

# Usability Comparison White Paper: Oracle ZFS Storage vs. NetApp FAS Storage

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Twenty Years Experience In  
Technical Evaluation

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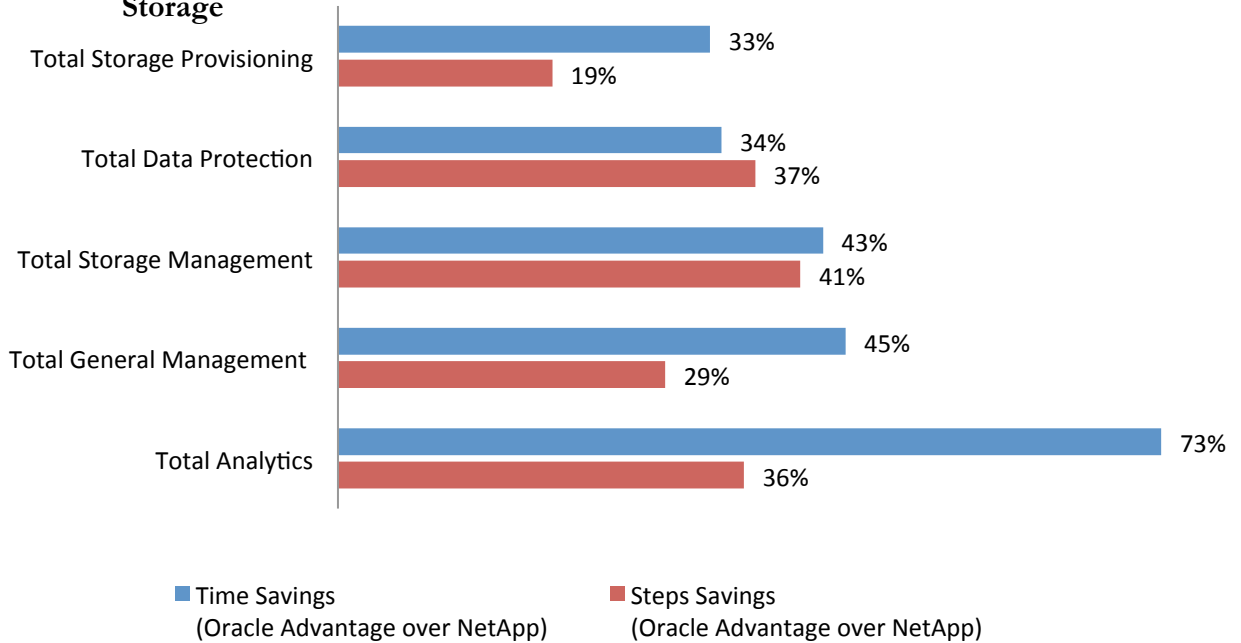
## 1.0 Executive Summary

This report is an evaluation of two leading storage offerings, Oracle ZFS Storage and NetApp FAS Storage. The purpose of this usability study is to provide Storage Administrators and IT management with practical information related to the usability of each solution. The evaluation was performed using thirty-four tasks that normally are performed by Storage Administrators in both common and critical use case scenarios. The study results show that while they each offer a full range of management features, Oracle ZFS Storage provides users with significant advantages over NetApp FAS Storage. Table 1.0 summarizes the savings in time and steps needed to execute a number of use cases in the areas of storage provisioning, data protection, storage management, general management and analytics. Table 1.1a thru 1.1g identifies the critical Oracle features within ZFS that gives the system this advantage.

**Table 1.0: Results of Time Savings: Oracle ZFS Storage Vs. NetApp FAS Storage**

<b>Task Areas</b>	<b>Time Savings</b>	<b>Steps Savings</b>
	<b>Oracle Advantage over NetApp (%)</b>	<b>Oracle Advantage over NetApp (%)</b>
<b>1.Total Storage Provisioning</b>	33% Less Time	19% Fewer Steps
<b>2.Total Data Protection</b>	34% Less Time	37% Fewer Steps
<b>3.Total Storage Management</b>	43% Less Time	41% Fewer Steps
<b>4.Total General Management</b>	45% Less Time	29% Fewer Steps
<b>5.Total Analytics</b>	73% Less Time	36% Fewer Steps

**Summary Results of Time Savings: Oracle ZFS Storage Vs NetApp FAS Storage**



**Table 1.1a: Critical Oracle Differentiator: Protection Profiles**

Criteria	Oracle Advantage	NetApp Disadvantage
Storage Pool with hot spares	+Oracle ZFS Storage provisioning allows for 6 different protection (RAID) profiles (Double Parity, Mirrored, Single Parity, Striped, Triple Mirrored, Triple Parity).	-- NetApp FAS Storage offers only two different protection profiles (RAID 4 and RAID-DP)

**Protection Profiles Importance:** The six different protection profiles provide Oracle ZFS Storage Administrators with options to manage the storage efficiently by utilizing the appropriate protection profiles based on the business needs. These profiles allow for a proper level of protection and performance for a Storage Pool.

