storage. VMware administrators using HP StoreFront Analytics are able to visualize and analyze data from their HP 3PAR StoreServ storage array directly within vCOps, without switching to another tool.

HP StoreFront Analytics for VMware vC Ops installs directly as an adapter extension through VMware vC Ops. HP StoreFront Analytics for VMware vC Ops provides basic health information for all resources at no charge, but requires a license for advanced key metrics that include performance and capacity data after 60 days evaluation. HP StoreFront Analytics for VMware vC Ops comes with preconfigured dashboards to troubleshoot performance problems and forecast capacity information.

HP StoreFront Analytics for VMware vC Ops integrates directly into vC Ops and manifests as a set of additional dashboard tabs within vC Ops. These dashboards allow the vSphere administrator to quickly get storage capacity information and enable troubleshooting scenarios that span virtual layers and include the physical HP 3PAR StoreServ storage arrays. These clear relationships between virtual machines, datastores, and storage increase the vSphere administrator’s productivity, and ability to ensure quality of service.

The latest version of HP StoreFront Analytics for VMware vC Ops may be downloaded from:
Key features and benefits

- Monitors health, performance, and capacity for HP 3PAR StoreServ components including volumes, CPGs, storage systems, controllers, drive cages, disk drives, ports, and fans.
- Provides a visual mapping from virtual machines and datastores to HP 3PAR StoreServ components, enabling administrators to quickly identify health, workload, and capacity problems impacting the performance of virtual machines.
- Administrators can quickly identify storage resources that need attention. Identify bottlenecks based on response time. Identify resource hogs based on capacity utilization, IOPS, or throughput.
- Provides preconfigured dashboards focused on monitoring, troubleshooting, and performance analysis. The user can also create their own dashboards customized for their environment.
- VMware vCenter Operations Manager provides advanced capacity planning with the HP StoreFront Analytics data.

The vCenter Operations Manager Support option shows what adapters have been installed. Figure 12 shows the 3PAR plug-in has been installed for vCOps, and it shows the adapter version.

Figure 12. Identifying HP 3PAR storage adapter version in vCOps
Figure 13 shows all the 3PAR resources discovered using the 3PAR StoreFront Analytics plug-in, including all of the resource details like adapter, array, array controller, disk drive, etc.

**Figure 13.** Identifying HP 3PAR Resources in vCOps

HP StoreFront Analytics for VMware vCOps provides the user with several ways to access storage information in the vCOps user interface. The preconfigured dashboards allow the user to quickly get started and access different views of the detailed storage information:

- **HP Storage Monitoring:** This dashboard provides summary and detailed information about the HP storage deployed in the vSphere environment. Included is summary information describing HP storage system health, the CPG and volume capacity information, top 50 least healthy resources and HP storage system alerts.

- **HP Storage Troubleshooting:** Provides summary and detailed information about VMs and how they map to HP storage volumes, pools, disks and ports. Included are metric graphs for key performance metrics such as IOPS and bandwidth which are displayed in relation to the selected object of the VMs to storage dependency graph.

- **HP Storage Performance Dashboard:** The performance dashboard lists the top five most heavily utilized resources among the configured storage arrays. The user can quickly tell which volumes are running out of space, which ports have high response time, or which disks are doing the maximum IOPS.

The views are provided as easy to use dashboards and customers can utilize vCOps widgets to configure their own specialized views based on HP 3PAR StoreServ metrics.
Figure 14 shows the dashboard of HP 3PAR storage details in a detailed graphical view and identifying most of the 3PAR storage details without logging into the 3PAR array console. Here you can see storage utilization, LUN utilization, health status and graphical storage view. You can configure much more using the edit option.

**Figure 14.** HP Storage Monitoring dashboard

![HP Storage Monitoring dashboard](image)

Figure 15 shows the HP Storage Troubleshooting dashboard, which is used to troubleshoot the storage system hardware. The dashboard also provides summary and detailed information about VMs and how they map to HP storage volumes, pools, disks and ports. The dashboard includes graphs for key performance metrics such as IOPS and bandwidth, which are displayed in relation to the selected object of the VMs to volume dependency graph. The dashboard incorporates customized widgets and interactions to display information on the selected storage system or resource.

**Figure 15.** HP Storage Troubleshooting dashboard

![HP Storage Troubleshooting dashboard](image)
Summary

Advanced integration exists between HP 3PAR StoreServ Storage and VMware vSphere 5 through VAAI technologies, HP Insight Control Storage Module, and HP StoreFront Analytics for VMware vCops. In addition to managing the HP 3PAR array itself, an administrator can also get insight into how virtual machines are mapped to datastores and individual disk volumes, as well as create and manage both datastores and virtual machines with HP Insight Control Storage Module for vCenter. HP StoreFront Analytics allows vSphere administrators to visualize and analyze data from their HP 3PAR storage directly within vCops, without switching to another tool.

Thin provisioning

HP 3PAR Thin Provisioning allows for creating Thinly-Provisioned Virtual Volumes (TPVVs) as an alternative to fully-provisioned volumes. A TPVV uses logical disks (LD) that belong to a logical disk pool, or the Common Provisioning Group (CPG).

All TPVVs associated with the same CPG draw user space from a shared LD pool as needed and are allocated space on demand in one chunklet increments of 1 GB per controller node. As the volumes that draw space from the CPG require additional storage, the system automatically creates additional logical disks and adds them to the pool until the CPG reaches the user-defined growth limit that restricts the CPG’s maximum size. The maximum TPVV volume size limit is 16 TB. These allocations are adaptive since subsequent allocations are based on the rate of consumption for previously allocated space.

As the TPVV reaches either its exported size or its user-defined allocation limit, the system allows for allocation of an additional 128 MB per node beyond these limits in order to ensure that the exported TPVV address space is usable. With VMware vSphere 5, HP 3PAR Thin Provisioning simplifies management by allowing creation of large VMFS datastores without impacting VM performance, while also increasing ROI by not having to pay for more storage than actually used. For more information on performance enhancements with HP 3PAR StoreServ, refer to the VAAI section in this document.

