# Understand VMware VAAI with QNAP Turbo NAS

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# About VAAI

vStorage API for Array Integration (VAAI) is a technology that VMware makes available for storage vendors to use. The main goal of this technology is to offload the storage operations from the VMware server virtualization hardware to the storage array.

# Audience

This document will treat the VAAI technology applied to QNAP users in a simple way to explain simply the way it works, the benefits, and why it should be used.

Supported hardware

- QNAP Turbo NAS, Business Series with firmware QTS 4.0
- VMware 5.x
- NAS Models : TS-x69 Series, TS-x70 Series, TS-x79 Series, TS-x79U-SAS Series, SS-x79U-SAS Series

# Audience

This document is intended to help understanding VAAI technology on a technical point of view (requires some IT knowledge), and its benefits on a user point of view. It includes the description of a test environment to illustrate it and its usage in real situation other than labs and experiments.

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# 1. The VAAI technology explained and it's benefits

# What is VAAI?

VMware vStorage APIs Integration (VAAI) is a set of APIs provides by vSphere that allows the ESXi hosts to offload data processing of certain storage-related services to storage systems. The QNAP Turbo NAS will process the data instead of the ESXi hosts.

# Overall Benefits:

The integration of QNAP NAS with VMware VAAI offers customers the chance to deploy a virtualized environment with optimized performance. It will offload the data processing to the NAS and releases the ESXi hosts of certain tasks.

# VAAI for iSCSI supports 4 features:

- Full copy (hardware-assisted copy)
- Block zeroing (hardware-assisted zeroing)
- Hardware-assisted locking
- Thin provisioning and space reclaim

VAAI for NAS (NFS) supports 3 features:

- Full File Clone
- Space Reserve
- Extended Statistic

# VAAI for iSCSI

# VAAI iSCSI - Block Copy

Block Copy enables the QNAP storage to make full copies of data within the NAS without needing to have the ESXi host read and write the data.

# Without VAAI:

When an ESXi host copies data without VAAI, it will have to read the data from the NAS, and write back the data to the NAS to copy the data. This process consumes memory, network bandwidth, and CPU from the ESXi host, decreasing the resources available for the VMs.

# With VAAI:

When an ESXi host copies data with VAAI, it will send a command to the NAS, and wait for the result. This process offloads the loading to the Turbo NAS, and leaves the resources allocated to the VM unchanged. The copy process is done in the NAS directly by the NAS. CPU, memory, and network bandwidth are not used in the copy procedure.

# Benefits:

- Reduces the loading of ESXi hosts
- Faster virtual machine cloning
- Faster template deployment
- Faster storage vMotion



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### VAAI iSCSI - Block Zeroing

Block Zeroing allows the QNAP NAS to zero out a large number of blocks to speed up the provisioning of VMs.

# Without VAAI:

When an ESXi host creates and initializes a virtual disk without VAAI, it has to write numerous zeroes to the NAS to create the initialized file. This process consumes memory, network bandwidth, and CPU from the ESXi host, decreasing the resources available for the VMs.

# With VAAI:

When an ESXi host creates and initializes a virtual disk with VAAI, it will send a command to the NAS, and waits for the result. This process offloads the loading to the Turbo NAS, and leaves the resources allocated to the VM unchanged. The block initialization process is done by the NAS directly. CPU, memory, and network bandwidth are not used for that operation.

# Benefits:

- Reduces the loading of ESXi hosts.
- Faster allocation of the capacity for virtual machines.

### Effective usage:

- Create Thick Provision Eager Zeroed virtual disks.
- Create VM with Thick Provision Eager Zeroed virtual disks.



iSCSI datastore

ESXi Host





# VAAI iSCSI - Hardware assisted Locking

Hardware Assisted Locking improves efficiency on large clusters by locking only required blocks instead of the entire LUN. When read/write operations occur from one ESXi server, it will keep the rest of the LUN available to be accessed to increase efficiency.

# Without Hardware Assisted Locking:

When an ESXi host is accessing a datastore on an iSCSI LUN, the iSCSI LUN will be locked and other ESXi hosts have to wait the LUN to be released. The more ESXi hosts that share the same datastore, the lower the performance will be.

# With Hardware Assisted Locking:

When an ESXi host is accessing a datastore on an iSCSI LUN, the required blocks are locked, and the iSCSI LUN remains available for the other ESXi hosts. More concurrent operations can be achieved while maintaining a good performance level.

# Benefits:

- Permits the QNAP NAS to scale to more VMs
- Permits more ESXi hosts without performance penalty.

# Effective usage:

- Large VMware cluster with shared datastores.







### VAAI iSCSI - Thin Provisioning and Space Reclaim

Thin Provisioning allows the allocation of capacity only when it's needed. It is possible to pre-allocate capacity for iSCSI LUNs without effectively using it. This capacity will be used only when data, Virtual Machines or virtual disks, will be stored in the LUN.

Space Reclaim allows the space to be released when VM or virtual disks are deleted or migrated to other LUNs. It avoids wasting capacity after data has been removed.

# Without Thin Provisioning and Space Reclaim:

Without Thin Provisioning and Space Reclaim, the space allocation is done at LUN creation, and cannot be released until the LUN is deleted. In that case, if an administrator creates a 100 TB LUN, the 100 TB will be reserved for the LUN and cannot be used for any other applications. If some data are deleted from the LUN, the NAS will not have more free space, as the deleted data cannot be freed. The storage management is less flexible, requires more physical capacity (Hard Drives) and increases costs.



# With Thin Provisioning and Space Reclaim:

With Thin Provisioning and Space Reclaim, the space allocation is done only when data is effectively written, and it can be released when data is deleted. In that case, if an administrator creates a 100 TB LUN, but will be consumed only when VM are created, and will be released when VMs are deleted. The free space on the NAS will dynamically increase and decrease as the VMs are created and deleted. The storage management is much more flexible and requires less physical capacity (Hard Drives). It increases efficiency and reduces costs of storage.

