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ZFS STORAGE APPLIANCE

An Oracle Technical White Paper
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VMware vSphere Storage APIs for Array Integration (VAAI for NAS) with Oracle ZFS Storage Appliance

An overview of installation, best practices, and recommendations of VMware VAAI for NAS with Oracle ZFS Storage Appliance.

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Introduction

VMware provides a number of different application programming interfaces (APIs) that are used to better integrate its products with storage vendors' offerings. One of the better known storage APIs is the VMware vSphere Storage APIs for Array Integration, known simply as VAAI. VAAI can be implemented at the block or file level, and it allows certain storage operations such as cloning, linked cloning, and thin provisioning to be offloaded from the VMware virtualization hosts to the storage array.

VAAI for NAS API implements four different network-attached storage (NAS) hardware acceleration primitives: Full File Cloning, File Space Reservation, Extended Statistics, and Fast File Clone/Native Snapshot Support.

The Full File cloning primitive enables VMware virtual disks to be cloned by the NAS device rather than using VMware Data Mover. The benefits of the Full File Cloning primitive are faster cloning operations for VMware virtual machines and less resource utilization, such as CPU cycles or network usage, on the hypervisor side.

The File Space Reservation primitive allows VMware administrators to reserve the space required by a virtual machine disk (VMDK), and also to provision thick VMDK files such as lazy-zero or eager-zero on NAS devices. In previous vSphere releases, only the thin provisioning format was allowed on NAS devices.

Extended Statistics enable better visibility for disk space utilization on NAS datastores (especially for thin-provisioned VMDKs). With this primitive, VMware administrators have a much better insight into the real disk space utilization on the VMware vSphere Client side, eliminating the need to work with third-party storage tools to identify the real disk space utilization of thin-provisioning VMDKs.

The Fast File Clone/Linked-Clone Native Snapshot primitive enables the creation of snapshots and linked-clones as well as their offload to a NAS storage array. This primitive is very useful for virtual desktop deployments (such as VMware View Composer) which use linked-clone technology. In addition, this VAAI primitive forms the basis of VMware View Composer API for Array Integration, known as VCAI.

With its version 1.0 release, the Oracle ZFS Storage Appliance Plug-in for VMware vSphere Storage APIs for Array Integration –NAS supports full file cloning implementation only.

Highlighted in this paper are:

• Overview of the Oracle ZFS Storage Appliance Plug-in for VMware vSphere Storage APIs for Array Integration – NAS

• Deployment of and best practices for Oracle ZFS Storage Appliance Plug-in for VMware vSphere Storage APIs for Array Integration – NAS

• Use case of Oracle ZFS Storage Appliance Plug-in for VMware vSphere Storage APIs for Array Integration – NAS

Oracle ZFS Storage Appliance Plug-in for VMware vSphere Storage APIs for Array

Oracle ZFS Storage Appliance Plug-in for VMware vSphere Storage APIs for Array Integration (VAAI for NAS) enables the offloading operation of one of the most important primitive and storage operations, Full File Cloning. As previously highlighted, the Full File Cloning primitive enables VMware virtual disks to be cloned by the NAS device rather than the VMware Data Mover, resulting in faster cloning operations for VMware virtual machines and templates, and less CPU and network resource utilization on the hypervisor side. Figure 1 illustrates the plug-in's role as intermediary between the VMware virtual machine environment and the Oracle ZFS Storage Appliance.
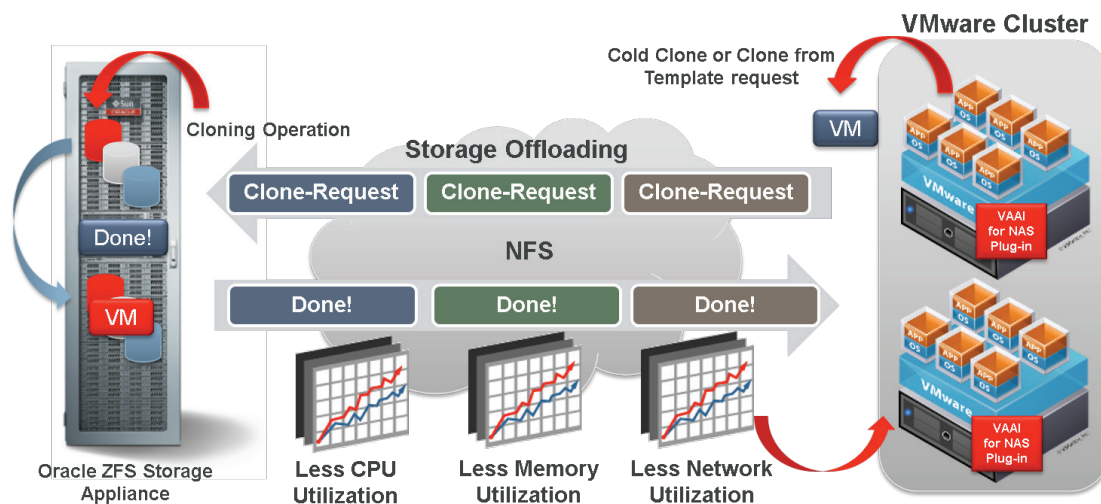

Figure 1. Overview of Oracle ZFS Storage Appliance Plug-in for VMware vSphere Storage APIs for Array Integration (VAAI for NAS) with Oracle ZFS Storage Appliance

The Full File Cloning primitive cannot be called for VMware vSphere vMotion operations, so only powered-off virtual machines and cold clone operations such as clones from templates are offloaded to the Oracle ZFS Storage Appliance and used by this primitive.

Implementing the Oracle ZFS Storage Appliance Plug-in for VAAI for NAS

This section provides information on how to install and configure the Oracle ZFS Storage Appliance Plug-in for VAAI for NAS, and implement best practices and recommendations for optimal performance.