HP 3PAR Thin Provisioning vs. vSphere Thin Provisioning

When implementing HP 3PAR StoreServ TPVVs, administrators often ask whether implementing vSphere Thin Provisioning for VMDK files makes any sense. In general, Thin Provisioning with HP 3PAR StoreServ and vSphere accomplish the same end-result, albeit at different logical layers. With VMware vSphere Thin Provisioning, administrators realize greater VM density at the VMFS layer, at the cost of some CPU and disk I/O overhead as the volume is incrementally grown on the ESXi hosts. By implementing HP 3PAR StoreServ TPVVs, the same VM density levels are achieved, however the thin provisioning CPU work is offloaded to the HP 3PAR StoreServ ASIC. If the goal is to reduce storage costs, maximize storage utilization, and maintain performance, then use HP 3PAR Thin Provisioning Software to provision VMFS volumes. If performance is not a concern but over-provisioning VMs at the VMFS layer is important, then administrators can consider implementing both Thin Provisioning solutions. However, administrators should realize that there are no additional storage savings realized by using vSphere Thin Provisioning on top of 3PAR TPVVs and in fact, implementing both solutions adds more management complexity to the environment. For a better understanding of the performance tradeoffs implementing both Thin Provisioning solutions, see the Virtual SCSI adapter and virtual disk types topic in the Performance tuning section of this document.

When creating VMs, there are a number of options that are available for the VMDK files. VMware vSphere creates VMs using the “Lazy Zeroed Thick” option by default. With this option, when a new VM is created, the full size of the VMDK is not immediately zeroed. Instead, zeros are returned upon reads from unwritten areas, but not actually backed by physical storage until actual write operations. For performance-intensive environments and security concerns, VMware recommends using “Eager Zeroed Thick” (EZT) virtual disks. EZT disks have the smallest overhead but require zeros to be written across all of the capacity of the VMDK at the time of creation. Unlike many other storage vendors, HP 3PAR Thin Persistence Software and HP 3PAR Zero Detect enabled virtual volumes allow clients to retain the thin provisioning benefits when using Eager Zeroed Thick VMDKs without sacrificing any of the performance benefits offered by this VMDK option. Please see the Virtual SCSI adapter and virtual disk types section of this document for a comparison of the available disk types with VMware vSphere 5.

HP 3PAR Thin-to-Fat and Fat-to-Thin Conversion

In previous releases of the HP 3PAR OS, customers had to perform an offline transition in order to change the provisioning attributes of a volume. This used the legacy physical copy technology where upon completion of the copy, all the VLUNs and applications had to be manually moved from the old VV to the new one. With HP 3PAR OS 3.1.2 you now have the ability with HP 3PAR Thin-to-Fat and Fat-to-Thin Conversion to convert from a thin-provisioned volume to a fully-provisioned

3 For HP 3PAR StoreServ 7000 and 10000 systems, older HP 3PAR F-Class and T-Class systems use a 256MB chunklet size
volume (or vice versa) without requiring an offline transition. Fat-to-thin saves space for volumes that are sparsely consumed VMware datastores, while thin-to-fat saves on thin provisioning license usage for datastores that are currently thin provisioned volumes and mostly or completely allocated.

**HP 3PAR Thin Persistence Software**

HP 3PAR Thin Persistence Software is an optional feature that keeps TPVs and read/write snapshots of TPVVs small by detecting pages of zeros during data transfers and not allocating space for those pages. This feature works in real-time and analyzes the data before it is written to the source TPVV or read/write snapshot of the TPVV. Freed blocks of 16 KB of contiguous space are returned to the source volume and freed blocks of 128 MB of contiguous space are returned to the CPG for use by other volumes.

Thin Copy Reclamation Software is an optional feature which reclaims space when snapshots are deleted from a system. As snapshots are deleted, the snapshot space is reclaimed from a Thinly-Provisioned Virtual Volume (TPVV) or fully-provisioned virtual volume and returned to the CPG for reuse by other volumes. Deleted snapshot space can be reclaimed from virtual copies, physical copies, or remote copies.

**HP 3PAR Inline Zero Block Deduplication**

All models of HP 3PAR StoreServ Storage employ purpose-built HP 3PAR ASICs at the heart of each controller that feature an efficient, silicon-based, zero-detection mechanism to drive inline zero block deduplication. This unique, built-in hardware capability identifies an incoming write request of 16 KB of zeros or larger and prevents this “zero block” from being written to physical storage. Instead, a pointer is created to a global zero block on each node (one per node). This process replaces the redundant chunk of data (in this case, a block of zeros) with a small reference pointer to a stored chunk (the existing zero block on each node). Whenever data is read from a logical block address that has undergone zero block deduplication, the system references the pointer to the global zero block, which results in zeros being returned. This option can be enabled via the Zero Detect flag when creating a TPVV, and it’s enabled by default in HP 3PAR OS 3.1.2 and above. In previous versions of the HP 3PAR OS, it was disabled by default. It is a best practice to enable Zero Detect on TPVVs and thus why it is enabled by default. Zero Detect can be disabled by using the “Advanced options” checkbox of the 3PAR Management Console when creating a TPVV. Zero Detect enables Thin Persistence and achieves space reclamation. For example, when a vSphere administrator starts a reclaim operation on an HP 3PAR TPVV, the HP 3PAR StoreServ ASIC detects those zeros as the same pattern (SCSI write_same). Those blocks having been earlier utilized triggers HP 3PAR Thin Persistence reclamation of those blocks and releases them back to the CPG. Thin persistence can reclaim space in chunks of 128 MB of contiguous unused or zero-filled space on the LD. See Figure 16 and take note of approximately 7 GB total space reclaimed.