# Benefits:

- More accurate reporting of real disk space usage.
- Better and more efficient storage management
- Reduce costs of storage.
- Use capacity only when needed
- Purchase Hard Drives only when needed

### Effective usage:

- VM creation / deletion
- Snapshot creation/deletion





# VAAI for NAS (NFS)

# VAAI NAS - Full file clone

Similar to the Full Copy in VAAI iSCSI, it enables the QNAP storage to make full copies of data within the NAS without needing to have the ESXi host read and write the data.

# Without Full File Clone:

When an ESXi host copies data without VAAI, it will have to read the data from the NAS, and write back the data to the NAS to copy the data. This process consumes memory, network bandwidth, and CPU from the ESXi host, decreasing the resources available for the VMs.

# With Full File Clone:

When an ESXi host copies data with VAAI, it will send a command to the NAS, and wait for the result. This process offloads the loading to the Turbo NAS, and leaves the resources allocated to the VM unchanged. The copy process is done in the NAS directly. CPU, memory, and network bandwidth are not used for the

### Benefits:

- Reduces the loading of ESXi hosts

# Effective usage:

- vCenter Cloning
- Storage vMotion (cold clone)
- Deploy VMs from templates







### VAAI NAS - Space Reserve

Historically, vSphere only supported building thin provisioned virtual disks on NFS. By supporting the Reserve Space, a space pre-allocated virtual disk (thick provision eager zeroed disk) is possible in QNAP NFS datastores, by offloading the file creation onto the NAS.

# Benefits:

 Better virtual disk read/write performance (thin provision disks vs thick provision disks)

Without Space Reserve:

 Without Space Reserve, user cannot create Thick Provisioned virtual disks on NFS datastore and only Thin Provisioned is available.



- With Space Reserve, user can create Thick Provisioned virtual disks on NFS datastores.

#### VAAI NAS - Extended statistic

Extended Statistic enables vSphere to query space utilization details for virtual disks on QNAP NFS datastores. This includes the size of a virtual disk and the real space consumption of the virtual disk.

The extended statistics are used by VMware during some specific operations like Space Reserve and Clone.



Also, it can be retrieve by command line from the ESXi host:

/vmfs/volumes/86721f64-65fb714e/MyVM1	<pre># vmkfstoolsextendedstat MyVM1.vmdk</pre>
Capacity bytes: 17179869184	
Used bytes: 1608630272	
Unshared bytes: 1608630272	

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# 2. Installation and Verification

# VAAI for iSCSI

VAAI iSCSI does not require any installation. It is enabled in VMware by default.

To Verify that the storage supports VAAI, simply open the storage configuration in vSphere Client, select the datastore. The column "Hardware Acceleration" (VAAI) will show supported.

172.17.31.203 ¥Mware E5Xi, 5.0.0, 1024	429	
Getting Started Summary Virtual Mach	ines Performance Configuration Tasks & Events Alarms Permissions Maps QNAP	Storage Views Hardware Status Update Manager
Hardware	View Datastores Devices	<u> </u>
Processors	Datastores	Refresh Delete Add Storage Rescan All
Memory	Identification    Status Device Drive Type Capacity	Free Type Last Update Alarm Actio Storage I/O Cont Hardware Acceler
<ul> <li>Storage</li> </ul>	👔 10gnfs 🛛 🥑 Normal 192.168.219 Unknown 1,007.93 G 9	962.23 GB NF5 8/24/2013 1 Enabled Disabled Supported
Networking	😝 datastore1 (1) 🛛 🤣 Normal Local ATA Disk Non-SSD 231.50 GB 23	223.46 GB VMF53 8/24/2013 1 Enabled Disabled Unknown
Storage Adapters	😝 ISOs (read only) 🔥 Warni 10.8.13.54:/I Unknown 1.34 TB 20	262.60 GB NFS 8/24/2013 1 Enabled Disabled Not supported
Network Adapters	😭 NFS 879 Pro 🛛 🧑 Normal pm-vmstore Unknown 10.82 TB	5.27 TB NFS 8/24/2013 1 Enabled Disabled Not supported
Advanced Settings	🔋 QNAP-REXP1-Thin 📀 Normal QNAP iSCSI D Non-SSD 499.75 GB 4	498.80 GB VMF55 8/24/2013 1 Enabled Disabled Supported
Power Management	👔 QNAP-REXP2-Thin 🥑 Normal QNAPTSCSTU Non-SSD 499.75 GB 4	498.80 GB VMF55 8/24/2013 1 Enabled Disabled Supported
	A TS-870 Dro - Hear A Normal ONAD ISCST D Non-SSD 10.75 CB	18.85 GR VMESS 8/24/2013 1 Enabled Dicabled Supported
Software	<u>N</u>	
Licensed Features	Datastore Details	Properties
Time Configuration	QNAP-REXP1-Thin 499.75 GB C	Capacity
DNS and Routing	Location: /vmfs/volumes/52183c18-271ea7fe-aed6-e4115b102154	
Authentication Services	Hardware Acceleration: Supported 973.00 MB	Used
Power Management	Refresh Storage Canabilities	
Virtual Machine Startun/Shutdown		×

Enabling and disabling VAAI in VMware is possible. Please refer to VMware documentation for this operation: Disabling the VAAI functionality in ESXi/ESX (1033665): <u>http://kb.vmware.com/kb/1033665</u>

Additionally, it can be verified by command line through SSH or ESXi Shell with the command:



We can see the 4 VAAI features supported by the QNAP iSCSI LUN.

# VAAI for NAS (NFS)

VAAI NFS requires the installation of VAAI plugin on each ESXi hosts.

If the ESXi servers are not connected to internet:

- Download the VAAI NAS plugin from: <a href="http://www.qnap.com/utility">http://www.qnap.com/utility</a>
  - Or with the current direct link: <u>http://eu1.qnap.com/Storage/Utility/QNAP\_QNPNasPlugin\_1.0.zip</u>
- Install the plugin following VMware procedure:
  - Installing patches on an ESXi 5.x host from the command line: <u>http://kb.vmware.com/kb/2008939</u>
- Reboot each ESXi host.
- Verify from vSphere client that "Hardware Acceleration" is supported.