Configuring the Oracle ZFS Storage Appliance for VAAI for NAS

Before installing and configuring Oracle ZFS Storage Appliance Plug-in for VAAI for NAS, you need to ensure that the Oracle ZFS Storage Appliance has all requirements for VAAI for NAS, such as credentials and configuration, already in place. To ensure the correct configuration on the Oracle ZFS Storage Appliance, follow these steps:

1. In the Oracle ZFS Storage Appliance browser user interface (BUI), go to Configuration, Services, and ensure that the HTTP service is enabled, as seen by the green light in the following figure.
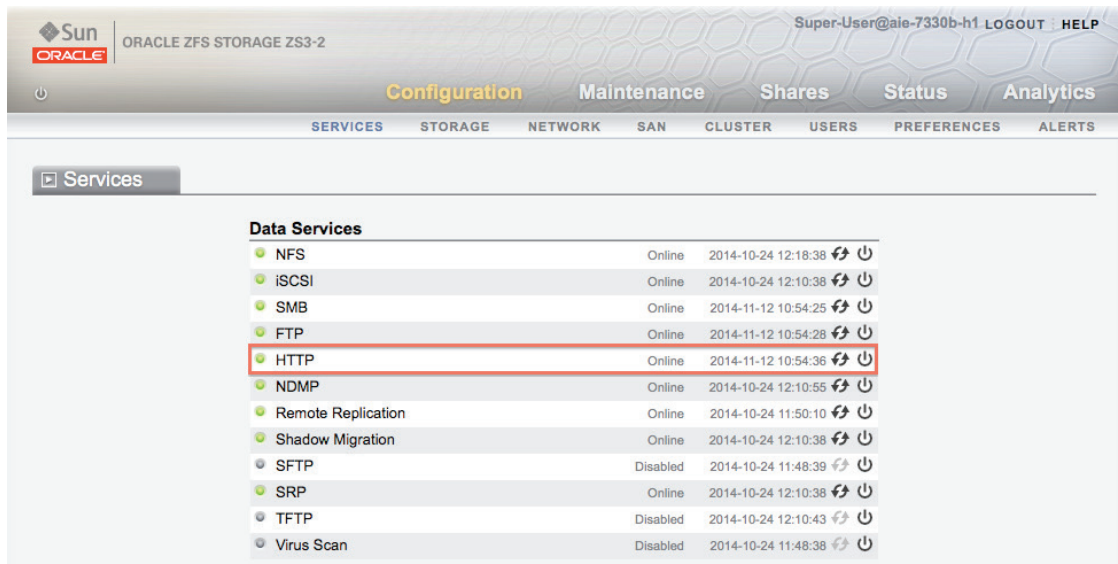

Figure 2. Oracle ZFS Storage Appliance BUI – HTTP service overview

2. Under the Data Services list, click on HTTP service and ensure that both protocols (http/https) with their respective ports are correctly enabled and configured.

    Oracle Storage Appliance VAAI for NAS plug-in uses WebDev environment to establish the communication between VMware ESXi hosts and Oracle ZFS Storage Appliance, ensuring that the HTTPS service is configured if critical to establishing that communication.
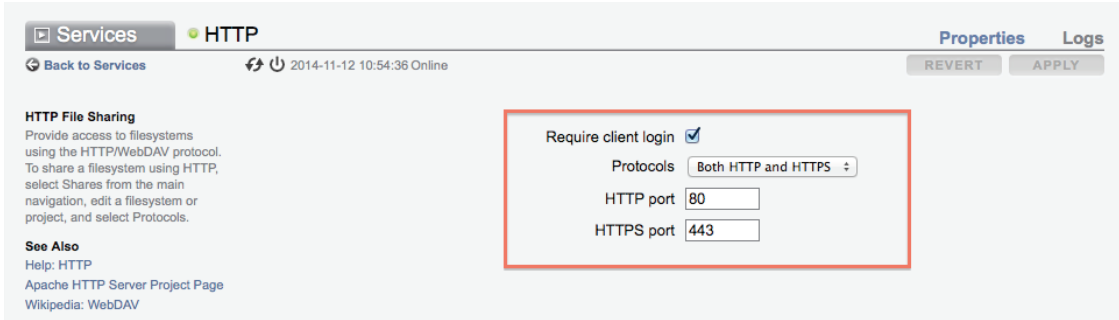
Figure 3. Oracle ZFS Storage Appliance BUI – HTTP service configuration overview

3. Assuming that the HTTP service is correctly enabled and configured, return to the Configuration tab and click on Users to create a local user for the VAAI for NAS plug-in's authentication purposes. The Properties dialog screen of Add User, seen in the following figure, will be presented.

    The username used by the VAAI for NAS plug-in does not need to be associated with any Oracle ZFS Storage Appliance role, and it can be any username of your preference. The following example presents the username VAAI. As you can see, there is no Oracle ZFS Storage Appliance role associated with this username.
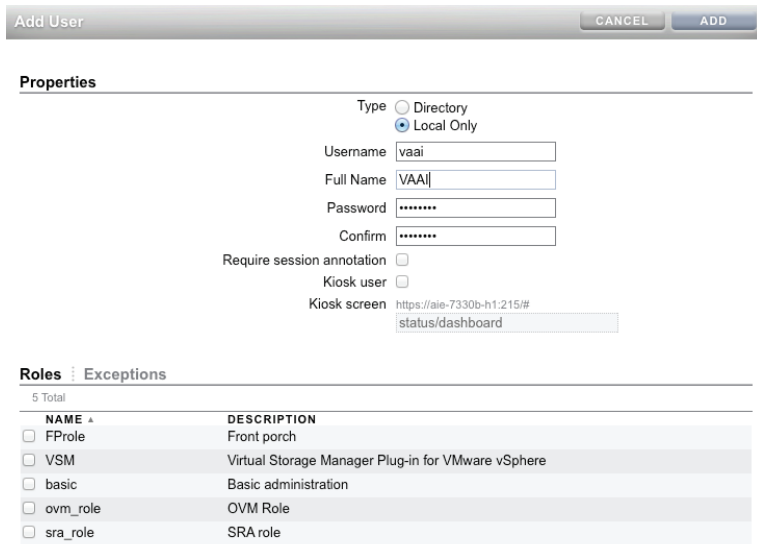