**Summary**

HP 3PAR Thin Provisioning Software increases storage system efficiency and optimizes capacity utilization. It does this by addressing the problem of capacity over-allocation through eliminating the need to dedicate storage capacity up-front. HP 3PAR Thin-to-Fat and Fat-to-Thin Conversion allows conversion from a thin-provisioned volume to a fully-provisioned volume (or vice versa) without requiring an offline transition and enabling the Storage Administrator to properly manage space and thin provision licensing usage. HP 3PAR Thin Persistence Software and HP 3PAR Zero Detect ensure that thin volumes on HP 3PAR StoreServ Storage systems stay as lean and efficient as possible by reclaiming unused space associated with deleted data.
**HP 3PAR StoreServ Adaptive Optimization**

Tiered storage is a data storage environment consisting of two or more kinds of storage, typically identified by the following characteristics:

- **Tier 0** – Low capacity / High IOPS tier (Usually Solid State Drives (SSD) drives)
- **Tier 1** – Mid-capacity / Mid IOPS tier (Usually Fast Class (FC) drives)
- **Tier 2** – High capacity / Low IOPS tier (Usually Nearline (NL) drives)

With tiered storage, administrators can assign different classes of storage to different workloads in their environments based on protection levels, performance requirements, and frequency of access. With both HP 3PAR StoreServ and VMware vSphere storage assignments can be both manual and automated functions and based upon company defined storage policies. The benefit of tiered storage for storage consumers are reduced costs, by moving idle storage to lower cost tiers, and greater performance by rapidly migrating frequently accessed data to the higher performing storage tiers. The following sections provide an overview of the options available in an HP 3PAR StoreServ and VMware vSphere 5 environment.

**Dynamic and Adaptive Optimization on HP 3PAR StoreServ**

HP 3PAR StoreServ Dynamic Optimization and Adaptive Optimization software are optional features that allow storage administrators to seamlessly migrate data between storage tiers in their environment without interrupting data access. With HP 3PAR StoreServ Dynamic Optimization, users can manually and non-disruptively alter service levels associated with a storage volume by RAID level, subsystem failure protection level, drive type, stripe width, and/or radial placement to take greater advantage of storage resources. For example, when a system is upgraded by adding nodes, cages, or physical disks, the initial volume and logical disk layouts may no longer be optimal for the new system configuration. Updating the system layout with Dynamic Optimization optimizes the use of all physical resources in the system at a given time.

HP 3PAR StoreServ Adaptive Optimization Software takes the capabilities of HP 3PAR StoreServ Dynamic Optimization to another level by taking an autonomic, fine-grained, and highly automated approach to service level optimization. HP 3PAR StoreServ Adaptive Optimization uses policy-driven, granular data movement, providing highly reliable, non-disruptive, cost-optimized storage tiering at the sub-volume level to deliver the right Quality of Service to the right data at the right time on a large scale. Figure 17 shows how HP 3PAR StoreServ Adaptive Optimization uses chunks of every tier in an HP 3PAR StoreServ array to ensure the best performance and cost effectiveness of the array.

**Figure 17. HP 3PAR StoreServ Tiering – Non-Tiered vs. Tiered**
For further details on Adaptive Optimization, please see the following:

**VMware vSphere Storage DRS**

VMware vSphere Storage DRS is a new Datastore Cluster object introduced in vSphere 5 giving users the capability to automate provisioning and maintenance of virtual machines on tiered storage resources. Users of vSphere have grown accustomed to the many benefits of host clusters. With vSphere Storage DRS, users can now aggregate storage resources yielding similar high availability and performance functionality. vSphere Storage DRS provides both initial and ongoing placement recommendations of virtual machine and virtual disk drives based on capacity and I/O latency metrics. Note that when using HP 3PAR Adaptive Optimization, the recommendation is to use Storage DRS for initial VMDK placement and ongoing load balancing based only on capacity measures (as opposed to I/O latency metrics) in order to prevent downtime due to out of storage scenarios. To implement this recommendation, configure Storage DRS in manual mode with I/O metric disabled.

For further details on Storage DRS, please see the following:

For the Storage DRS Interoperability guide, please see the following:
vmware.com/resources/techresources/10286

**HP 3PAR StoreServ performance and capacity optimization features**

**HP 3PAR StoreServ Dynamic Optimization**

HP 3PAR StoreServ Dynamic Optimization is an optional and licensed feature that analyzes the entire storage system and automatically analyzes and corrects virtual volume and physical disk capacity imbalances for optimal performance. HP 3PAR StoreServ Dynamic Optimization is part of HP 3PAR OS and does not require separate installation. Once initiated, Dynamic Optimization's automated tuning process has three phases:

1. Analyze the system and detect virtual volumes which are not correctly balanced between nodes. If virtual volumes are not balanced correctly, the volumes are tuned to correct the imbalance.
2. Analyze the system and detect any chunklet imbalance between physical disks associated with the same node. After the analysis, chunklets are moved from overused physical disks to under used physical disks associated with the same node.
3. Analyze the system and verify that logical disks associated with a CPG have the same characteristics as the CPG. If the logical disk characteristics do not match the CPG, the logical disk is modified to match the CPG characteristics.

Dynamic Optimization tasks can be performed with both the HP 3PAR StoreServ Command Line Interface and the HP 3PAR StoreServ Management Console. Users can reference the HP 3PAR StoreServ CLI Administrator’s Manual and the HP 3PAR StoreServ Management Console Online Help for instructions on how to administer Dynamic Optimization tasks.

**HP 3PAR StoreServ Adaptive Optimization**

Beginning with HP 3PAR OS version 3.1.2, a new On-Node HP 3PAR StoreServ Adaptive Optimization implementation has been released that runs entirely on the HP 3PAR StoreServ system. This enhanced design replaces the previous implementation whereby a separate HP 3PAR StoreServ System Reporter installation was required for data collection used by HP 3PAR StoreServ Adaptive Optimization processes. This data collection provides historical statistical data characterizing the HP 3PAR StoreServ workloads, which is then analyzed to determine optimal placement of data regions between tiered storage on the system. Also with the new implementation it is now possible to reduce licensing cost by eliminating the separate database requirement and Microsoft® Windows® Server for System Reporter if the only use for it was for Adaptive Optimization.

**Note**

In the HP 3PAR OS 3.1.2 release (and later), only the data needed for HP 3PAR StoreServ Adaptive Optimization has been moved from HP 3PAR System Reporter and moved onto the HP 3PAR StoreServ system nodes. HP 3PAR StoreServ System Reporter is still needed to view historical performance and utilization data.