**Table 1.1b: Critical Oracle Differentiator: Project Inheritance**

Criteria	Oracle Advantage	NetApp Disadvantage
Project	+ The concept of Projects helps to ensure a Storage Administrator can deliver like configurations for all LUNs/FileSystems for a given type of workload.	-- While NetApp's FlexVol provides some similarities, it lacks the capability to deliver like configurations; it is a very manual and time consuming process

		-- Delivering like configurations is a very manual and time consuming process in NetApp FAS Storage
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**Project Importance:** The Oracle ZFS Storage, “Project” functionality leverages configuration inheritance to standardize all configurable attributes for objects like LUNs and FileSystems within a given Project. Oracle ZFS Storage allows administrators to create Projects within a storage pool. A Project allows a Storage Administrator to standardize the configuration settings for all LUNs and FileSystems that are a part of a member of the Project. In addition, a Project may standardize configurations such as quotas, data deduplication, data compression, AV scanning, thin provisioning, protocols, snapshots, and replication. This results in significant work load reduction for administrators.

**Table 1.1c: Critical Oracle Differentiator: Unlimited Snapshots**

Criteria	Oracle Advantage	NetApp Disadvantage
Snapshot	+ Oracle ZFS Storage allows for unlimited snapshots	-- NetApp FAS Storage supports only 255 snapshots per volume

**Snapshot Importance:** Storage Administrators need to be able to simply and quickly take a snapshot of data allowing Server or Database Administrators to perform upgrades while being provided a reliable rollback plan. The capability of Oracle ZFS to allow unlimited snapshots provides greater flexibility for the recovery of these systems as defined by business and IT needs.

**Table 1.1d: Critical Oracle Differentiator: Un-configuring Pool**

Criteria	Oracle Advantage	NetApp Disadvantage
Destruction of LUN, FileSystem, Project or Pool	+ A deletion action can be prevented if LUNs, FileSystems or Projects are marked with a "Prevent Destruction" configuration	-- No option to avoid accidental destruction

**Importance of Un-configure Pool:** As business applications are retired, pools of storage resources can be returned back to an array and leveraged for other business needs. The "Prevent Destruction" flag prevents un-intentional destruction of Projects, LUNs, or FileSystems. This reduces risk of accidental deletion and data loss to an organization.

**Table 1.1e: Critical Oracle Differentiator: Customization of Views**

Criteria	Oracle Advantage	NetApp Disadvantage
Customization of views within the UI	+ Provides customization of dashboards with specific thresholds on a per metric basis to enhance usability	-- Customization of views is possible only at the individual storage component level like Volume and Aggregate in system manager

**Importance of Customization of views within the UI:** By allowing a Storage Administrator to create standardized dashboards that meet specific application, performance or business needs, the workload or time to react to issues can be reduced. This reduction in workload or reaction time can be critical in ensuring business critical applications are functioning properly.

**Table 1.1f: Critical Oracle Differentiator: Managing Physical System from UI**

Criteria	Oracle Advantage	NetApp Disadvantage
Managing the physical system from the UI	+ All aspects of the array allow drill-down functionality in a detailed representation of the physical array.  + Allows the ability for an administrator to "beacon" a disk light.	-- Not supported

**Importance of Managing the physical system from the UI:** The ability to have visibility in the physical configuration of a system has become increasingly important as the location of data centers has become separated from the Storage Administrator. Oracle ZFS Storage provides an exact visual representation of its physical attributes. This representation allows a Storage Administrator the ability to drill down into any aspect of the hardware, view its location or status and enable a beacon on the hardware component.

**Table 1.1g: Critical Oracle Differentiator: VM Analytics**

Criteria	Oracle Advantage	NetApp Disadvantage
VM Analytics	+ Provides for real-time data analytics for metrics  + Capable of drilling down between inter-related metrics  + Capable of reviewing historical metrics	-- Requires use of an additional tool: OnCommand Balance, which requires installation of VM Appliance  -- Requires the installation of a "Proxy" server for monitoring  -- Requires log-on rights to virtual servers that are to be monitored



	+ Directly integrated with the thin web client, Oracle ZFS Storage BUI (Browser User Interface)	-- Limited to 15 minute granularity
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**Importance of VM Analytics:** With analytics reporting that storage performance issues account for 80% of virtualization performance problems, a storage platform must be capable of quickly and reliably identifying the nature of these issues. The Oracle ZFS Storage BUI (Browser User Interface) provides the ability to drill down to the individual virtual machine files to identify the type of workload and the performance impact which is critical to managing application performance. Oracle ZFS Storage BUI (Browser User Interface) allows a Storage Administrator to see this data in real-time or in a historical performance context, which makes identifying potential problems in Oracle ZFS Storage an extremely valuable tool in today's highly virtualized data centers.