Figure 4. Oracle ZFS Storage Appliance BUI – User configuration for VAAI for NAS plug-in

4. Assuming that an Oracle ZFS Storage Appliance project is already configured, create an NFS share with the following configurations:

Note: The following example shows a project called VAAI, and an NFS share called vaai_nas. These names are example names only. Projects and NFS datastores names should be chosen to best fit your VMware production environment.

    a. Enter a name for the NFS share (for the example, the NFS share name is vaai_nas).

    b. Data migration source: select none

    c. For User, enter: vaai.

    d. For Group, enter: other

    e. Permissions: Set permission to 755 RWX (User), RX (Group), and RX (Other)

    f. Do not check Inherit mountpoint options

    g. Enter the mountpoint path that will best fit in your VMware environment. The example path is /export/vaai_nas.

    h. The remaining options such as: Reject non UTF-8, Case sensitivity, Normalization, and Encryption should be set as their default values.
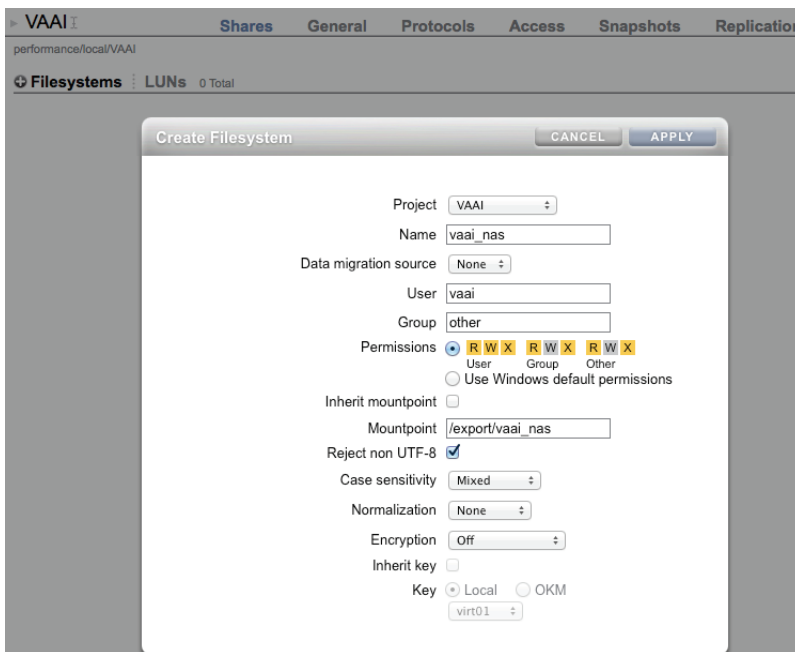

Figure 5. Oracle ZFS Storage Appliance BUI – NFS share configuration for VAAI for NAS plug-in

5. Assuming that the NFS share has been successfully configured; use the following steps to complete the VAAI for NAS configuration on Oracle ZFS Storage Appliance.

a. Double click on the vaai_nas NFS share, and then click General. Change to the space reservation that best fits your VMware production environment. Click APPLY for applying the space usage configuration. See figure 6.

Note: As shown in figure 6, Oracle ZFS Storage Appliance provides the space reservation feature at the NFS share level, but not for file level. Space reservation configuration is not mandatory for VAAI for NAS plug-in, and it has been used for illustration purposes only. However, it can be used in production environments without any problems.

Note: Since this NFS share will be mounted as a VMware datastore, ensure that the proper block size and best practices for VMware NFS datastores with Oracle ZFS Storage Appliance are in place. For additional information, see the white paper "Best Practices for Oracle ZFS Storage Appliance and VMware vSphere 5.x" available on the Oracle Technology Network's (OTN's) NAS Storage Documentation site:

http://www.oracle.com/technetwork/server-storage/sun-unified-storage/documentation/index.html

Figure 6. Configuring space usage and properties for the NFS share

b.   On the same screen, click on Protocols to add NFS exceptions configuration, to configure NFS exception, and to set up HTTP permissions. The NFS exception can be based on host FQDN or netgroup, DNS domain name, or network. The example is based on network 192.168.57.0. This network is the 10GbE network used as the storage network by VMware ESXi hosts.

c.   For NFS Share mode, select Read/write

d.   For Character set, choose default.

e.   Under the NFS Exceptions section, enable the checkbox for Root Access.

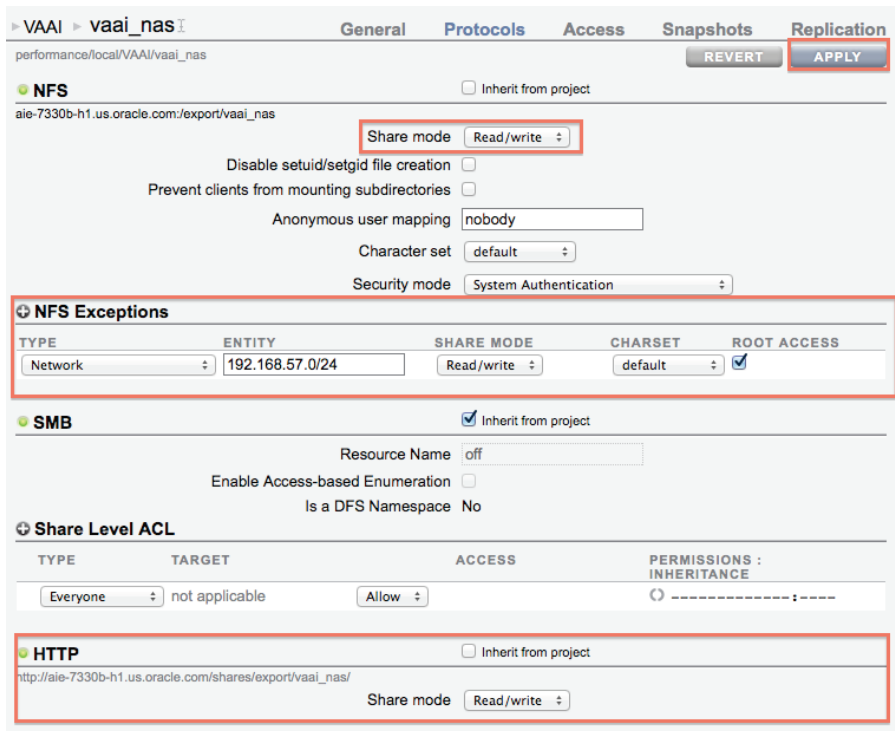f.   For HTTP, enable HTTP access for this share, altering Share mode to Read/write.