It is also no longer possible to use and configure HP 3PAR StoreServ System Reporter for Adaptive Optimization. The only place that Adaptive Optimization can be configured with an HP 3PAR OS 3.1.2 (and later) based array is via the HP 3PAR StoreServ Management Console or CLI.

On-Node Adaptive Optimization provides several customer benefits over previous HP 3PAR StoreServ Adaptive Optimization implementations. First, Adaptive Optimization configuration is now managed directly via the HP 3PAR CLI and/or Management Console interfaces eliminating the need for a separate HP 3PAR StoreServ System Reporter for Adaptive
Optimization use. The region movement data of System Reporter is now embedded into the HP 3PAR StoreServ system. Due to this implementation, Adaptive Optimization functionality now has built-in clustered node redundancy which was never possible before with the separate HP 3PAR StoreServ System Reporter implementation.

There are also several enhanced algorithms provided with HP 3PAR StoreServ Adaptive Optimization:

- Ability to define measurement/sampling intervals used to determine region movements
- Ability to define maximum Adaptive Optimization run time (minimum=1 hour)
- Ability for a single Adaptive Optimization run to iterate through successive region move passes
- Finer user control over CPG compaction (trim (remove unused logical disk space), auto (trim and region moves), or none)
- More efficient sample analysis consuming less time and system overhead
- No Adaptive Optimization configuration size limit

With On-Node Adaptive Optimization, active configurations can be either scheduled or manually initiated to analyze statistical data gathered by the on-board data collector processes. As with previous implementations of HP 3PAR StoreServ Adaptive Optimization, all virtual volumes in each defined CPG are automatically included in Adaptive Optimization analysis for region movement. If space and IOPS on the destination CPG permit, heavily used (high I/O) regions will be moved to a higher tier, and lightly or not used regions will be moved to a lower tier.

Region movement can be biased using one of 3 settings:

- Performance – move as much data as possible to higher tiers
- Cost – move as much data as possible to lower tiers
- Balanced – do not aggressively move between tiers

Adaptive Optimization (AO) can be configured with four easy steps:

1. Ensure the HP 3PAR StoreServ array has the proper licensing for Adaptive Optimization.
2. Define a minimum of two CPG tiers per Adaptive Optimization configuration specification.
3. Create an AO Configuration via the HP 3PAR StoreServ Management Console or CLI.
4. Schedule Adaptive Optimization to perform the analysis and tier movement.

**Note**
Adaptive Optimization requires a minimum of 3 hours data collection before effectively moving data regions between tiers.

Adaptive Optimization tasks can be performed with both the HP 3PAR OS Command Line Interface and the HP 3PAR Management Console. Users can reference the HP 3PAR OS CLI Administrator’s Manual and the HP 3PAR StoreServ Management Console Online Help for instructions on how to administer Adaptive Optimization tasks.

Adaptive Optimization should not be mixed with any other application or processes that move data on or between volumes based on I/O load balancing. VMware Storage DRS for initial VMDK placement and ongoing load balancing based on capacity measures (as opposed to I/O latency metrics) is acceptable and recommended to prevent downtime due to out of storage scenarios.

In a real world case, a customer was able to increase overall performance and expand available storage for virtual machine datastores by adding a mix of SSD drives and Nearline drives and using Adaptive Optimization rather than adding a larger number of “FC” drives to their StoreServ array to improve performance. By doing so, the customer cut the average latencies for their workloads on Nearline drives in half while greatly expanding their storage capacity. For more information on the implementation of 3PAR Adaptive Optimization and more detail on the specific customer case study, see the white paper titled “Adaptive Optimization for HP 3PAR Storage” referenced at the end of this document in the For more information section.

**HP 3PAR Priority Optimization**
HP 3PAR Priority Optimization software for HP 3PAR StoreServ Storage systems implements and manages a priority policy per Virtual Volume set (VSet) that serves as a proxy for applications. HP 3PAR Priority Optimization places limits on I/O requests with lower-priority policies to help ensure that workloads with higher priority achieve their performance targets. HP 3PAR Priority Optimization is flexible and easy to configure and monitor, and it requires minimal supervision from storage system administrators.

HP 3PAR Priority Optimization applies policies to 3PAR virtual volumes grouped in sets (where a 3PAR VVset is comprised of one or more virtual volumes). This grouping allows common policies to be applied to virtual volumes associated with a
common workload. For instance, policies can be developed for virtual volumes associated with a particular vSphere cluster, or volumes associated with a particular application workload. Or, “production” workloads can be given higher priority than development and test workloads. Limits can be set so that no particular workload monopolizes the array at the expense of all others.

While HP 3PAR Priority Optimization can manage workloads across multiple hosts, users may still wish to use I/O Resource Control facilities available through vSphere, such as Storage I/O Control (SIOC), Adaptive Queue Depth (AQD) and Storage Distributed Resource Scheduler. Care should be taken when combining all of these different features to ensure the desired effect is achieved. Table 2 provides a summary of the characteristics of each type of control mechanism. Additional details about SIOC and AQD may be found in the Performance tuning section of this paper. More information about Priority Optimization and interactions with the vSphere facilities may be found in the white paper “HP 3PAR Priority Optimization” at [http://h20195.www2.hp.com/V2/GetDocument.aspx?docname=4AA4-7604ENW](http://h20195.www2.hp.com/V2/GetDocument.aspx?docname=4AA4-7604ENW).