## 2.0 Objective of the Study

The goal of this paper is to document a comparative usability study of the management functions of Oracle's ZFS Storage against NetApp FAS Storage appliance. The paper is intended to provide potential customers of Oracle with an in-depth understanding of the productivity savings, additional usability options and the business value advantages of choosing Oracle's ZFS Storage portfolio over similar offerings from NetApp. In order to illustrate these advantages, Strategic Focus compared Oracle ZFS Storage ease of management for day-to-day management tasks, across a variety of Use Cases, with that of the NetApp FAS family of storage arrays.

## 3.0 Project Scope

The following were the areas of focus for this technical evaluation project:

**Provisioning:** The storage provisioning tasks that were evaluated are common tasks for creation, deployment and modification of storage. These tasks followed the logical steps a typical deployment would involve such as creating a storage pool, LUN, FileSystem and target group as well as increasing the size of pools and LUNs.

**Data Protection:** The data protection tasks involved processes that would account for both local and remote data protection capabilities. The tasks included using manual, scheduled and continuous protection using snapshots, clones and replication of LUNs and FileSystems as well as the restoration of data from snapshots.

**Storage Management:** The storage management processes that were evaluated included several types of tasks a Storage Administrator is responsible for. These tasks included the following types of items:

- Decommissioning of pools, LUNs and FileSystems
- Use of cache devices
- Ability to monitor the performance characteristics of the platform
- Protocol management for FileSystems
- License management for additional vendor add-ons

**General Management:** The general storage management tasks defined in the paper relate to the ability to manage the storage array platform. This management includes tasks involving the physical components of the array as well as the ability to determine the health of the array.

**Analytics:** The analytics component of the analysis compares the native Oracle ZFS Storage DTrace utility to the separate NetApp OnCommand Balance software. The comparison was performed using 50 virtual machines with two of the virtual machines running high I/O workloads that were generated with Iometer. The two monitoring tools were used to identify how quickly and accurately they could identify which specific virtual machines were causing performance issues for the remaining 48 virtual machines.

## 4.0 Methodology

The methodology that was used to attain our objective was accomplished by a technical evaluation of both products. The specific steps that were employed using this approach were as follows:

- A. The Oracle ZFS Storage ZS3-2 and NetApp FAS 3250 Storage systems were set up and configured with required software to perform this technical evaluation.
- B. Several use cases were developed in collaboration with the Oracle team to fit the set of requirements provided by Oracle; these are detailed in Appendix B.
- C. Strategic Focus configured the required landscape/environment to execute using each of the use cases.
- D. A set of high-level technical criteria for each use case was developed to evaluate the product capabilities. Each of these criteria was then broken down to sub-criteria and sub-sub criteria where appropriate and was used to perform the core usability study.
- E. The use cases were executed to invoke the set of criteria scoped in the previous step on both the vendor products.
- F. The results, including key metrics of time and complexity to execute each task as well as the user experience, were methodically documented on an Excel spreadsheet against the developed set of criteria.
- G. Each of the tasks was assigned a level of importance based on the frequency of its execution by a Storage Administrator. A task that is likely to be executed several times during the course of a week was assigned “**High**” in frequency and considered very important. Tasks executed several times during the course of a month but not necessarily every week, was assigned a “**Medium**” level of frequency. Those tasks that are executed infrequently, perhaps a few times in a year, was assigned a “**Low**” frequency. This type of rating helps the customer to put the test results in their proper perspective in the selection of the right storage product, by not assigning too much importance to functionalities and features that may be infrequently used.
- H. Results from this exercise formed the basis for this usability report.