Figure 7. Configuring protocols for the NFS share for the VAAI for NAS plug-in

At this point, the Oracle ZFS Storage Appliance is ready for establishing communication with the VAAI for NAS plug-in.

Installing and Configuring the Oracle ZFS Storage Appliance Plug-in for VAAI for NAS

The Oracle ZFS Storage Appliance Plug-in for VMware vSphere Storage APIs for Array Integration (VAAI for NAS plug-in), can be downloaded from the Oracle ZFS Storage Appliance Plug-in Downloads website at:

http://www.oracle.com/technetwork/server-storage/sun-unified-storage/downloads/zfssa-plugins-1489830.html

Once the plug-in is downloaded, copy and unzip the file into the VMware ESXi host. Execute the following VMware command line for installing the VAAI plug-in for NAS:

```
esxcli software vib install -v /tmp/vmware-esx-
ORCLZFSNasPlugin_100b9.vib
```

Then reboot the ESXi host, and execute the following command line in order to ensure that VAAI for NAS plug-in has been correctly installed:

```
esxcli software vib list | more
```

The following shows the screen commands and output:

```
/tmp # unzip ORCLZFSNasPlugin-1.0-2152589.zip
Archive:  ORCLZFSNasPlugin-1.0-2152589.zip
  inflating: ORCLZFSNasPlugin-1.0-offline_bundle-2152589.zip
  inflating: vmware-esx-ORCLZFSNasPlugin_100b9.vib
  inflating: doc/README.txt

/tmp # esxcli software vib install -v /tmp/vmware-esx-
ORCLZFSNasPlugin_100b9.vib
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: Oracle_bootbank_ORCLZFSNasPlugin_1.0.0-009
   VIBs Removed:
   VIBs Skipped:

/tmp # reboot

~ # esxcli software vib list | more

Name                          Version                              Vendor
Acceptance Level  Install Date
----------------------------  -----------------------------------  ------
----------------  ------------
ORCLZFSNasPlugin              1.0.0-009                            Oracle
VMwareAccepted    2014-10-04
```

The output of the `esxcli software vib list` command should appear as presented in the previous display, including the name of the VAAI for NAS plug-in for Oracle ZFS Storage Appliance, the version, vendor (Oracle), and the acceptance level, which is VMwareAccepted.

At this point the VAAI for NAS plug-in has been successfully installed. The next step is registering the plug-in with Oracle ZFS Storage Appliance.

After rebooting the ESXi servers, execute the `/opt/oracle/zfsnas/register` script on the ESXi host to begin registration of the VAAI for NAS plug-in with the Oracle ZFS Storage Appliance. The script will prompt for:

- The username and password of the user used by the VAAI for NAS plug-in to establish communication with the Oracle ZFS Storage Appliance

- The IP address of the Oracle ZFS Storage Appliance

- The NFS share mount point that has been configured to work with VAAI for NAS

- Information related to HTTP/WebDav protocols.

Ensure that the information you provide is correct in order for the VAAI for NAS plug-in to work properly.

Sample output of the script is shown. In this example, 192.168.57.1 is the Oracle ZFS Storage Appliance's 10GbE network used as the storage network for the VMware ESXI host, and the username, password and NFS share mount point match the Oracle ZFS Storage Appliance configuration.

```
~ # /opt/oracle/zfsnas/register
Enter the HTTP/WebDAV IP address: 192.168.57.1
Is HTTPS enabled? (y|n) y
Enter the HTTPS port number: 443
Is client login required? (y|n) y
Username: vaai
Password:
Confirm:
Enter the NFS share remote mount point: /export/vaai_nas
Configuration info is verified successfully and stored in
https://192.168.57.1:443/shares/export/vaai_nas/.orclzfsvaainas
```

At this point, the VAAI for NAS plug-in is ready to be enabled on VMware NFS datastores. In the VMware vSphere Client, mount the `/export/vaai_nas` NFS share as a VMware NFS datastore. Notice that the hardware acceleration option will be visible as "supported."