Table 2. Characteristics of Priority Optimization and VMware’s I/O resource control mechanisms

<table>
<thead>
<tr>
<th>I/O control technique</th>
<th>HP 3PAR Priority Optimization</th>
<th>vSphere SIOC</th>
<th>vSphere AQD</th>
<th>vSphere Storage DRS</th>
</tr>
</thead>
<tbody>
<tr>
<td>I/O control technique</td>
<td>Set Min Goal (3PAR OS 3.1.3) and Max Limit for IOPS and bandwidth, set latency goal (3.1.3), set priority level (3.1.3)</td>
<td>Enforce predefined I/O shares for each VM</td>
<td>Control queue depth of datastore SAN LUN in VMkernel</td>
<td>Migrate VM to other datastore</td>
</tr>
<tr>
<td>Reaction on</td>
<td>None</td>
<td>I/O latency growing</td>
<td>Queue Full or Device Busy at LUN or port level</td>
<td>I/O latency and space utilization growing</td>
</tr>
<tr>
<td>Granularity</td>
<td>Vset, Virtual Domain, System</td>
<td>All VMs in a single datastore</td>
<td>All hosts using the SAN LUN for the datastore or a particular port on the HP 3PAR StoreServ Storage system</td>
<td>Single VM</td>
</tr>
<tr>
<td>Managed from</td>
<td>HP 3PAR Management Console/HP 3PAR CLI</td>
<td>VMware vSphere/CLI</td>
<td>VMware vSphere/CLI</td>
<td>VMware vSphere/CLI</td>
</tr>
<tr>
<td>Available in</td>
<td>HP 3PAR OS 3.1.2 MU2 and later</td>
<td>vSphere 4.1 and later with Enterprise Plus license</td>
<td>vSphere 3.5 U4 and later with Standard license</td>
<td>vSphere 5.0 and later with Enterprise Plus license</td>
</tr>
</tbody>
</table>

HP 3PAR Priority Optimization is supported in HP 3PAR OS 3.1.2 MU2 and later. The HP 3PAR OS 3.1.3 release provides some additional enhancements to the service metrics available for specifying Quality of Service (QoS) rules. Table 3 shows the control types that can be set for each QoS rule.

Table 3. QoS control types

<table>
<thead>
<tr>
<th>Control type</th>
<th>Minimum HP 3PAR OS version</th>
<th>Description</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max limit</td>
<td>3.1.2 MU2 and later</td>
<td>Maximum threshold for IOPS or bandwidth for a QoS object</td>
<td>Max limit has no dependencies on the other control types.</td>
</tr>
<tr>
<td>Min goal</td>
<td>3.1.3</td>
<td>Minimum floor for IOPS or bandwidth below which HP 3PAR Priority Optimization will not throttle a QoS object</td>
<td>When a min goal is set on an object the user must also configure a max limit on the same object within the same rule. Min goal will be ignored if the system has no rules with latency goal set.</td>
</tr>
<tr>
<td>Latency goal</td>
<td>3.1.3</td>
<td>Service time target the system will try to achieve for a given workload in a QoS object</td>
<td>This control type requires other rules in the system with min goal to be set, as the latency goal algorithm needs direction on which workload to target and throttle. The order in which these will be throttled is provided by the priority levels.</td>
</tr>
<tr>
<td>Priority level</td>
<td>3.1.3</td>
<td>Precedence order for QoS subsystem to throttle workloads to meet latency goals</td>
<td>High priority should be used against critical applications, lower priority on less critical applications.</td>
</tr>
</tbody>
</table>
Summary

HP 3PAR Adaptive Optimization and HP 3PAR Priority Optimization are powerful features offering greater return on storage investments by realizing untapped and hidden storage potential. Adaptive Optimization offers tremendous flexibility and ease of management by allowing administrators to provision storage resources once and offering peace of mind that their application workloads will be continually and automatically tuned for best performance. Priority Optimization protects mission critical workloads enabling certainty and predictability for each application and tenant.

Performance tuning

While virtual environments certainly increase server consolidation, simplify administration, and maximize ROI, these environments also present unique performance challenges for storage administrators. After consolidation, typically most environments will find memory overutilization a significant factor. In fact, VMware vSphere utilizes several sophisticated techniques for handling memory over-commitment including page sharing, ballooning, compression and swapping. These techniques enable effective memory management which in turn enables more virtual machines to be hosted on a single host. However, several of these memory handling processes place a greater load on the backend storage system. Namely, ballooning and swapping often will page to disk, and it is here where high speed and low latency I/O is critical for optimum performance in a VMware vSphere environment. Compounding the reliance on storage resources is the random nature of virtualized workloads, which typically do not find data in storage read cache but must fetch it on disk. There is some benefit to enabling read cache in virtualized environments, but primarily, the ability for storage systems to deliver IOPS is going to achieve best performance.

I/O sizing

Traditional storage systems have administrators working through various storage sizing exercises seeking to define volume I/O per any given workload. With a traditional disk based array, administrators must identify storage performance requirements for given workloads using some of the following guidelines:

- Different RAID groups (think physical drives) tailored to specific I/O performance, capacity, and redundancy with volumes assigned to these different groups
- When RAID groups do not meet I/O requirements, additional, dedicated groups must be created for newly provisioned volumes
- Manually balancing/distributing the RAID groups and volumes across the available storage processors for best performance

These management considerations are time consuming, and can be expensive and complex to implement, especially when adding additional storage to meet I/O requirements. With HP 3PAR StoreServ Storage systems, there is no separation of underlying physical drives and logical RAID groups and all of the planning and spreadsheets to keep track of. Instead an HP 3PAR StoreServ system will leverage its built in wide striping capabilities to use every defined physical disk (FC, NL, SSD) on the array. Because of this, I/O sizing is significantly simplified with HP 3PAR StoreServ Storage, and storage administrators should consider the I/O requirements of their environment and then align the HP 3PAR StoreServ Storage configuration to meet those specific requirements.

Alignment considerations

The improper alignment of VMFS file system partitions may impact performance. The recommended practice is to add VMFS storage to ESXi hosts using the vSphere Client, as it automatically aligns VMFS partitions when it creates them. For vSphere 5, VMFS-3 and VMFS-5 file systems that are created using the vSphere Client are automatically aligned on a 1 MB boundary. VMFS-3 file systems created with a previous version of vSphere used 64 KB alignment. They can be upgraded to VMFS-5 partitions but will retain the partition characteristics of the original VMFS-3 datastore, including file block size, sub-block size of 64K, etc. To take full advantage of all the benefits of VMFS-5, migrate the virtual machines to another datastore, delete the existing datastore, and re-create it using VMFS-5. For more information about upgrading from VMFS-3 to VMFS-5, see the article “Frequently Asked Questions on VMware vSphere 5.x for VMFS-5” at http://kb.vmware.com/kb/2003813.