If the ESXi servers are connected to internet:

- Open the each ESXi console (or through SSH) and execute the command: ~ # esxcli software vib install -v http://eul.qnap.com/Storage/Utility/QNAP\_QNPNasPlugin\_1.0.vib --no-sig-check Installation Result Message: The update completed successfully, but the system needs to be rebooted for the changes to be effective. Reboot Required: true VIBs Installed: QNAP\_bootbank\_QNPNasPlugin\_1.0-1.0j VIBs Removed: VIBs Skipped: ~ #

- -no-sig-check is set to allow non-signed VIB packages. The package will be signed when it will be VMware Ready (At this time, the certification process is in progress).
- $\circ$   $\hfill A$  reboot is required to activate the new VIB.
- After each installation, it displays VIBs installed, removed, skipped.
- Reboot each ESXi host after installation
- Verify that VAAI NAS is supported on NFS datastores from vSphere Client :

Processors Memory	Datastores										
Memory									Refresh	Delete Ad	id Storage Resca
	Identification 🗠	Status	Device	Drive Type	Capacity	Free	Туре	Last Update	Alarm Actio	. Storage I/C	Cont Hardware Ac
Storage	👔 10gnfs	🦁 Normal	192.168.219	Unknown	1,007.93 G	962.23 GB	NFS	8/24/2013 1	Enabled	Disabled	Supported
Networking	datastore1 (1)	🦁 Normal	Local ATA Disk	Non-SSD	231.50 GB	223.45 GB	VMF53	8/24/2013 1	Enabled	Disabled	Unknown
Storage Adapters	ISOs (read only)	🔔 Warni	10.8.13.54:/I	Unknown	1.34 TB	262.60 GB	NFS	8/24/2013 1	Enabled	Disabled	Not supporte
Network Adapters	MES 879 Pro	Normal	pm-vmstore	Unknown	10.82 TB	5.27 TB	NFS	8/24/2013 1	Enabled	Disabled	Not supporte
Advanced Settings	QNAP-NF52	📀 Normal	172.17.31.21	Unknown	492.15 GB	491.46 GB	NFS	8/24/2013 1	Enabled	Disabled	Supported
Power Management	QNAP-REXP1-Thin	😸 Normal	QNAP ISCSI D	Non-SSD	499.75 GB	498.80 GB	VMFS5	8/24/2013 1	Enabled	Disabled	Supported
	ONAD-DEVD2-Thin	A Normal	ONIAD ISOST D	Non-SSD	400 75 CR	408 80 GR	UMESS	8/24/2013 1	Fnahlad	Dicabled	Supported
oftware											
Licensed Features	Datastore Details										Prope
Time Configuration	QNAP-NFS2				492.15 GB	Capacity					
DNS and Routing	Server: 172.17.31.2	18									
Authentication Services	Folder: nfs-ds-20130	824132243			712.04 MB	Used					

# Note: During the installation, if a previous version of the plugin was installed, it will be listed as VIBs Removed:

~ # esxcli software vib install -v http://eul.gnap.com/Storage/Utility/QNAP\_QNPNasPlugin\_1.0.vib --no-sig-check Installation Result Message: The update completed successfully, but the system needs to be rebooted for the changes to be effective. Reboot Required: true VIBs Installed: QNAP\_bootbank\_QNPNasPlugin\_1.0-1.0j VIBs Removed: QNAP\_bootbank\_QNPNasPlugin\_1.0-1.0h VIBs Skipped:





# 3. Application scenarios and results

# Difficulties that the storage has to face against virtualization storage

QNAP Turbo NAS provides administrators comfort and safety when using VMware, while saving storage budget for other usage. With the performance improvement, efficient storage management, and better storage usage reporting, QNAP Turbo NAS meet business needs by constantly adding and improving new features.

# Performance for VMs management and movement

Virtual Machine can be compared as large files, between 10GB and 100GB. When an administrator needs to deploy additional virtual machines or copy/backup existing virtual machines, the process can be compared as copying those large files. In a traditional environment, it would involve and require resources from different parts of the environment such as storage, network, ESX servers, and CPU and would reduce the available resources for the end-user using those virtual machines.

Using QNAP Turbo NAS and VMware VAAI, the copy process will be offloaded to the storage so that the impact of running virtual machines will be minimized.

# Performance for clusters

VMware Cluster allows connecting multiple ESXi host to the same datastore to provide high availability and easy live migration. However, the downside is that the more ESXi hosts belong the cluster performance will decrease when accessing the datastore, as explained in VAAI iSCSI - Hardware assisted Locking (page 5.) With traditional storage, it is advised to create multiple datastores with fewer virtual machines or to connect multiple storages.

Using QNAP turbo NAS and VAAI, the performance impact is largely reduced allowing for a larger number of VMs to be running.

### Storage efficiency management

IP-SAN/iSCSI Storage provides capacity to servers. However, without thin provisioning physical storage is needed and the whole allocated capacity must be purchased before being provisioned. With thin provisioning, the space can be allocated, without having the real capacity available. The downside of standard thin provisioning is that when the content is deleted from the LUN it cannot be freed, and capacity management can become more complicated. Space Reclaim can solve that last issue by allowing compatible client to reclaim the capacity.

QNAP Turbo NAS with Thin Provisioning and Space Reclaim allows a more efficient storage management. It is possible to virtually allocate storage capacity but use it only when it is really needed. The administrators can now allocate capacity in advance with thin provisioning.

The following tests illustrate those issues and solution with QNAP Turbo NAS.





# **The Test Environment**

The tests and results have been done with a non-official firmware before the official release. The performance result in this document may differ from the official firmware.

