

HP P2000 Software Plug-in for VMware VAAI

Technical white paper

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About this Document

This white paper discusses the HP P2000 Software Plug-in for VMware vStorage API for Array Integration (VAAI). This Plug-in enables array offload of key ESX operations to HP MSA P2000 Storage Array products.

Target audience

This document is intended for VMware vSphere 4.1/VMware vSphere 5.0 SAN administrators who are familiar with the storage features of VMware ESX/ESXi 4.1/ESXi 5.0 and also for those who are using P2000 G3 arrays as backend storage for their VMware deployments.

Introduction to VAAI

HP P2000 G3 Modular Smart Array (MSA) Systems provide storage solution offering excellent performance at a very competitive price point. The system delivers high performance, low cost, consolidated storage array solution to meet the needs of departmental and small to medium business requirements. It also gives flexibility to share the array resources over two protocols, supporting the needs of dissimilar departments and budgets. The P2000 G3 arrays come integrated with Web browser and command line interface (CLI) based software for storage and RAID management, setup, configuration, and troubleshooting.

VAAI is one of the storage application programming interface (API) sets in vSphere 4.1 and vSphere 5.0. VAAI is an API storage partner that can leverage to enhance performance of virtual machine (VM) management operations by delegating these operations to the storage array. With hardware offload, ESX/ESXi hosts perform certain operations faster and consume less server CPU and memory resources, and also storage port and storage fabric bandwidth. VAAI includes high performance and scalable VM data path primitives. HP introduced VAAI support for HP MSA P2000 Storage Array products starting with the T230 firmware release.

Storage Hardware Primitives for VAAI

In the VMware vSphere 4.1/5.0 release, the HP P2000 G3 MSA Array Systems offload capabilities support the following three primitives:

- Full Copy or Hardware Assisted Move
- Block Zeroing or Hardware Assisted Zeroing
- Hardware Assisted Locking or Atomic Test and Set (ATS)

Full Copy

Full Copy enables the storage arrays to make copies of the data within the array. The ESX host does not have to read the data from the array and then write the copy back to the array. Copy operations that would normally take minutes to complete without VAAI, can now be accomplished in seconds because of the reduced traffic. Operations like VM clones, deploying VMs from template, and Storage vMotion can be improved as follows:

- Reducing the time for many VMware storage-related tasks by 25 percent or more (in some cases up to 10x).
- Reducing the amount of CPU load on the ESX host and the array by 50 percent or more (in some cases up to 10x).
- Reducing the traffic on the storage connections by 99 percent for those tasks.

Block Zeroing

Block Zeroing (WRITE-SAME) enables storage arrays to zero out a large number of blocks to speed up provisioning of VMs. It eliminates redundant and repetitive write commands by having the array repeat zeroing commands internally.

Block Zeroing provides significant performance improvement during initialization of eagerzeroedthick VMDK volumes often used in VMware. Using the VAAI features to do hardware assisted zeroing reduces CPU and I/O storage resource needs from the host and improves performance.

Hardware Assisted Locking

Hardware Assisted Locking (Compare and Write) provides an alternative means to protect the metadata for VMFS cluster file systems and thereby improves the scalability of large ESX server farms sharing a datastore. ATS allows locking at the block level of a logical unit (LU) instead of locking the whole LUN.

The following are examples of VMFS operations that require locking metadata:

- Creating a VMFS datastore
- Expanding a VMFS datastore onto additional extents
- Powering on a virtual machine
- Acquiring a lock on a file
- Creating or deleting a file
- Creating a template
- Deploying a virtual machine from a template
- Creating a new virtual machine
- Migrating a virtual machine with vMotion
- Growing a file. For example, a Snapshot file or a thin provisioned Virtual Disk

VAAI Benefits and Use Cases

VAAI helps reduce the storage bandwidth consumed by an ESX/ESXi host and improves datacenter scalability. Storage operations like virtual machine provisioning, Storage vMotion, creation of virtual disks, and so on consumes less CPU, memory, and fabric bandwidth when using the P2000 G3 array running firmware which includes the VAAI component (T230 or above).

Use cases

The following use cases address the three VAAI features.