Partitions that are created using vmkfstools may be aligned manually using the partedUtil tool from the command line. For detailed instructions on using partedUtil, refer to the VMware Knowledge Base entry: http://kb.vmware.com/kb/1036609. Note that when using partedUtil, alignment is determined by the start sector parameter. Specifying a start sector at offset 128 will result in 64 KB alignment, and a start sector at offset 2048 will provide 1 MB alignment.

Virtual SCSI adapters and virtual disk types

vSphere 5 provides several virtual storage adapters, with the default depending upon the guest operating system and virtual hardware version. The paravirtualized SCSI storage adapter (PVSCSI), also called VMware Paravirtual,
recommended for optimal performance, especially for environments with I/O intensive applications. The PVSCSI adapter provides a significant reduction in CPU utilization with potential for increased throughput as compared to the default storage adapters. Note that virtual machines must be using virtual hardware version 7 or later in order to take advantage of PVSCSI. For details on configuring the PVSCSI adapter and a list of guest operating systems that support it for the boot disk, reference VMware Knowledge Base entry http://kb.vmware.com/kb/1010398.

The virtual disk options available to administrators include thick virtual disks which have all space allocated at time of creation and thin virtual disks which have their space allocated but written to upon first write operation. Additionally, two thick virtual disk options are available to choose from, eager-zeroed and lazy-zeroed. Eager-zeroed allocates all the space requested by writing zeros for the entire virtual disk at creation, while lazy-zeroed only zeros at first write. Administrators also have the option of provisioning raw device mapped (RDM) volumes which allow for management access of raw SCSI LUNs as VMDK files.

In terms of performance and overhead, RDM, eager-zeroed, and fully provisioned 3PAR VMDKs compared favorably with each other. However, 3PAR fully provisioned volumes experience the shortest disk service times and least amount of storage CPU cycles. Overall, all three virtual disk types perform remarkably similar and the choice of virtual disk type should be based on specific application requirements.

For performance-intensive environments, VMware recommends using eager-zeroed virtual disks; however, 3PAR Thin Persistence software allows customers to retain thin provisioning benefits when using eager-zeroed disks without sacrificing any of the performance benefits offered by this option. In this case, Thin Persistence ensures that when a new eager-zeroed volume is created, the entire volume is not allocated from physical storage, since all zeros that have been written to the VMDK were intercepted and discarded by the HP 3PAR ASIC.

**Wide striping**

The unique HP 3PAR StoreServ architecture stripes volumes widely across all drives to deliver maximum I/O throughput and minimum latencies, which mitigates server memory bottlenecks and traditional storage constraints. Increased array performance cannot only boost VM-based application performance, but when paired with the superior reliability of the HP 3PAR StoreServ Storage system and advanced support of VMware’s vSphere Storage APIs for Array Integration (VAAI) capabilities, results in higher VM density. This benefit enables organizations to double virtual machine density on physical servers by placing twice as many VMs on physical servers as compared with traditional storage platforms.

**Figure 18.** Wide striping on HP 3PAR arrays compared to traditional RAID

![Wide striping on HP 3PAR arrays compared to traditional RAID](image)

**Storage I/O Control**

**Note**

Storage I/O Control (SIOC) is a vSphere feature which manages ESXi device-queue depths, while AO is an HP 3PAR feature which moves data between storage tiers at scheduled intervals depending upon usage patterns. The two features operate at different layers, so there is no conflict between them.

SIOC provides finer-grained control than adaptive queue depth throttling, but the two features may be used together. SIOC reacts to latency increases for a datastore, while adaptive queue depth responds to Queue Full messages from the HP 3PAR array.

The vSphere Storage I/O Control (SIOC) feature manages shared storage resources across ESXi hosts to provide more predictable performance during periods of congestion. It monitors the latency of I/Os to a datastore for each ESXi host
sharing the device. When the average latency for a datastore exceeds a threshold (set by SIOC based upon storage type), SIOC distributes the storage resources to virtual machines according to their assigned shares. It accomplishes this by reducing the number of I/O queue slots available to lower priority virtual machines and increasing the slots for virtual machines with higher shares. By controlling the ESXi device-queue depths in proportion to the virtual machine shares, SIOC is able to control storage congestion for the datastore and distribute HP 3PAR StoreServ Storage array resources appropriately. Note that the congestion threshold represents a tradeoff between lower I/O latencies and throughput. When the threshold is set low, I/O throttling will be engaged more aggressively, which will help to maintain a lower I/O latency for the datastore, but will also reduce the overall throughput for the datastore.

The default latency threshold is 30 ms, but the optimal setting depends upon the storage type used for the datastore. A new feature in SIOC for vSphere 5.1 is the I/O injector, which calculates the peak throughput for a storage device, detects the 90 percent throughput value and measures latency at that point to determine the optimal threshold value for the storage device. The latency threshold is set automatically to the value determined by the I/O injector, and this value should be acceptable for most use cases.

To enable SIOC for a datastore:

- In the vSphere Web Client, select the datastore.
- From the Manage tab, select Settings and click the Edit button next to Datastore Capabilities.
- Click the Enable Storage I/O Control check box, as shown in Figure 19.

**Figure 19.** Configure SIOC for datastore
The VMware white paper *Storage I/O Control Technical Overview and Considerations for Deployment* makes the following recommendations for determining the congestion threshold values for various types of storage, including auto-tiered storage.

**Table 4. Recommended congestion threshold values**

<table>
<thead>
<tr>
<th>Type of storage backing the datastore</th>
<th>Recommended threshold</th>
</tr>
</thead>
<tbody>
<tr>
<td>SSD</td>
<td>10-15 ms</td>
</tr>
<tr>
<td>Fast Class</td>
<td>20-30 ms</td>
</tr>
<tr>
<td>Nearline</td>
<td>30-50 ms</td>
</tr>
<tr>
<td>Auto-tiered storage</td>
<td>Combine ranges of fastest and slowest storage types</td>
</tr>
</tbody>
</table>

The default threshold of 30 ms should be acceptable for most workloads using Fast Class or Nearline drives. If Adaptive Optimization is employed, then the threshold should be set to a value that is within the recommended ranges for the fastest and slowest storage types in use. For example, if Fast Class and SSD drives are specified by the AO policy, then the threshold for the datastore should be set in the range of 10 to 30 ms. The exact setting should be determined by the requirement to favor low latency (using a low congestion threshold) versus throughput (using a high threshold).