Figure 8 highlights the screen selections in the VMware vSphere Client for adding an Oracle ZFS Storage Appliance NFS share to a VMware environment. First, on the VMware vSphere Client GUI select the ESXi host which will have the NFS datastore mounted. After that, click on the Configuration tab, select Storage, and then click on the Add Storage option. The Add Storage screen will pop up, then select Network File Systems option and click on next.
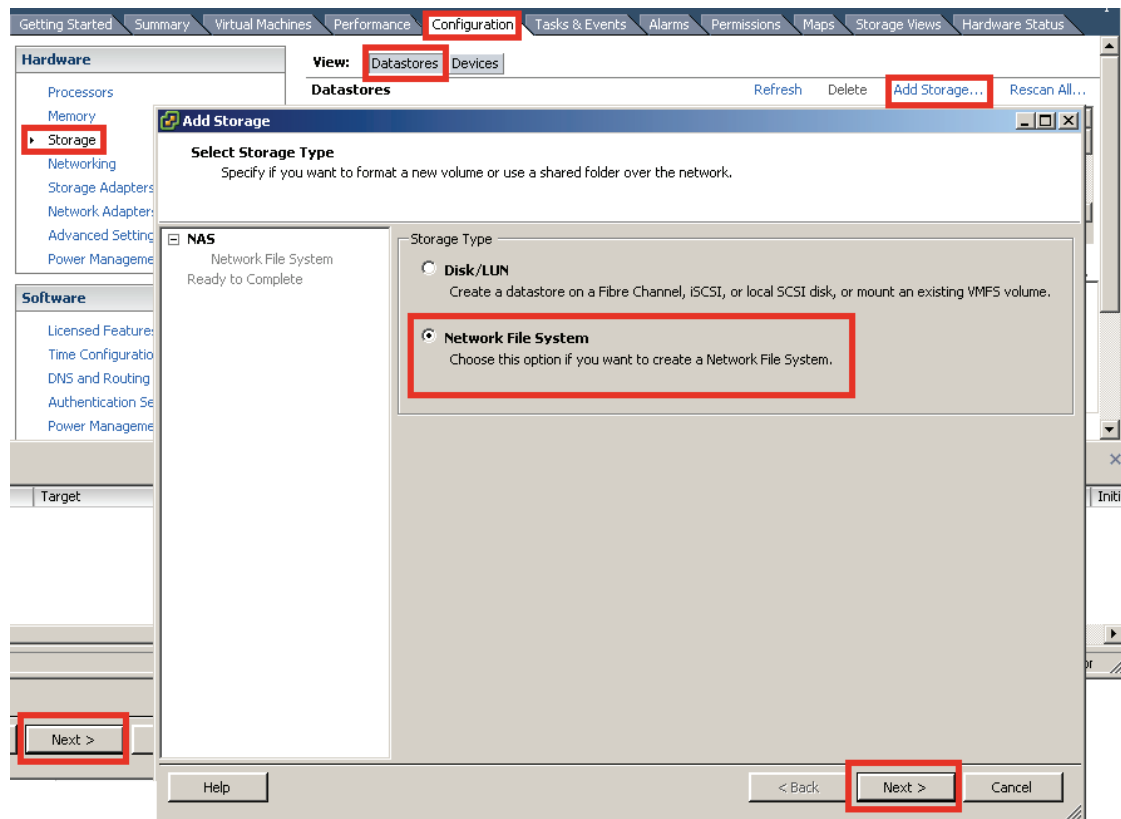

Figure 8. VMware NFS datastore provisioning on the VMware vSphere Client. Step 1

In the next screen, enter the information for the shared folder which will be used as a VMware vSphere datastore. Under properties, enter the Oracle ZFS Storage Appliance FQDN or IP address, the shared folder path, then a new datastore name, and click on Next.

Note that in the following screen, which shows network IP address 192.168.57.1, shared folder path `/export/vaai_nas`, and VMware datastore name `vaai_nas`, these values are fictitious and for example only.
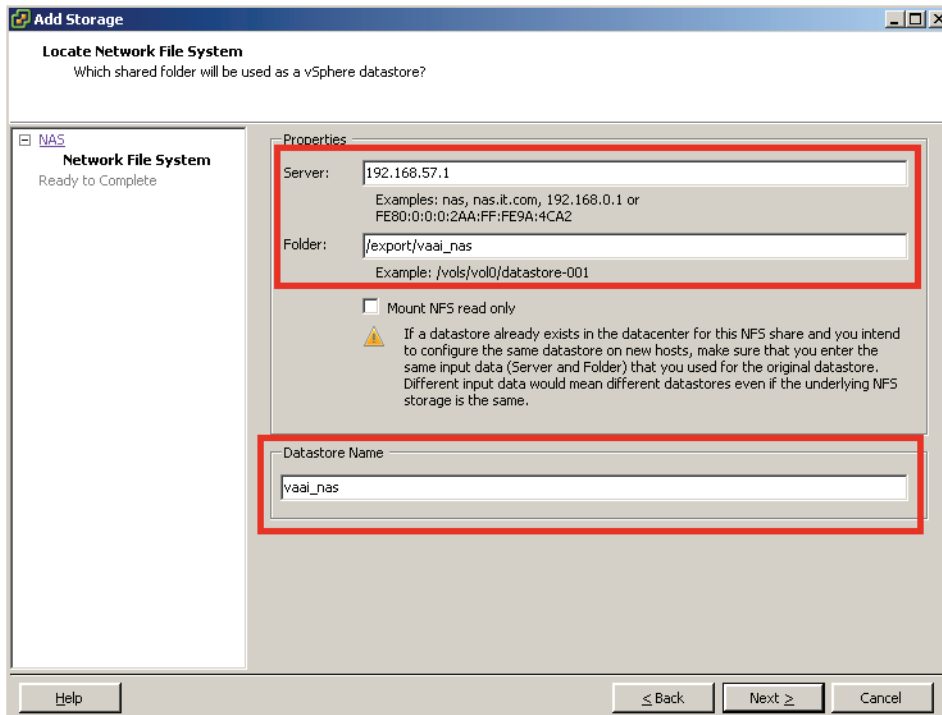