Use case 1

Using vCenter, a VMware administrator needs to migrate VMs between datastores by using vMotion. The ESX 4.1 host can take advantage of the VAAI xcopy command to perform migrations of VMs in a faster way. Using the VAAI feature set results in reducing VM deployment time and quicker migration of VMs between clustered hosts.

Use case 2

Using vCenter, a VMware administrator needs to provide 20 VMs for a training class by using Deploy from Template (using both xcopy and Block Zero commands).

Use case 3

A virtual machine-hosted application requires consistent performance despite the VMware clustering infrastructure process overhead by using Atomic Test and Set (ATS) for VMFS scalability. This is accomplished due to the more granular locking that ATS functionality unlocks.

Limitations and conditions

The VMFS DataMover does not leverage hardware offloads and instead uses software data movement in the following cases:

- The source and destination VMFS volumes have different block sizes.
- The source file type is RDM and the destination file type is non-RDM (regular file).
- The source VMDK type is eagerzeroedthick and the destination VMDK type is thin.
- The source or destination VMDK is any sort of sparse or hosted format.
- The source VM has a snapshot.
- The logical address and transfer length in the requested operation are not aligned to the minimum alignment required by the storage device (all datastores that are created with the vSphere Client are aligned automatically).
- The VMFS has multiple LUNs/extents and they are all on different arrays.
- Hardware cloning between arrays (even if within the same VMFS volume) does not work.

Performance Test Results on HP MSA P2000 Storage Arrays

This section provides the performance test analysis for Block Zero and Full Copy performed with and without VAAI for the HP P2000 G3 MSA Array Systems. When VAAI is enabled, a significant improvement is observed in the completion of operations involving Block Zero (for example, Deploy VMs) and Full Copy (for example, vMotion).

Note:

The performance analysis as shown in Table 1 is done in a controlled environment and the results may vary in the production environment.

Table 1: Performance test analysis for Block Zero and Full Copy performed with and without VAAI for the HP P2000 G3 MSA Array Systems

Storage Array	Block Zero						Full Copy					
	Time taken (in sec)			Load on SAN (Read/Write in Kbps)			Time taken (in sec)			Load on SAN (Read/Write in Kbps)		
	No VAAI	VAAI	% Change	No VAAI	VAAI	% Change	No VAAI	VAAI	% Change	No VAAI	VAAI	% Change
HP P2000 G3 iSCSI	455	123	72.96%	112706	154	99.86%	705	257	63.54%	148392	75	99.94%
HP P2000 G3 FC	136	120	11.76%	371749	156	99.95%	388	254	34.53%	267641	77	99.97%
HP P2000 G3 SAS	118	106	10.02%	465792	155	99.96%	384	240	37.51%	268714	73	99.97%
HP P2000 G3 10 GB iSCSI	123	113	8.13%	423713	191	99.95%	432	226	47.68%	244739	79	99.96%
HP P2000 G3 Combo (FC)	425	126	15.07%	114502	144	99.95%	699	259	37.59%	148299	74	99.97%
HP P2000 G3 Combo (iSCSI)	139	118	70.35%	371856	150	99.87%	399	249	62.94%	268750	76	99.95%

Hardware configuration

Install the ESX 4.1i on a HP ProLiant DL385 G6 server and connect to the P2000 G3 storage array. HP P2000 Software Plug-in for VMware VAAI is installed on the server. Different Host Bus Adapters (HBAs) are used based on the protocols (like 8 GB FC, 6 GB SAS, and 10 GB iSCSI HBAs) tested during that time. Tests are conducted across the entire HP P2000 G3 array systems.

Block Zero

Steps include the following:

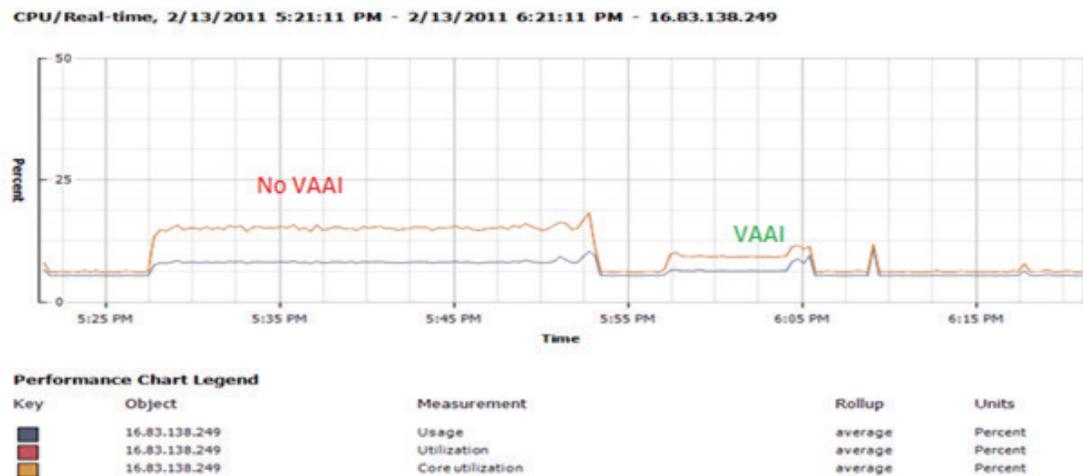
- Create RAID 5 vDisk with five (4+1spare) 300 GB SAS 6 GB drives.
- Create a Volume with 500 GB of space and map it to the ESX host.
- Create a datastore and format it with 256 GB of space and block size of 1 MB.
- Create five 10 GB eagerzeroedthick VMDK simultaneously and zero it. All these VMs go to the same datastore.
- Monitor the completion time, read/write rate, and number of read/writes per second (load on SAN) by using the vCenter performance graph and esxtop utility.

CPU usage during Block Zero

A significant reduction in the CPU utilization is observed when VAAI is enabled. This relieves the CPU to perform other tasks and the P2000 G3 array is tasked to handle the work load related to Block Zero operations.

Figure 1 shows an example of reduction in CPU usage from around 12 percent to 1 percent with P2000 G3 1 GB iSCSI array which is more than 90 percent less usage of CPU with VAAI enabled. Across other protocols like FC and SAS, a reduction in CPU usage is observed in the range of 80 to 90 percent when VAAI is enabled.

Figure 1: shows the reduction in CPU utilization by using a P2000 G3 with VAAI enabled.



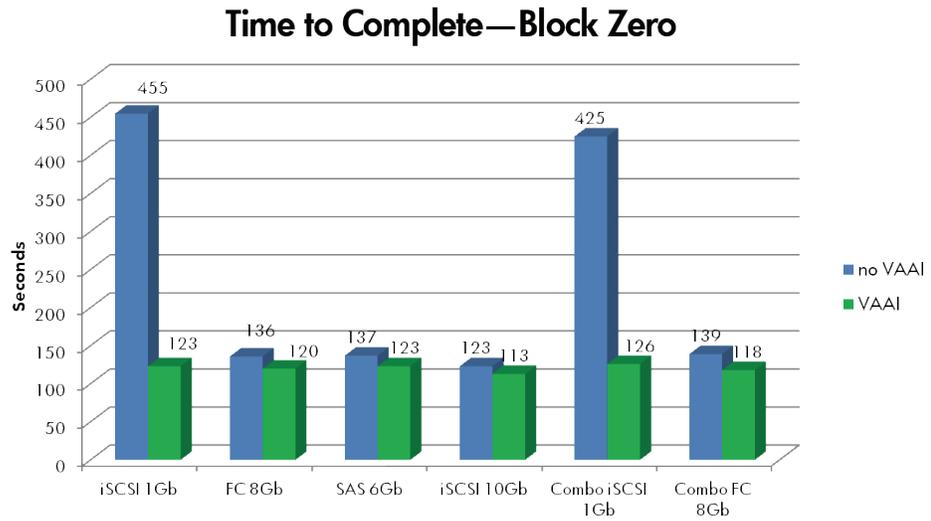
Legend:

X-axis denotes time.

Y-axis denotes percentage.

Figure 2 shows the time savings realized by using a P2000 G3 with VAAI enabled.