The virtual machine’s relative priority on the datastore is determined by its number of disk shares. This is configured by editing the settings for the VM as shown in Figure 20:

**Figure 20. Changing disk shares for a VM**
Select the **Virtual Hardware** tab, and select the Hard disk of interest. The default number of disk shares is 1000. To increase the priority of a VM relative to other VMs using the same datastore, increase the number of disk shares by clicking on the drop down menu next to **Shares** and change the value to **High**, or select **Custom** and enter a new value in the adjacent field.

**Adaptive queue depth throttling**

**Note**
Adaptive queue depth throttling may be used in conjunction with **Storage I/O Control**.
Adaptive queue depth throttling is not compatible with Storage DRS.

If adaptive queue depth throttling is enabled, it is important to enable it for all hosts which are accessing the HP 3PAR StoreServ Storage.

Each port on the HP 3PAR StoreServ Storage system has a finite queue depth that depends on the host bus adapter (HBA) model; each server attached to a port shares that port’s queue. If a host sends an I/O request to a port with a full queue, the host receives a “queue full” SCSI response from the HP 3PAR array. I/O commands sent to a port in an HP 3PAR StoreServ array that has reached its maximum queue depth are not processed beyond the “queue full” SCSI response.

Historically, an ESX host’s default reaction to this response would be to recognize it as a valid command and to continue sending requests to that port. Lack of I/O responses can result in VMs becoming unresponsive and can lead to a crash of the ESX host. ESX 3.5 Update 4 and later include an adaptive queue depth throttling algorithm which adjusts the LUN queue depth in the VMkernel I/O stack. This algorithm is activated when the storage array indicates I/O congestion by returning a “queue full” SCSI status. When congestion is detected, the VMkernel throttles the LUN queue depth and attempts to gradually restore the queue depth when congestion conditions subside.

Without adaptive queue depth throttling, administrators are forced to limit the number of VMs per physical server so as to reduce the risk associated with any particular VM overrunning I/O queues. Administrators are also forced to manually tune the number of VMs when they detect congestion—a reactive, slow, and error-prone process. By automating congestion control, administrators can confidently create a higher number of VMs per physical server without the need for manual congestion control.

The adaptive queue depth algorithm is disabled by default. For vSphere 5.1, it is enabled on a per datastore basis by setting the queue-full-sample-size and queue-full-threshold parameters. Setting the queue-full-sample-size parameter to a value greater than zero activates the algorithm. The queue-full-threshold parameter must be set to a value less than or equal to queue-full-sample-size. To set these parameters to optimal values for HP 3PAR StoreServ Storage, run the following command for each HP 3PAR StoreServ device utilized by the ESXi host:

```
#esxcli storage core device set --device device_name --queue-full-threshold 4 --queue-full-sample-size 32
```

These settings take effect immediately and are persistent across reboots of the ESXi hosts. Note that it is important to make the changes across all ESXi hosts sharing the storage.

For vSphere versions prior to 5.1, the algorithm was enabled by setting two VMware system-wide configuration parameters, QFullSampleSize and QFullThreshold on the ESXi hosts. The new per-device settings are preferred because the optimal settings differ by storage type. For more information, refer to the VMware Knowledge Base entry: [http://kb.vmware.com/kb/1008113](http://kb.vmware.com/kb/1008113).

**Tech tip**
You can monitor the “Qlen” values on the system (using System Reporter or the command `statvlun -ni -rw -host <ESX host>`) to make sure you are not exceeding these values.

**Summary**
HP 3PAR StoreServ Storage provides the high I/O throughput and low latency required for optimal performance in a VMware vSphere environment. The usage of HP 3PAR Thin Provisioning offloads the management of thin provisioned volumes from the ESXi host and reduces host overhead. VMware vSphere performance features such as paravirtualized SCSI storage adapter and Storage I/O Control also contribute to optimal I/O performance. SIOC and adaptive queue depth throttling are two methods to provide more predictable performance for VMs during periods of I/O congestion. SIOC provides finer-grained control than adaptive queue depth throttling and is also compatible with Storage DRS thus it is a more robust solution.
HP 3PAR Recovery Manager Software for VMware vSphere

HP 3PAR Recovery Manager Software for VMware vSphere is an array-based, online virtual machine snapshot and recovery solution that gives administrators superior control over data protection and recovery – including granular, rapid online recovery for VMware vSphere environments.

Leveraging HP 3PAR Virtual Copy Software technology, Recovery Manager enables vSphere administrators to create hundreds of space-efficient, VM-aware, point-in-time snapshots without taking virtual machines offline. A simple, automated process enables administrators to simply and efficiently protect and recover Virtual Machine Disks (VMDK), VMware vStorage Virtual Machine File Systems (VMFS), individual virtual machines, and even individual files within VMware vSphere environments.

The following features of Virtual Copy are key to making HP 3PAR Recovery Manager for VMware vSphere a superior snapshot management product:

- Non-duplicative snapshots reduce the capacity required for disk-to-disk (D2D) backups. When a production volume is changed, a single copy-on-write operation is performed, and little capacity is consumed regardless of the number of snapshots associated with the production volume.
- Reservationless snapshots reduce management overhead and the wasted capacity introduced by snapshot reservations in other technologies.
- Read-write snapshots can be mounted directly by the hosts and used for processing. This extends the benefit of snapshots to their use in test or development environments. Traditional read-only snapshots can be read but not mounted for processing.

Best practices

For the best performance and reliability, HP 3PAR Recovery Manager for VMware vSphere should be installed on a dedicated Microsoft Windows server or a separate VM residing in the network, so that it may interface with the vSphere clusters and the HP 3PAR Storage. It is also not a replacement for provisioning using the HP 3PAR Management Console. If provisioning requires specific attributes, the HP 3PAR Management Console should be used.