Figure 9. VMware NFS datastore provisioning on the VMware vSphere Client. Step 2

Figure 10 presents the configuration summary that includes the FQDN or IP address of the Oracle ZFS Storage Appliance, the shared folder, and the volume label of the new VMware NFS datastore. This is the final step for configuring Oracle ZFS Storage Appliance Plug-in for VMware vSphere Storage APIs for Array Integration (VAAI for NAS plug-in) on VMware vSphere5.x environemts.
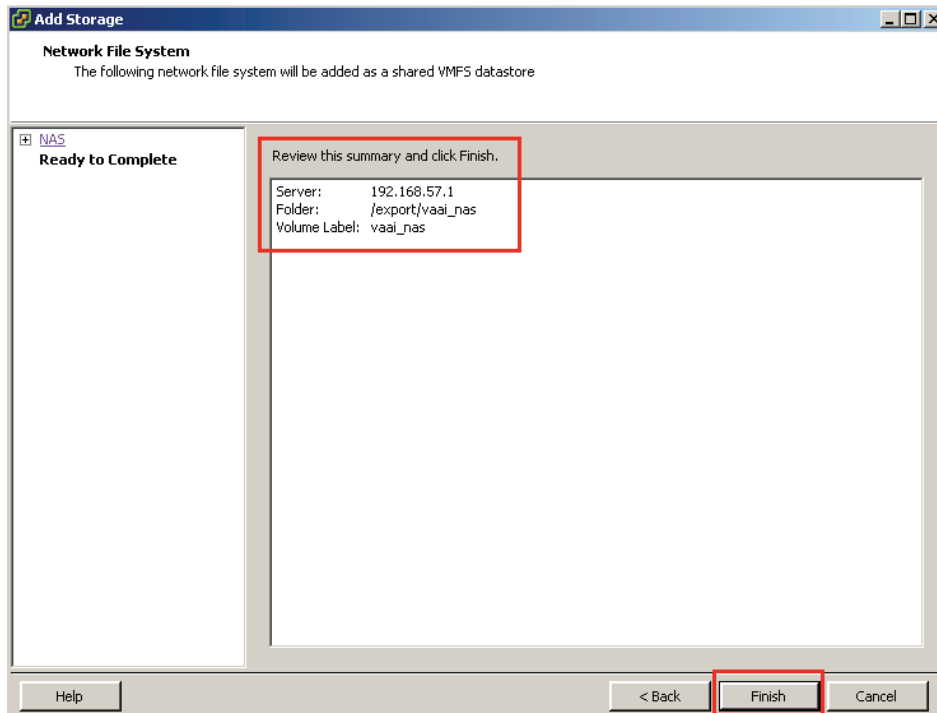

Figure 10. VMware NFS datastore provisioning on the VMware vSphere Client. Step 3

As presented in figure 11, the Oracle ZFS Storage Appliance NFS share called `vaai_nas` has been successfully mounted as a VMware NFS datastore, registered with the Oracle ZFS Storage Appliance, and the VAAI plug-in for NAS Hardware Acceleration feature has been enabled and presented as supported. At this point, the VAAI for NAS Full File Cloning primitive is enabled and ready to offload cold clone operation of virtual machines or templates, and also to perform the offloading of EazgerZeroedThick VMDK virtual disks provisioning operations.

Figure 11. VMware NFS datastore provisioning on the VMware vSphere Client – Datastore overview

Recommendations for Usage and Performance Comparison

Oracle ZFS Storage Appliance Plug-in for VMware vSphere Storage APIs for Array Integration (VAAI for NAS plug-in) will provide better results if implemented in the following scenarios:

- Cold clone operations of virtual machines and clones from templates, which will be offloaded to the Oracle ZFS Storage Appliance.

- Scenarios requiring an EagerZeroedThick VMware VMDK format on top of VMware NFS datastores.

- When network bandwidth and CPU resources are limited; for example, in instances where Oracle ZFS Storage Appliance has high CPU and network utilization, or where VMware NFS datastores are mounted on top of limited network resources, such as networks with 1 Gbps of available bandwidth.

The use case and performance comparison information was generated using the system components tested and presented in the following tables.

Overview of Tested System Components

The following tables describe the hardware configuration, operating systems, and software releases utilized by the systems under test for the findings highlighted in this white paper.

TABLE 1. HARDWARE USED IN REFERENCE ARCHITECTURE

EQUIPMENT	QUANTITY	CONFIGURATION
Storage	1 cluster (2 controllers)	Oracle ZFS Storage ZS3-2 cluster 256 gigabytes (GB) direct random access memory (DRAM) per controller Four x 20 3-terabyte (TB) disk drivers - Oracle Storage Drive Enclosure DE2-24C Four x 10 gigabit Ethernet (GbE) network interface cards (NICs) (per controller) Four x 73 GB log devices
IP Network Switch	2	10 GbE network switch
X86_64	1	X86_64 Server

TABLE 2. VIRTUAL MACHINE COMPONENTS USED IN REFERENCE ARCHITECTURE

OPERATING SYSTEM	QUANTITY	CONFIGURATION
Oracle Linux	1	Oracle Linux 6.4 x86_64 Virtual Machine

TABLE 3. SOFTWARE USED IN REFERENCE ARCHITECTURE

SOFTWARE	VERSION
Oracle ZFS Storage Appliance Software	2013.1.2.0
Oracle ZFS Storage Appliance Plug-in for VMware vSphere Storage APIs for Array Integration – NAS	1.0.0
VMware vCenter Server	5.5u2
VMware ESXi	5.5u2

The following use case is a performance comparison of an ESXi host performing a cloning operation of a 100 GB EagerZeroedThick Linux virtual machine with and without VAAI for NAS plug-in enabled. The operation is 100 percent visible through Oracle ZFS Storage Appliance Analytics.

During the offloading operation, Oracle ZFS Storage Appliance is cloning the virtual machine (VM) using adaptive replacement cache (ARC), and the network utilization as well as NFS operations per second, are almost nil.