This application scenarios and tests have been realized using the following components:

- 2 ESXi hosts
  - HP ProLiant ML 110, with Xeon Processor and 24 GB of RAM
  - $_{\odot}$   $\,$  HP ProLiant ML 110, with Xeon Processor and 24 GB of RAM  $\,$
- 1 QNAP Turbo NAS
  - TS-EC1279U-RP + expansion units
  - Turbo NAS firmware version 4.0 (supports VAAI NAS and VAAI iSCSI)
  - Expansion Units : REXP-1200U-RP x2
  - Hard Drives : SEAGATE ST9300653SS (SAS drives)
  - RAID configuration : RAID 6 with 9 hard drives + 1 Hot Spare on each expansion unit (total 10 HDD per unit)
- vSphere 5.0

0

- VMware ESXi 5.0
- Enterprise Licensed to support VAAI
  - 2 VMFS Datastores (iSCSI), block based, with thin provisioning
    - VMFS Datastore 1 : QNAP-REXP1-Thin
      - VMFS Datastore 2 : QNAP-REXP2-Thin
- 2 NFS Datastores
  - NFS Datastore 1 : QNAP-NFS1
  - NFS Datastore 2 : QNAP-NFS2
  - ESXi host 1 with VAAI NAS disabled
  - ESXi host 2 with VAAI NAS enabled
- Standard gigabit network connection

# VM template deployment: Offload data processing when copying data

### Deploy a VM template to create a new VM- with VAAI iSCSI Full Copy or VAAI NAS Full File Clone

One possible application of VAAI is to deploy a new virtual machine from a template. To deploy a template to a new virtual machine, click on the template and select "Deploy Virtual Machine from this template".

MyCluster     172.17.31.202     172.17.31.203	Getting Started Summary Virtua	al Machines Hosts DR5 Reso	ource Allocation Perform	mance 🔪 Tasks & Ever	nts Alarms Permi	ssions 🔪 Map
🗉 🧑 Pre-prod	Name	√ State	Status	Host	Provisioned Space	Used Space
🕀 🧑 Test	in second all	Powered Off	🛞 Normal	172.17.31.202	2.11 GB	383.45 KB
Contraction Contraction Contraction		Powered Off	🗑 Normal	172.17.31.202	5.36 GB	4.27 GB
AAI NAS	Windows 2012 Evaluation Syspre	ap 1000	A 11 1	170 17.31.202	32.11 GB	30.00 GB
🛨 📷 prod		Clone		7.31.202	33.67 GB	21.77 GD
	and the second states	Convert to Virtu	ial Machine	7.31.208	47.16 GB	45.00 GB
	A state of a state	Deploy Virtual M	lachine from this Template	7.31.202	34.15 GB	32.00 GB
	added and comments	Add Permission		rl+P 7.31.202	22.16 GB	20.00 GB
	- and the second second			7.31.202	32.11 GB	30.00 GB
		Open in New Wi	indow Ctrl+A	lt+N 7.31.202	30.02 GB	28.59 GB
	a - manufacture	Rename		7.31.202	22.11 GB	1.60 GB
	and the second second	Remove from In	iventory	7.31.202	21.87 GB	6.53 GB
	A reduced 1	Delete from Disl	<	7.31.202	32.03 GB	17.04 GB
	a - mainten		2 21	7.31.202	17.15 GB	1.77 GB
	and an other	Copy to Clipboa		ri+C 7.31.202	21.16 GB	20.00 GB

The Template is stored on the VMFS Datastore 1, on an iSCSI LUN with Thin Provisioning. On the above screenshot, we see how to deploy the template. It uses 30 GB of capacity.

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Name	Target	Status	Details	Initiated by	vCenter Server	Requested Start Ti 🗸	Start Time	Completed Time
Clone virtual machine	🗿 Windows 2012 Ev	aluation Syspr 🥝 Completed		PMAD\jaussa	pm-vcenter5	9/5/2013 10:21:32	9/5/2013 10:21:32	9/5/2013 10:22:39
		Requested Start Ti 🔽	-   Start Time	Completed	d Time			
		9/5/2013 10:21:32	9/5/2013 10:21:32	9/5/2013	10:22:39			

From VMware logs, we can see that the time needed to deploy the template to create a new VM is only **1 minute and 7 seconds**! Because the template is 30 GB, this corresponds to a throughput of **458 MB/s**. Note that the speed of the deployment can vary depending on the environment, hardware, software and template location.

From the NAS UI, we can verify that the network has not been used. The copy operation has effectively been offloaded to the NAS.







To compare, we repeat the procedure to another LUN without using VAAI.

We can easily see the network usage from the NAS resource monitor, with a max throughput of 100 MB/s using 1 gigabit LAN. Because the NAS is fast enough, we can reach the maximum throughput allowed with 1 gigabit network, but it is still lower than using VAAI.



vCenter Server	Requested Start Ti ▽	Start Time	Completed Time
pm-vcenter5	9/5/2013 10:30:33	9/5/2013 10:30:33	9/5/2013 10:36:18

As a result we can conclude that in this test, there is a huge difference when deploying a template with VAAI and the benefit can easily be understood, in time, and resource usage:

	With VAAI	Without VAAI
Time to deploy 30 GB template	67 seconds	5 minutes 45 seconds
Average bandwidth to deploy the template	458 MB/s	89 MB/s

VAAI in this test is 5 times faster for deploying a template!

# Clone a VM - with VAAI iSCSI Full Copy or VAAI NAS Full File Clone

The benefits obtained above when deploying a VM template can also be found when cloning a VM. VAAI provides this functionality for VMFS datastores (iSCSI) and for NAS (NFS).

- VAAI iSCSI provides "Full Copy"
- VAAI NAS provides "Full File Clone"

The behavior of cloning a virtual machine is the same as deploying a template. The process is offloaded to the NAS. The network will not be used to perform the copy and the performance needed time will be lower.

Note: VAAI will be used only with the same datastore type:

- VAAI will be used between 2 iSCSI LUNs
- VAAI will be used between 2 NFS shares.
- VAAI cannot be used between 1 iSCSI LUN and 1 NFS share.