Figure 2: Time to complete—Block Zero



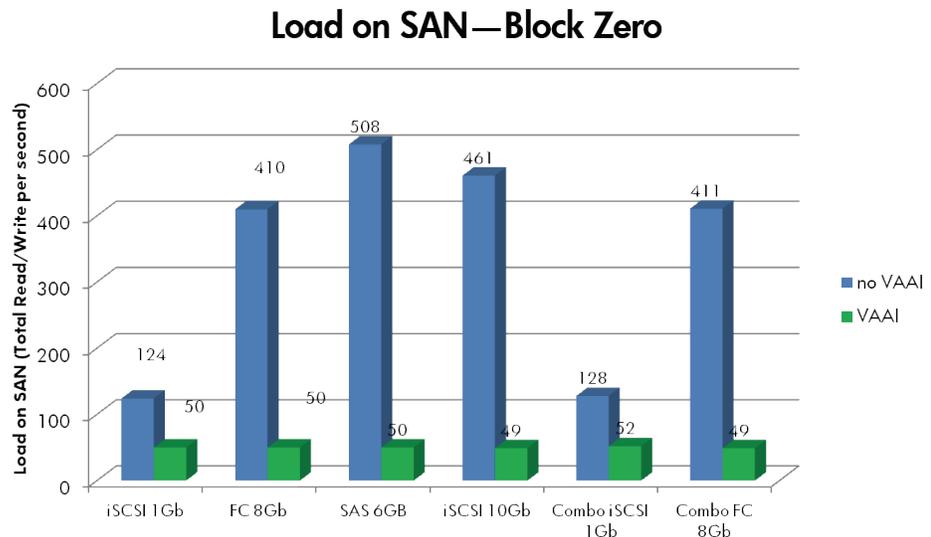
Legend:

X-axis denotes different P2000 G3 arrays.

Y-axis denotes the time taken to complete the command (create a VM using vmkfstools).

Figure 3 shows load reduction (in total read/write per second) on SAN by using a P2000 G3 with VAAI enabled.

Figure 3: Load on SAN—Block Zero



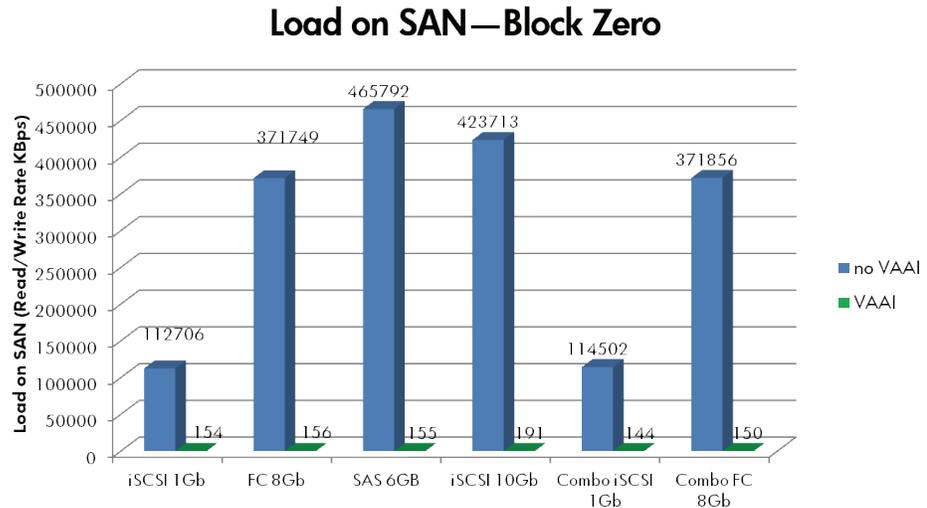
Legend:

X-axis denotes different P2000 G3 arrays.

Y-axis denotes average commands obtained through esxtop command per second while the command is executed.

Figure 4 shows load reduction (in read/write per Kbps) on SAN by using a P2000 G3 with VAAI enabled.

Figure 4: Load on SAN—Block Zero



Legend:

X-axis denotes different P2000 G3 arrays.

Y-axis denotes average total reads and writes in Kbps while the command is executed.

Full Copy

Steps include the following:

- Create RAID 5 vDisk with five (4+1spare) 300 GB SAS 6 GB drives.
- Create a Volume with 500 GB of space and map it to the ESX host.
- Create a datastore and format with 256 GB of space and Block Size of 1 MB.
- Create five 10 GB eagerzeroedthick VMDK simultaneously and zero it.
- Clone five 10 GB VMs simultaneously from the above.
Clone operation is done across the same datastore.
- Monitor the completion time, read/write rate, number of read and number of writes per second using vCenter performance graph and esxtop utility.