Figure 12 shows the performance of a cloning operation in an ESXi host with and without the VAAI for NAS plug-in installed. As you can see, with VAAI there are more ARC hits and caching utilization than without VAAI. Consequently, using VAAI results in less CPU utilization compared to not using VAAI, as the VAAI offloading operation translates to less NFS traffic, less network utilization.
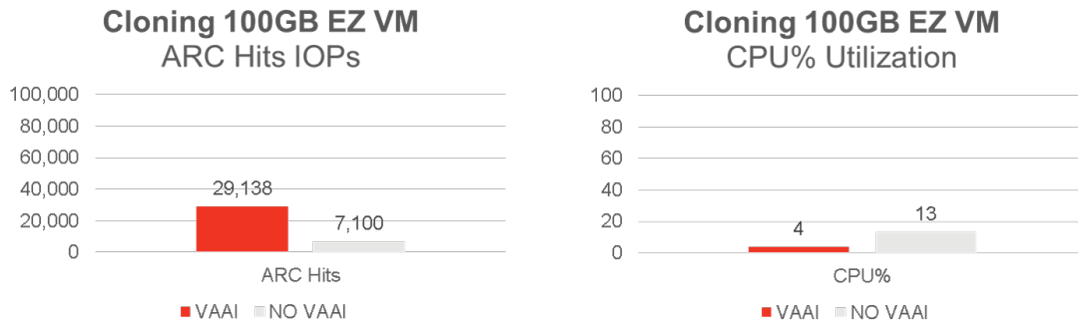

Figure 12. VMware VAAI for NAS plug-in for Oracle ZFS Storage Appliance offloading operation – ARC hits and CPU utilization with and without VAAI for NAS plug-in enabled

The next figure presents disk IOPs, NFS, and network utilization with and without VAAI for NAS plug-in enabled. As you can see, NFS and network usage is almost nil. It is also due to the VAAI for NAS offloading operation.
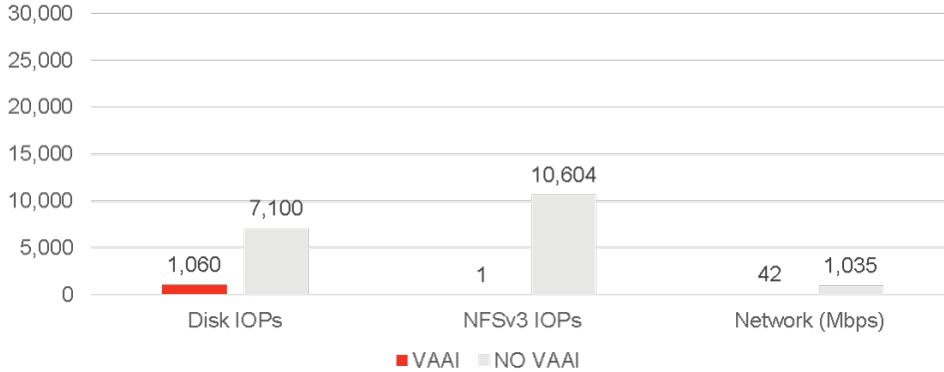
Figure 13. VMware VAAI for NAS plug-in for Oracle ZFS Storage Appliance offloading operation – Disk IOPs, NFS, and network utilization – with and without VAAI for NAS plug-in enabled

Figures 14, 15, 16, and 17 present Oracle ZFS Storage Appliance Analytics screenshots of the offloading cloning operation of a LINUX virtual machine attached to a 100 GB VMware EagerZeroedThick virtual disk. The storage metrics used for measurements are: Cache ARC accesses per second broken down by hit/miss, CPU utilization broken down by CPU identifier, NFS operation broken down by type of operation, and interface bytes per second broken down by interface. For better performance comparision, all the following listed metrics were analyzed with and without VAAI for NAS plug-in enabled.

Figure 14 presents the performance results and comparison of important data storage metrics with and without the VAAI for NAS plug-in. As you can see, during the cloning operation, the plug-in will offload the operation to Oracle ZFS Storage Appliance, which will be responsible for the task, and then a higher caching utilization (ACR data hits) will be visible on the Oracle ZFS Storage Appliance.
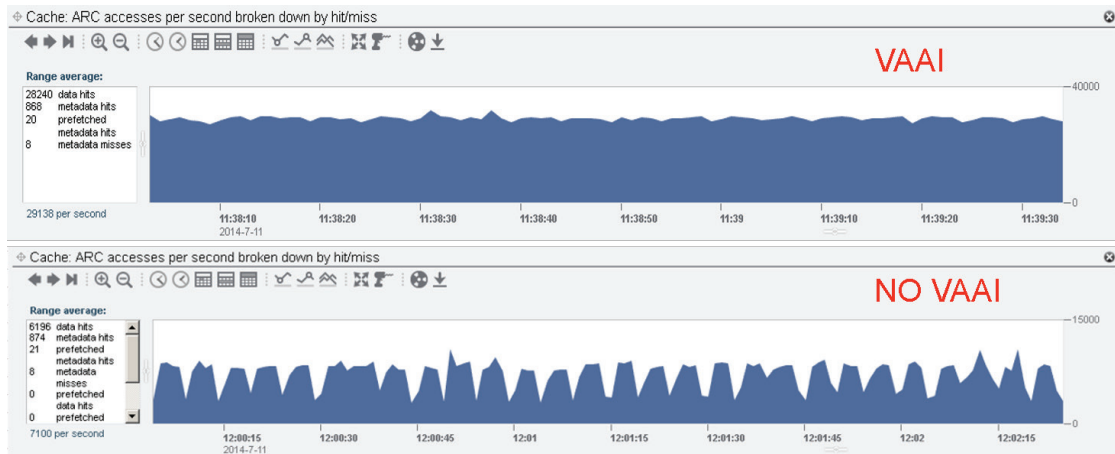

Figure 14. Oracle ZFS Storage Appliance Analytics – Offloading operation with and without VAAI for NAS plug-in enabled – ARC accesses per second broken down by hit and miss.