When using HP 3PAR Recovery Manager for VMware vSphere for datastore restoration through the promotion of a virtual copy, it does not check if a volume being unmounted is in use. Ensure that the volume is inactive prior to unmounting it in preparation for the restoration of the copy. Also, when a VM or datastore is removed, the associated scheduled tasks continue to run but are no longer manageable from the Recovery Manager for VMware vSphere scheduling interface. In this case, the task needs to be manually removed from the Windows scheduler.

When copying or cloning a virtual machine to a different datastore, the source VM’s Universally Unique Identifier (UUID) is retained in the target VM. When using HP 3PAR Recovery Manager for VMware vSphere to show the virtual copies on the target VM, the virtual copies from the source VM will be displayed. To resolve this problem, the target VM’s UUID should be changed by editing the VMX configuration file (.vmx) while the VM is powered-off. By deleting the uuid.bios="..." line, a new uuid.bios entry is generated.

When using the “Copy to Datastore” option to copy a virtual disk to a datastore, it is recommended that the copy and paste functions of the datastore browser be used in order to preserve the VMware Thin Provisioning disk feature. Using other features like SCP will not preserve the thin provisioning.

HP 3PAR integration with VMware vCenter Site Recovery Manager (SRM)

VMware vCenter Site Recovery Manager is a management and automation product that helps build, manage, test and execute disaster recovery plans for a VMware virtual infrastructure. The HP 3PAR StoreServ Storage system, as the storage component in a VMware virtual infrastructure, holds virtual machine information for a protected site/location and recovery site/location. HP 3PAR Storage Replication Adapter for VMware vCenter SRM 5 is an important integration component that communicates with HP 3PAR StoreServ Storage systems to execute specific storage and HP 3PAR Remote Copy functions needed for VMware vCenter Site Recovery Manager operation.

The cost and complexity of replicating data using traditional recovery products can deter some customers from implementing a disaster recovery plan at all. By leveraging the simplicity and efficiency of HP 3PAR Remote Copy, HP 3PAR Replication Adapter for VMware vCenter Site Recovery Manager enables HP 3PAR StoreServ customers to easily implement VMware vCenter Site Recovery Manager for end-to-end management of array-based replication and failover of virtual machines. The combination of HP 3PAR Remote Copy and VMware vCenter Site Recovery Manager lets customers build resilient utility computing infrastructures, protect applications at a lower cost, and recover data more quickly and efficiently compared to traditional disaster recovery offerings.
When creating virtual volumes and presenting them to your ESXi host, the same LUN ID should be used for every host in the same Access group; and, LUNs must be presented to each HBA of each host. Also when leveraging an HP 3PAR StoreServ virtual volume set, be sure to include all virtual volumes in a single HP 3PAR Remote Copy group and in the same protection group. Otherwise there is a potential of losing connectivity to the VMs if virtual volumes are included in more than one HP 3PAR Remote Copy group and not all Remote Copy groups are included in the protection group.

**Summary**

Deploying HP 3PAR StoreServ Storage in VMware vSphere environments helps remove the performance, efficiency, availability, and management headaches associated with traditional storage platforms. Not only does leveraging HP 3PAR StoreServ Storage enable seamless integration with VMware vCenter to deliver enhanced performance, agility, and scalability in vSphere environments, but it also enables organizations using VMware vSphere with HP 3PAR StoreServ several other key benefits:

- Using HP 3PAR StoreServ Storage with VMware vSphere enables its users to double virtual machine density on physical host servers as compared with traditional storage platforms.
- HP 3PAR Thin Provisioning Software allows physical storage to be consumed only when required for actual written data, rather than when allocated.
- With HP 3PAR Thin Persistence, as the ESXi host writes zeros to the VMDK file, the zeros are detected in-line by the HP 3PAR StoreServ ASIC, and no space is allocated for the VMDK in the thin provisioned volume. Also, when a VM is deleted or moved to another datastore, that now unallocated storage can be released back to the array rather than keeping it assigned to the LUN.
- HP 3PAR Persistent Ports allows for Online Software Upgrades, non-disruptive HBA Firmware upgrades and node maintenance on HP 3PAR StoreServ arrays all while the normally affected host path remains online. There is no dependency on the software multipathing as the host port remains online.
- HP 3PAR Peer Persistence software enables HP 3PAR StoreServ systems located at metropolitan distances to act as peers to each other, presenting a nearly continuous storage system to hosts and servers connected to them. This capability allows you to configure a high-availability solution between two sites or data centers where failover and failback remains completely transparent to the hosts and applications running on those hosts.
- HP 3PAR Adaptive Optimization Software can be used to tailor storage performance without disruption to VMware vSphere and contribute new autonomic space reclamation functionality.
- Tight integration of VMware vCenter Server and the HP 3PAR Recovery Manager Software for VMware vCenter allows administrators to monitor and manage HP 3PAR Storage volumes to create point-in-time, VM- and application-aware, disk-based snapshots from within the vSphere Client.
- The combination of HP 3PAR Remote Copy and VMware vCenter Site Recovery Manager lets customers build resilient utility computing infrastructures, protect applications at a lower cost, and recover data more quickly and efficiently compared to traditional disaster recovery offerings.

These are among the unique advantages that make HP 3PAR StoreServ Storage the ideal foundation for building or expanding a virtualized server environment with VMware vSphere as part of a converged infrastructure to meet the needs of the Instant-on Enterprise.
For more information

HP 3PAR StoreServ Storage Family, [hp.com/go/3PAR](http://hp.com/go/3PAR)
HP Insight Control for vCenter, [hp.com/go/cvcenter](http://hp.com/go/cvcenter)
HP Converged Storage for VMware, [hp.com/go/storage/vmware](http://hp.com/go/storage/vmware)

HP/VMware technical papers

Storage I/O Control Technical Overview and Considerations for Deployment, [vmware.com/files/pdf/techpaper/VMW-vSphere41-SiOCPDF](http://vmware.com/files/pdf/techpaper/VMW-vSphere41-SiOCPDF)

HP 3PAR documentation


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