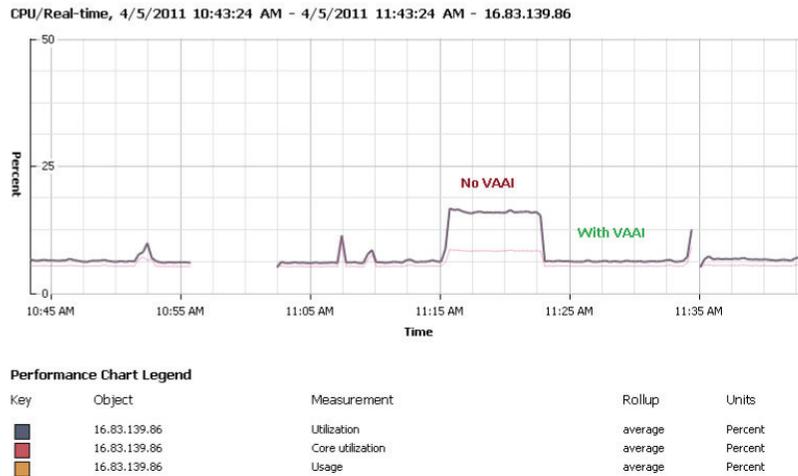
CPU usage during Full Copy

A significant reduction in the CPU utilization is observed when VAAI is enabled. This relieves the CPU to perform other tasks as the P2000 G3 array is tasked to handle the work load related to Full Copy.

In figure 5, CPU utilization changed from around 11 percent to 1 percent when VAAI Hardware Acceleration was enabled for a Full Copy (clone) operation using P2000 G3 10 GB iSCSI storage system, which is around 90 percent reduction in CPU usage. Similarly, reduction in CPU usage is observed across other protocols like FC and SAS.

Figure 5 shows reduction in CPU utilization by using a P2000 G3 with VAAI enabled.

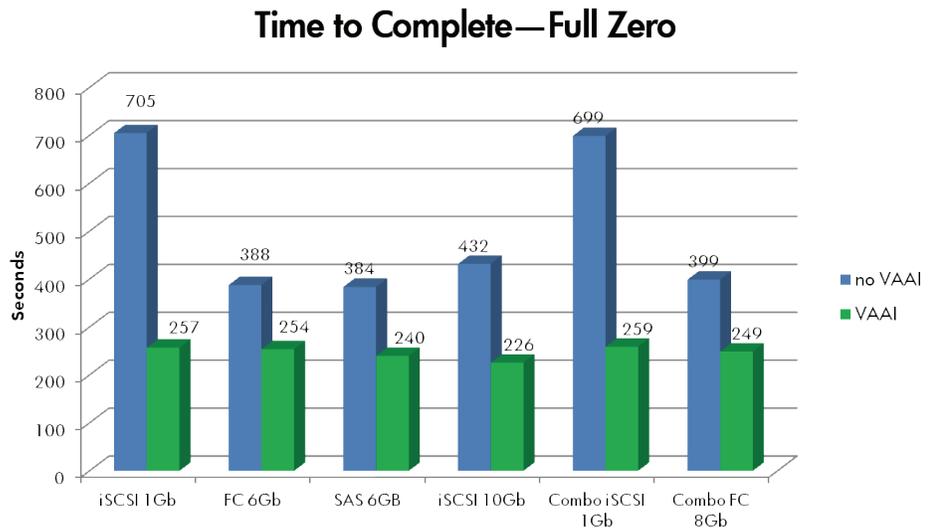
Figure 5: Reduction in CPU utilization when VAAI is enabled



Legend:
 X-axis denotes time
 Y-axis denotes percentage

Figure 6 shows the time savings realized by using a P2000 G3 with VAAI enabled.