# Create new VMs and Offload data processing

# Create a new VM on a iSCSI datastore with eager zeroed disks - with VAAI iSCSI Block Zeroing

During the creation of a new Virtual machine, the user as the choice to choose Thick provisioning (lazy or eager zeroed) and Thin Provisioning. If the user choose "Thick Eager Zeroed" disk, VMware will perform a virtual disk creation, reserve the capacity, and initialize the disk with zeros. This requires a lot of time if VAAI is not available, where it can take only a few second with VAAI.

In our test environment, we are equipped with only a gigabit LAN, so if we create a 100 GB Hard Drive, the time would be more than 15 minutes at 100 MB/s (single gigabit LAN average speed).

Using VAAI, the test shows that to create a 100 GB virtual machine with Thick Provisioned Eager Zeroed Disk, It took only 7 sec!

Config ration	- Capacity	
Consideration Resource Dool Storate Virtual Machine Version Gest Contraction System CPUs Memory Network Soft Controller Select a Disk <b>Create o Disk</b> Advanced Options Ready to Complete	Capaday Disk Size: 100	Browse
Help	< Bai	k Next > Copyel

Thick Provisioned Eager Zeroed Disk on the QNAP Thick Provisioned iSCSI LUN takes 2 minutes 21 seconds:

Name	Target	Status	Details	Initia	vCenter Server	Requested Start Ti 🖙	Start Time	Completed Time
🌮 Create virtual machine	MyDatacenter	Completed		PM	pm-vcenter5	9/5/2013 11:00:30	9/5/2013 11:00:30	9/5/2013 11:02:21

Thick Provisioned Eager ZeroedDisk on the QNAP Thin Provisioned iSCSI LUN takes 7 seconds:

Name	Target	Status	Details	Initia	vCenter Server	Requested Start Ti ▽	Start Time	Completed Time
Create virtual machine	MyDatacenter	Completed		PM	pm-vcenter5	9/5/2013 11:04:50	9/5/2013 11:04:50	9/5/2013 11:04:57





### Create Thick Provision Disk on NFS Datastore – with VAAI NAS Space Reserve

te New Virtual Machine Ite a Disk ipecify the virtual disk size and provisioning policy		Virtual Machine Version: 8	Create New Virtual Machine Create a Disk Specify the virtual disk size	e and provisioning policy		Virtua
anne and Location source Pool corae     Capacity       bits Ster     100 ± 10 ± 10 ± 10 ± 10 ± 10 ± 10 ± 10	d d ed store duster: 		Conflouration Name and Location Besource Dod Storace Victual Nachine Version Guest Constant System CEUs Manary Network SCSI Controller Select a Dek Advanced Options Ready to Conglete	Capacity Disk Stee: No Capacity C Thick Provisioning C Thick Provision Lary Zero C Thick Provision C Thick Provision C Store with the girtual mac C Specify a glatastore or da	eed roed stastore duster:	Without VAAI NAS, in not possible to creat Thick Provision Disk a NFS datastore.
HEFE		astore	Uithout VAAI N	AS, only Thin I	Provisioned	_≤Back Next≥ d Disk are allow
AI NAS allows Thick Provisio	 ned Disk on NFS Data	astore	Uithout VAAI N	AS, only Thin F	Provisioned	sBack Next≥ d Disk are allow
AI NAS allows Thick Provisio Resources Consumed Host CPU: Consumed Host Memory: Active Guest Memory:	seek № ned Disk on NFS Data 0 M 0.00 0.00	astore HHz MB MB	Without VAAI N Resource Consum Active G	AS, only Thin F ces ed Host CPU: ed Host Memory: juest Memory:	Provisioned	sBack Next≥ d Disk are allow 0 MHz 0.00 MB 0.00 MB
AI NAS allows Thick Provisio Resources Consumed Host CPU: Consumed Host Memory: Active Guest Memory: Provisioned Storage: Not-shared Storage: Used Storage: Consumed Host CPU: Consumed Host CPU: Co	0 M 0 M 0.00 0.00 0.00 0.00 0.00 0.00 0.	astore HHz MB GB GB GB	Helo Without VAAI N Consum Consum Active C Provision Not-sha Used Str	AS, only Thin F es ed Host CPU: ed Host Memory: uest Memory: ned Storage: red Storage: orage:	Provisioned	SBack Next≥ d Disk are allow 0 MHz 0.00 MB 0.00 MB 0.00 MB 2.26 KB 2.26 KB 2.26 KB
AI NAS allows Thick Provisio Resources Consumed Host CPU: Consumed Host Memory: Active Guest Memory: Provisioned Storage: Used Storage: Storage  Star @ QNAP-NFS2 @	sned Disk on NFS Data 0 M 0 0 M 0.00 0.00 Refresh Storace Us 104.11 100.00 100000000	astore	Uithout VAAI N Resource Consum Active C Provision Not-sha Used St Storage	AS, only Thin F ces ed Host CPU: ed Host CPU: ed Host Memory: juest Memory: iuest Memory: red Storage: red	Provisioned rovisioned Provisioned Provisioned Provisioned Provisioned	SBack Next≥ d Disk are allow 0 MHz 0.00 MB 0.00 MB 0.00 MB 0.00 MB 2.25 KB 2.26 KB 2.26 KB 2.26 KB 2.26 KB 2.26 KB 2.26 KB 2.26 KB 2.26 KB
AI NAS allows Thick Provisio Resources Consumed Host CPU: Consumed Host Memory: Active Guest Memory: Active Guest Memory: Provisioned Storage: Used Storage: Storage  Stat QNAP-NFS2  V I	Unknown	astore	Without VAAI N Resource Consum Consum Active G Provision Not-sha Used St. Storage	AS, only Thin F ces ed Host CPU: ed Host Memory: iuest Memory: iuest Memory: red Storage: red	Provisioned Provisioned Normal	SBack Next≥ d Disk are allow 0 MHz 0.00 MB 0.00 MB 0.00 MB 0.00 MB 2.26 KB 2.26 KB 2.26 KB 2.26 KB 0 MHz 0.00 MHZ
AI NAS allows Thick Provisio Resources Consumed Host CPU: Consumed Host Memory: Active Guest Memory: Active Guest Memory: Not-shared Storage: Used Storage: Storage  Stat QNAP-NFS2  Stat Network Typ	Ined Disk on NFS Data oned Disk on NFS Data 0 M 0.00 0.00 Refresh Storage Us 104.11 100.00 100.00 100.00 tus Drive Type Normal Unknown	astore	Used Stronger	AS, only Thin F tes ed Host CPU: ed Host Memory: uest Memory: red Storage: red Storage: red Storage: s > 55 NAP-NFS1	Provisioned Provisioned Normal	Stack Next≥ Stack Next≥ Contract Storage Logg Contract Storage L
AI NAS allows Thick Provisio Resources Consumed Host CPU: Consumed Host Memory: Active Guest Memory: Active Guest Memory: Not-shared Storage: Used Storage Used Storage Storage Stat QNAP-NF52 Provisioned Storage: Network Typ Private1 Star	Ined Disk on NFS Data oned Disk on NFS Data 0 M 0.00 0.00 Refresh Storage Us 104.11 100.00 100.00 100.00 tus Drive Type Normal Unknown e ndard port group	astore	Uithout VAAI N Resource Consum Active G Provision Not-sha Used St Storage Q Networ Q Networ Q Provision Not-sha	AS, only Thin F tes ed Host CPU: ed Host Memory: uest Memory: red Storage: red Storage: red Storage: red Storage: s k k Ty rivate1 St	Provisioned tatus Normal ype tandard port gro	Steep Steep