CPU utilization on both operational sides – the storage array and the VMware ESXi servers – is another important aspect of plug-in usage. Since the plug-in offloads the operation to the storage array, less network utilization, NFS operations, and data moving between VMware ESXi servers and the arrays is achieved, which consequently reduces CPU utilization in both system sides. Figure 15 shows the performance results and comparison of a cloning operation of a LINUX virtual machine that is attached to a 100GB EagerZeroedThick virtual disk. As you can see, with VAAI for NAS plug-in there will be less CPU utilization during cloning of EagerZeroedThick virtual machines, and that only 4 percent of CPU resources have been consumed. Without the VAAI for NAS plug-in, the same operation consume 13 percent of the array CPU.
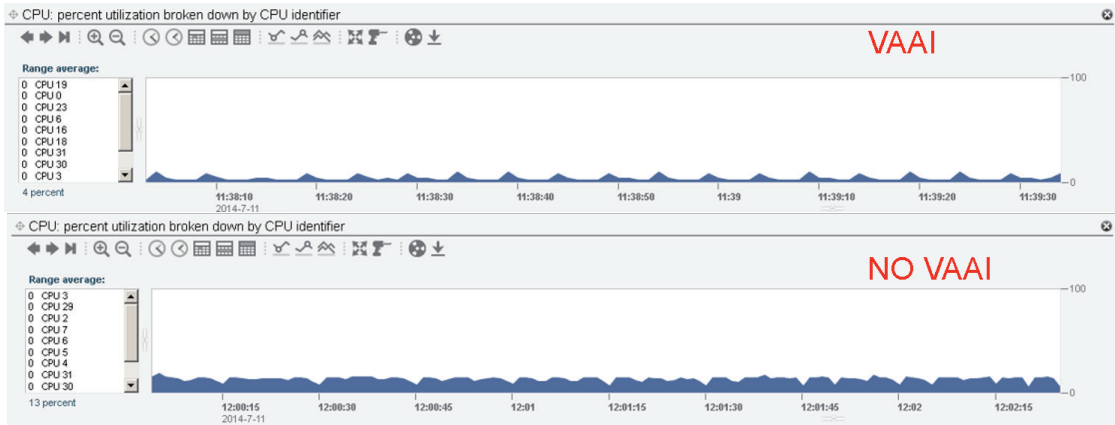

Figure 15. Oracle ZFS Storage Appliance Analytics – Offloading operation with and without VAAI for NAS plug-in enabled – CPU percent of utilization broken down by CPU identifier

While working with the VAAI for NAS plug-in, NFS operations are also reduced because of the plug-in offload function, as shown in figure 16. Once a cloning operation is offloaded, the Oracle ZFS Storage Appliance takes charge of the task, which is internally executed in the storage array. Without cloning operations traffic between VMware ESXi hosts and the storage array, the NFS operations appear close to zero.

Figure 16. Oracle ZFS Storage Appliance Analytics – Offloading operation with and without VAAI for NAS plug-in enabled – NFSv3 operations per second broken down by type of operation

The final figure shows network utilization. Oracle ZFS Storage Appliance Plug-in for VMware vSphere Storage APIs for Array Integration (VAAI for NAS plug-in) saves a huge amount of network bandwidth. During a cloning operation, the plugin initially utilizes the network to communicate with the storage array, and send it commands to be performed. Once the cloning operation has been initialized and the Oracle ZFS Storage Appliance takes charge of the cloning task, the network is not utilized to move date between VMware Data Mover and Oracle ZFS Storage Appliance, at significant savings to network bandwidth.

Figure 17. Oracle ZFS Storage Appliance Analytics – Offloading operation with and without VAAI for NAS plug-in enabled – Network: Interface bytes per second broken down by interface

Conclusion

While the primary concept for VAAI for NAS is to enable better integration with NAS storage devices, the Oracle ZFS Storage Appliance plug-in implementation for VAAI for NAS – the Oracle ZFS Storage Appliance Plug-in for VMware vSphere Storage APIs for Array Integration – provides beneficial offloading technology for the most important storage operations used in a VMware environment. This technology improves performance and efficiency, particularly reducing resource utilization on the hypervisor side.

Combining Oracle ZFS Storage Appliance performance with VMware vSphere hypervisors is an excellent choice for your virtualized environment.

Appendix A: Benchmark Results

Refer to the following web sites for further information on testing results for the Oracle ZFS Storage Appliance.

SPC-2 Results

http://www.spec.org/sfs2008/results/res2013q3/sfs2008-20130819-00227.html

http://www.storageperformance.org/benchmark_results_files/SPC-2/Oracle_SPC-2/B00067_Oracle_ZFS-ZS3-4/b00067_Oracle_ZFS_Storage_ZS3-4_SPC-2_full-disclosure-report.pdf

http://www.storageperformance.org/results/benchmark_results_spc2/#sun_spc2

Appendix B: References

See the following resources for additional information relating to the products covered in this document:

- Oracle ZFS Storage Appliance Documentation Library, including Installation, Analytics, Customer Service, and Administration guides:
  http://www.oracle.com/technetwork/documentation/oracle-unified-ss-193371.html

- The *Oracle ZFS Storage Appliance Administration Guide* is also available through the Oracle ZFS Storage Appliance help context.
  The Help function in Oracle ZFS Storage Appliance can be accessed through the browser user interface.

- Oracle Support Center
  http://www.oracle.com/support

- Patches and updates downloads from My Oracle Support (MOS)
  (search under Oracle ZFS Storage Software Patches)

- Oracle ZFS Storage Appliance Plug-ins
  http://www.oracle.com/technetwork/server-storage/sun-unified-storage/downloads/zfssa-plugins-1489830.html

- Oracle Storage Product Information
  http://www.oracle.com/us/products/storage/overview/index.html

- Oracle ZFS Storage Appliance Technical White Papers and Solution Briefs,
  including "Best Practices for Oracle ZFS Storage Appliance and VMware vSphere5.x"
  http://www.oracle.com/technetwork/server-storage/sun-unified-storage/documentation/index.html

- VMware
  http://www.vmware.com

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VMware vSphere Storage APIs for Array
Integration (VAAI for NAS) with
Oracle ZFS Storage Appliance
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