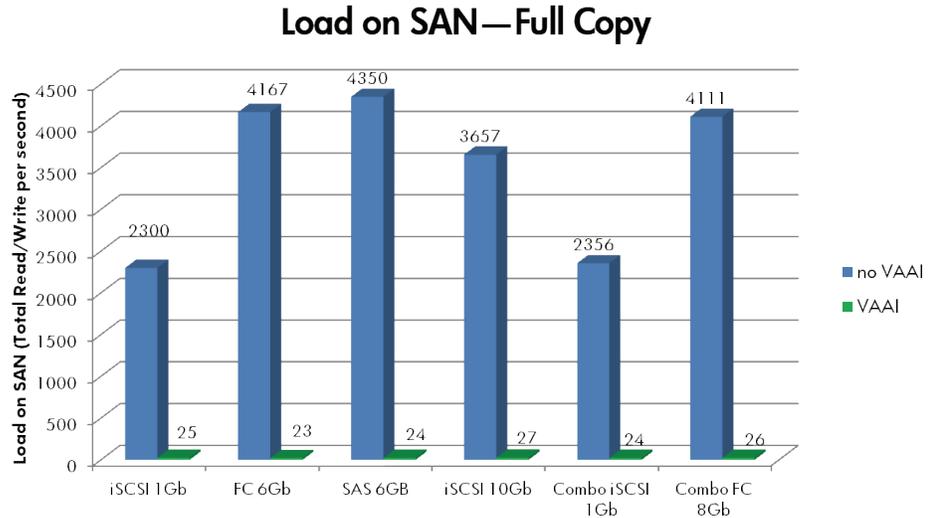
Figure 6: Time to Complete—Full Copy



Legend:
 X-axis denotes different P2000 G3 arrays.
 Y-axis denotes the time taken to complete the command (create a VM using vmkfstools.)

Figure 7 shows load reduction (in total read/write per second) on SAN by using a P2000 G3 with VAAI enabled.

Figure 7: Load on SAN—Full Copy



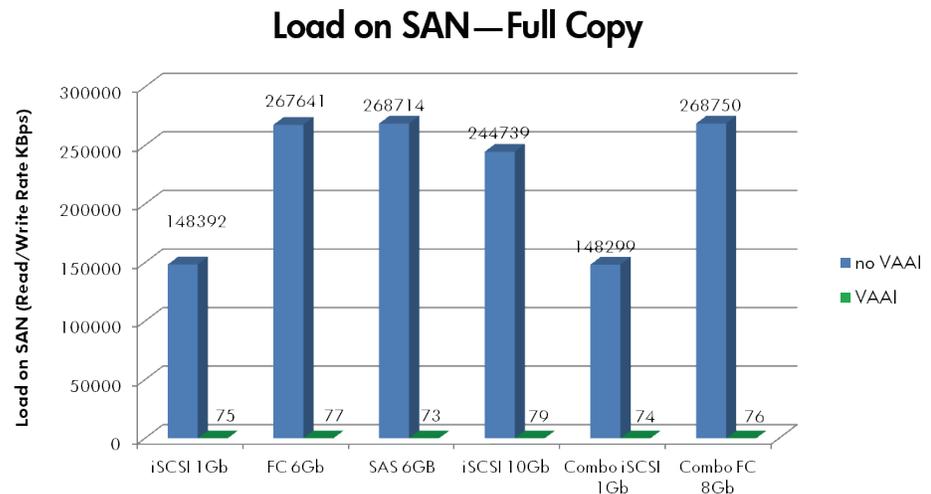
Legend:

X-axis denotes different P2000 G3 arrays.

Y-axis denotes average commands per second obtained through esxtop command while the command is executed.

Figure 8 shows load reduction (in read/write per Kbps) on SAN by using a P2000 G3 with VAAI enabled.

Figure 8: Load on SAN—Full Copy



Legends

X-axis denotes different P2000 G3 arrays.

Y-axis denotes average total reads and writes in Kbps while the command is executed.

Summary

VAAI speeds up virtual machine management operations by delegating these operations to the storage array and enhancing performance. The primitives are ATS, Block Zero, and Full Copy. Each of these primitives can be enabled or disabled.

HP P2000 G3 storage arrays VAAI Plug-in integrates VAAI operations between ESX 4.1 hosts and P2000 G3 arrays running the T230 or later firmware. This integration allows offloading to storage workloads such as vMotion, VM cloning, and template deployments, making these functions more efficient, saving time, CPU usage, and network and storage bandwidth. Hence, using VMware's VAAI primitives coupled with P2000 G3 VAAI enabled storage arrays provides the end user with a highly available, scalable, and efficient virtual environment.