VAAI NAS allows for VMware to pre-allocate and reserve the capacity using Thick Provision Disk.

Only Thin Provision Disk on NFS datastore are allowed. Therefore it is not possible to reserve the capacity on NFS datastore without VAAI NAS.

VM Storage Profiles:

Profiles Compliance:

Refresh

Note about VAAI iSCSI Block Zeroing and VAAI NAS Space Reserve:

As explained previously, historically only Thin Provisioned Disk was possible on NFS datastores. With the introduction of Space Reserve, it is possible to create Thick Provisioned VMDKs on NFS datastores.

Refresh

However VAAI NAS Space Reserve is not like VAAI iSCSI block zeroing; it does not send the command to the storage to offload the operation, but simply allow the operation that was not possible in the past. When creating a VMDK on a VAAI NAS storage, Space Reserve will check the NAS storage to make sure that the space is available. Then, VMware has the possibility to create and reserve the capacity for the VMDKfile. This means that creating a Thick Provisioned Eager Zeroed Disk on a NFS datastore is a slow operation, and any write operations are sent over the network, and not offloaded as it is for iSCSI storage.

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VM Storage Profiles:

Profiles Compliance:

# Efficient Storage Capacity Management with Thin Provisioning and Space Reclaim

As explained previously, Thin Provisioning LUN and Space Reclaim allow a better and more efficient capacity management. This can be demonstrated simply.

The first step is to create a small datastore. "Small" so that it is easy to see the effect with a small example as the one below.

In this example, we are going to connect 2 hard drives and create a small Storage Pool in the QNAP NAS, only to demonstrate Thin Provisioning and Space Reclaim:



In the screenshot above, we added 2 disks in order to create a small storage pool for this test: 285 GB.



Now, we create a Thin Provisioned iSCSI LUN, which will be used as datastore for VMware. iSCSI LUN size : 250 GB





Then we connect the newly created LUN to VMware and create a new datastore to test Thin Provisioning and Space Reclaim.

We can verify that VAAI is supported: "Hardware Acceleration Supported"

The free capacity is around 250 GB as we did not create or store any VM inside.

QNAP-Thin-Reclaim-Test Location: /vmfs/volumes/522d8b93-r8c3e424-065f-000e1e0a63f8 Hardware Acceleration: Supported Refresh Stroam Canabilities					249.75 GB Capa	city	
					972.00 MB 🔲 Used 248.80 GB 🔲 Free		
User-defin	ed Storage	Capability: N/A					
Path Selection		Properties Extents		Eutopte			Ebavage I/O Control
	at 11	Propercies		LAUCIUS			Storage 1/ O Control
Most Recei	ntly Us	Volume Label:	QNAP-Thin	QNAP ISC	SI Disk (naa.6e84	250.00 GB	Disabled
Most Recei	ntly Us	Volume Label: Datastore Name:	QNAP-Thin QNAP-Thin	QNAP ISC	SI Disk (naa.6e84	250.00 GB	Disabled
Most Recer Paths	ntly Us	Volume Label: Datastore Name:	QNAP-Thin QNAP-Thin	QNAP ISC Total Forr	SI Disk (naa.6e84 natted Capacity	250.00 GB 249.75 GB	Disabled
Most Recer Paths Total:	ntly Us	Volume Label: Datastore Name: Formatting	QNAP-Thin QNAP-Thin	QNAP ISC Total Forr	SI Disk (naa.6e84 natted Capacity	250.00 GB 249.75 GB	Disabled
Most Recer Paths Total: Broken:	ntly Us 1 0	Volume Label: Datastore Name: Formatting File System:	QNAP-Thin QNAP-Thin VMFS 5.54	QNAP ISC Total Forr	SI Disk (naa.6e84 natted Capacity	250.00 GB 249.75 GB	Disabled



At this stage, we have 1 Storage Pool (285 GB Capacity), 1 datastore (250 GB):

On the NAS side, we can see below that only the real used data has been allocated. Because the datastore is empty, the Storage Pool on the NAS has almost no capacity allocated, and still has all capacity free that could be shared for other usages.

The next step is to store some data into the datastore.

Now that the test datastore is created, we are going to clone multiple VMs (7 in total) in the new datastore called "QNAP-Thin-Reclaim-Test", and see how the storage usage evolves.

Name 🛆	State	Status	Host	Provisioned Space	Used Space
👜 vmtest1	Powered Off	🦁 Normal	172.17.31.203	32.12 GB of 32.12 GB	30.00 GB of 30.00 GB
🛅 vmtest2	Powered Off	🤣 Normal	172.17.31.203	32.12 GB of 32.12 GB	14.21 GB of 14.21 GB
🛅 vmtest3	Powered Off	🤣 Normal	172.17.31.203	32.12 GB of 32.12 GB	14.21 GB of 14.21 GB
👜 vmtest4	Powered Off	🤣 Normal	172.17.31.203	32.12 GB of 32.12 GB	14.21 GB of 14.21 GB
😰 vmtest5	Powered Off	🤣 Normal	172.17.31.203	32.12 GB of 32.12 GB	14.21 GB of 14.21 GB
👘 vmtest6	Powered Off	🤣 Normal	172.17.31.203	32.12 GB of 32.12 GB	14.21 GB of 14.21 GB
🔂 vmtest7	Powered Off	🤣 Normal	172,17,31,203	32.12 GB of 32.12 GB	14.21 GB of 14.21 GB





# On VMware side:

- 115 GB used on the new datastore
- 225 GB Provisioned on the datastore
- 133 GB free space in the datastore

General	Capacity	
Location: ds:///vmfs/volumes/522d8b93-c8c3e4	Ref	irest
	Capacity: 249.75	GB
Tuner UMEC	Provisioned Space: 225.81	GB
Type: VMP5	Free Space: 133.47	GB
Virtual Machines and Templates: 7	Last updated on: 9/10/2013 13:23:	42
	Storage Capabilities	
Commands		
Defrech	Ref	resh
( Refresh	System Storage Capability: N/A	
Enter SDRS Maintenance Mode	User-defined Storage Capability: N/A	
Browse Datastore		
Accion Licer-Defined Storage Canability		

Storage Pool List - Total 4 Pool(s) New Storage Pool Remove Pool Expand Pool
Storage Pool 1 Name/Alias Capacity Allocated Free Size Status Storage Pool 4 288.59 GB 118.57 GB 170.02 GB 🔗 Ready
Storage Pool 2
Storage Pool 3
Storage Pool 4 Panage   KAID Group of Storage Pool 4 Panage   Name/Alias Capacity RAID Type Bitmap Status
AAID Group 4 288.59 GB RAID 1 Disable & Ready Volume of Storage Pool 4      New Volume
iSCSI LUN in the storage pool 4
Name/Alias Capacity Allocated Thin Status

At this stage, we have 1 Storage Pool (285 GB Capacity), 1 datastore (250 GB), and some VM in the datastore: *Thin Provisioning:* 

On NAS side, we can see that only the real used data has been allocated. 170 GB free capacity remains to be used for other services or LUN.

115 GB has been used in VMware and 118 GB allocated on the NAS (the small difference is due to metadata.)

If some data is removed within the datastore, by deleting 4 VMs for example, we can see below that the free space in the datastore increases and the used space decreases:

General	Capacity		
Location: ds:///vmfs/volumes/522d8b93-c8c3e4	Refrest		
	Capacity:	249.75 GB	
Tune: VMEC	Provisioned Space:	97.32 GB	
Type, Price Number of Horts Connected: 1	Free Space:	206.14 GB	
Virtual Machines and Templates: 3	Last updated on: 9/:	10/2013 14:08:43	
	Storage Capabilities		
Commands	-	Defrech	
🕜 Refresh	System Storage Capability: N/A	Kerresi	
Enter SDRS Maintenance Mode	User-defined Storage Capability: N/A		
🚭 Browse Datastore			
Assign User-Defined Storage Canability			

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However, if we check the capacity on the NAS, the free capacity didn't change. The explanation is that thin provisioning allows dynamic capacity allocation, but, without any other function to get it back. With storages that supports only thin provisioning, once the capacity as been allocated, it cannot be freed. QNAP NAS provides a solution for this.

		s	Storage Manager	Θ 🕀 😣
				尊?
DASHBOARD	~	Storage Pool List - Total 4 Pool(s)	New Storage Pool Remove Pool	Expand Pool
Overview				
STORAGE	~	Storage Pool 1	Name/Alias Capacity Allocated Free Size	Status
🚐 Volumes		Storage Pool 2		Ready
Storage Pools			Allocated: 41 % Free Size: 59 % Alert thr.: 80 %	et Threshold
🚇 Disks		Storage Pool 3		
P Encryption		Storage Pool 4	RAID Group of Storage Pool 4	Manage 👻
SSD Cache			Name/Alias Capacity RAID Type Bitmap Status	
iSCSI	~		▲ RAID Group 4 288.59 GB RAID 1 Disable   Rear	dy
🖨 iSCSI Storage			Volume of Storage Pool 4	lew Volume
🗘 Advanced ACL			iSCSI LUN in the storage pool 4	
🛋 LUN Backup			Name/Alias Capacity Allocated Thin	Status
			ds20130909164806 No	✓ Ready
🚽 Remote Disk				
			i	
iSCSI Storage ☆ Advanced ACL ⓒ LUN Backup VIRTUAL DISK 릏 Remote Disk	• •		Volume of Storage Pool 4	dy Iew Volume Status ✔ Ready

QNAP Turbo NAS with QTS 4.0 provides Space Reclamation function, supported by QTS and by VMware VAAI. Using this function it is possible to get back the capacity not used anymore, coming from deleted VMDK and deleted VMs from a datastore.

To trigger the space reclamation on iSCSI LUN with VAAI, it must be done by command line. vSphere Client do not provide any option from the graphical interface to trigger this function.

Moreover, it is not possible to estimate in advance the time needed to perform the space reclamation, as it depends on the number and size of deleted files, and the size of the datastore.

It is recommended to use space reclamation during maintenance timeframe, or out of business hours.