Table 2 shows the key findings after the performance analysis.

Table 2: Key findings after doing performance analysis

VAAI Primitive	Benefits
Block Zero	Time for completion of commands is less (around 70%) and less load on SAN (99% less load), which leads to a faster provisioning of VMs.
Full Copy	Less CPU usage (80 to 90%) and around 99% reduction in load on SAN. This will make deployment of VMs faster.
ATS	Performance is not enhanced specifically with this feature but scalability is improved.

FAQs

1. Is VAAI a new feature to VMware vSphere 4.1?

Yes, it is one of the enhancements of VMware added to the new ESX 4.1.

2. Is VAAI supported on all HP MSA array families?

No, VAAI is not supported for any MSA 2000 G1 and G2 product families. It is supported across all protocols of P2000 G3 arrays that are running on TS230 or later firmware.

3. Is VAAI enabled on ESX/ESXi?

By default, primitives like Full Copy and Block Zero are not enabled upon installation and must be enabled in the advanced settings on the ESX/ESXi server. (Configuration Advanced Settings).

For installation instructions, refer to the release notes of VAAI Plug-in (HP P2000 Software Plug-in for VMware VAAI Release Notes).

4. How can I verify if Hardware Acceleration (VAAI) is enabled in my ESXi host by using the console mode?

Using service console in ESX/RCLI in ESXi, type the following commands and ensure that the value is 1:

```
# esxcfg-advcfg -g /DataMover/HardwareAcceleratedMove #
esxcfg-advcfg -g /DataMover/HardwareAcceleratedInit #
esxcfg-advcfg -g /VMFS3/HardwareAcceleratedLocking
```

5. Can I disable VAAI?

Hardware Acceleration can be disabled by setting the value to 0 for above mentioned primitives.

6. What happens if I have VAAI enabled on the host but some of my disk arrays do not support it?

When storage devices do not support or provide only partial support for the host operations, your host reverts to its native methods to perform the unsupported operations.

7. Where can I download VAAI Plug-in for my HP P2000 G3 arrays?

a) Go to HP Support "Downloads" website at www.hp.com/support/downloads

b) Navigate through the display and select your P2000 G3 array from the list.

c) Select your model and operating system.

d) Scroll through the display and download the HP P2000 Software Plug-in for VAAI named as `hp_vaaip_p2000-xxx.zip`.

8. What happens if I deploy a P2000 array with an older firmware that does not support Hardware Acceleration?

You can define how often ESX should see if Hardware Acceleration is supported on the storage array:

```
# esxcfg-advcfg -g /DataMover/HardwareAcceleratedMoveFrequency
Value of HardwareAcceleratedMoveFrequency is 16384
```

This means that even if during the initial deployment, a storage array does not support the offload primitives but at a later date the firmware on the arrays gets upgraded and the offload primitives are now supported, nothing is required to be done at the ESX side. It automatically starts to use the offload primitives.

9. Is a VAAI Plug-in available for ESXi 5.0 also?

Yes, you can download the VAAI Plug-in for ESX 5.0 from hp.com

Reference

HP P2000 G3 FC MSA Best Practices Technical white paper:

<http://h20195.www2.hp.com/v2/GetPDF.aspx/4AA3-2141ENW.pdf>

vStorage APIs for Array Integration FAQ:

http://kb.vmware.com/selfservice/microsites/search.do?language=en_US&cmd=displayKC&externalId=1021976

vStorage APIs for Array Integration (VAAI):

<http://communities.vmware.com/docs/DOC-14090>

VMware documentation on ESX and vCenter:

<http://pubs.vmware.com/vsphere-50/topic/com.vmware.ICbase/PDF/vsphere-esxi-vcenter-server-50-installation-setup-guide.pdf>

www.vmware.com/pdf/vsphere4/r41/vsp_41_esx_vc_installation_guide.pdf

www.vmware.com/support/vsphere4/doc/vsp_41_new_feat.html

VMware vCenter Update Manager:

www.vmware.com/pdf/vsp_vum_41_admin_guide.pdf



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