The space reclamation is triggered with the command "vmkfs", which takes an argument of the percentage of capacity to reclaim. Examples:

~ # cd /vmfs/volumes/QNAP-Thin-Reclaim-Test/
/vmfs/volumes/522d8b93-c8c3e424-065f-000e1e0a63f8 # vmkfstools -y 99
Attempting to reclaim 99% of free capacity 206.1 GB (204.1 GB) on VMFS-5 file system 'QNAP-Thin-Reclaim-Test' with max file size
64 TB.
Create file .vmfsBalloonOkovyE of size 204.1 GB to reclaim free blocks.
Done.
/vmfs/volumes/522d8b93-c8c3e424-065f-000e1e0a63f8 #

Note: VMware recommend reclaiming 60% of the volume only.

After using the command above on the test datastore we can observe the result from the NAS UI:





	Sto	rage Manager 😑
		L.
DASHBOARD V	Storage Pool List - Total 4 Pool(s)	New Storage Pool Remove Pool Expand Pool
🔲 Overview		
STORAGE V	Storage Pool 1	Name/Alias Capacity Allocated Free Size Status
🚍 Volumes	Etorago Bool 3	30018ge F0014 20035 GB 01.05 GB 220.50 GB
📑 Storage Pools	Storage Poor 2	
🚇 Disks	Storage Pool 3	Allocated: 21 % Free Size: 79 % Alert thr.: 80 %
P Encryption	Storage Pool 4	RAID Group of Storage Pool 4 Manage
💻 SSD Cache		Name/Alias Capacity RAID Type Bitmap Status
iscsi v		🛇 RAID Group 4 288.59 GB RAID 1 Disable 🥑 Ready
		Volume of Storage Pool 4 New Volume
		iSCSI LUN in the storage pool 4
		Name/Alias Capacity Allocated Thin Status
S LUN Backup		ds20130909164806 250.00 GB 42.78 GB Yes 🖌 Ready
VIRTUAL DISK V		
💂 Remote Disk		



After using the Space Reclaim function, the capacity reclaimed in the NAS Storage Pool corresponds to the VM we have deleted from the datastore, around 56 GB (4 VMs of 14 GB).

Space Reclaim is not necessary when only 1 datastore is created on 1 NAS Storage Pool. It becomes useful when there are multiple datastores on a Storage Pool. All the datastores can now share the same storage pool. When needed, the Space Reclaim can be called to free the Storage Pool capacity. The Capacity that has been reclaimed can be used for other datastore if a new datastore needs to be created, can be used for new VM creation, or even other services if the QNAP NAS (service different than iSCSI).

One reason of using Thin Provisioning and Space Reclaim is to over-allocate the storage. On a 285 GB Storage Pool, it is possible to create 2 or more iSCSI LUNs if they are using Thin Provisioning:

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		Ste	orage Manager 😑 🤆
3			\$
DASHBOARD	~	Storage Pool List - Total 4 Pool(s)	New Storage Pool Remove Pool Expand Pool
Overview			
STORAGE	~	Storage Pool 1	Name/Alias         Capacity         Allocated         Free Size         Status           Storage Pool 4         288.59 GB         61.82 GB         226.77 GB         Image: Ready
🚐 Volumes		Storage Pool 2	
Storage Pools			
🚇 Disks		Storage Pool 3	Allocated: 21 % Free Size: 79 % Alert thr.: 80 %
P Encryption		Storage Rool 4	RAID Group of Storage Pool 4 Manage
SSD Cache		Storage Pool 4	Name/Alias Capacity RAID Type Bitmap Status
- coor			🔕 RAID Group 4 288.59 GB RAID 1 Disable 🥑 Ready
	<u> </u>		Volume of Storage Pool 4 New Volume
🚍 iSCSI Storage			ISCET LUN in the starsee need 4
Advanced ACL			
🗟 LUN Backup			Name/Alias Capacity Allocated Thin Status
VIRTUAL DISK	~		ds20130909164806 250.00 GB 42.78 GB Yes 🧹 Ready
			ds20130910172525 250.00 GB 102.40 MB Yes 🖌 Ready

With Thin-Provisioning and Space Reclamation, the 2 LUNs above will be able to grow as data is stored.

# In conclusion:

Thin Provisioning allows "over-allocation": It is possible to create iSCSI LUN larger than the real available capacity (provided by the Storage Pool).

**Over-Allocation** allows being flexible and scalable: With Thin Provisioning, the capacity will be used only when real data is stored in the LUN. Therefore, it is possible to create in advance iSCSI LUNs even if the capacity is not totally. When more capacity is needed because of data growth, it is possible to expand the Storage Pool online, with new hard drives for a scalable storage. It is also possible to create additional LUNs and datastores for temporary usage with Thin Provisioning, and remove them later.

**Space Reclaim** allows being flexible and efficient: When the Storage Pool is running out of space, it is also possible to reclaim the space with Space Reclaim, from the deleted data from VMware, and/or the deleted VMs. In that case, it may be not necessary to purchase additional hard drives. The storage management becomes more efficient.

But be careful of **not running out of space**! Over-allocation is a great, flexible and efficient way to manage the storage, but be aware that if not monitored correctly, the Storage Pool can run out of space. It is necessary to set-up an alert threshold on the storage pool with email notifications so that the administrator can know in advance the remaining capacity of the storage pool and decide what action to take.





# 4. Good to know

Thin volumes/LUNs offer better and more efficient capacity management. Thick volumes avoid the out-of-space condition risk. VAAI NAS and VAAI iSCSI are different. Clone a VM from NFS to iSCSI will not use VAAI, but ESXi resources and network.

# 5. References

Disabling the VAAI functionality in ESXi/ESX (1033665):

http://kb.vmware.com/kb/1033665

Installing patches on an ESXi 5.x host from the command line: http://kb.vmware.com/kb/2008939

VMware vSphere® Storage APIs – Array Integration (VAAI):

<u>http://www.vmware.com/files/pdf/techpaper/VMware-vSphere-Storage-API-Array-Integration.pdf</u> VMware vSphere Blog - VAAI Thin Provisioning Block Reclaim/UNMAP In Action:

http://blogs.vmware.com/vsphere/2012/04/vaai-thin-provisioning-block-reclaimunmap-in-action.html