## 5.0 Test Results and Analysis

### 5.1 Storage Provisioning

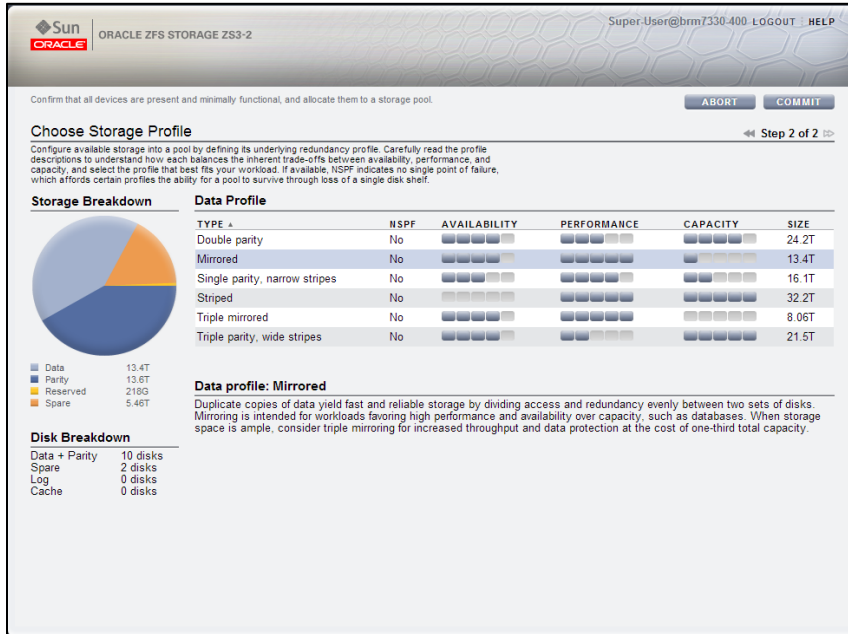
**Overview:** The storage provisioning process is used by all Storage Administrators as part of their fundamental storage tasks. These process tasks involve creating, resizing, and/or assigning storage pools, LUNs, and FileSystems. These tasks will be used to ensure that storage is used in the most efficient manner possible in an environment while defining the performance characteristics that will be available to any given workload. When these tasks are done correctly the costs of storage can be effectively managed leading to a higher ROI for the storage platform.

The primary advantages of Oracle ZFS Storage over NetApp FAS Storage for storage provisioning tasks can be summarized as follows:

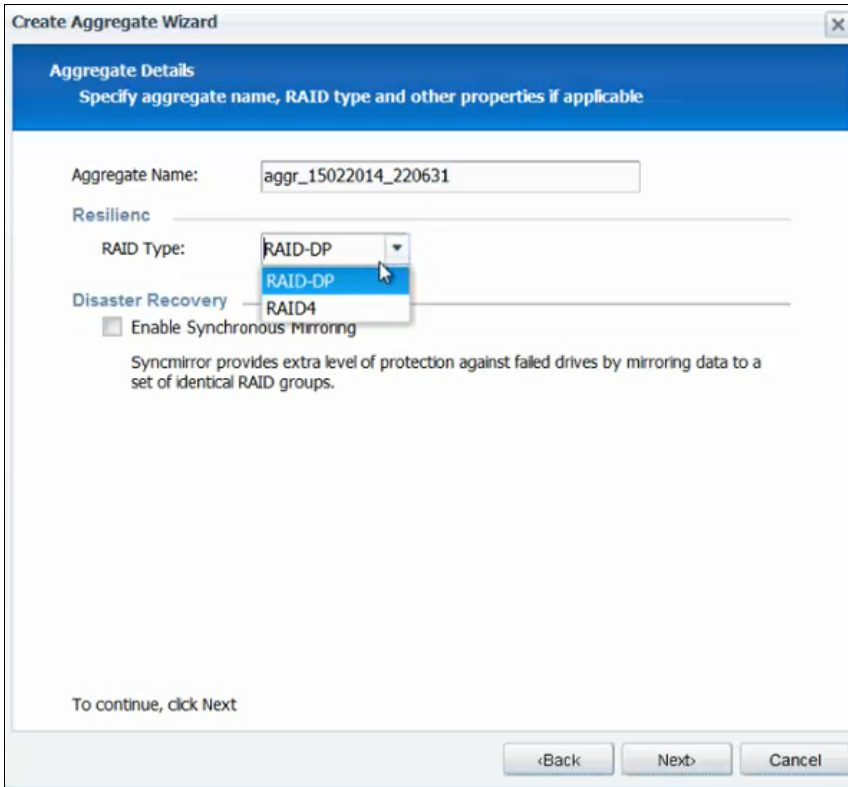
#### **Create Storage Pool with hot spares:**

Administrators are presented options on protection types that easily outline the performance characteristics and protection methodologies that can be used. Administrators are not required to define hot spares. Oracle ZFS Storage takes care of ensuring they are available, assuming the protection type will support hot spares. The Oracle ZFS Storage pool creation process also ensures that administrators understand that Single Points of Failure may exist within the protection scheme they are selecting, by displaying a representation saying "NSPF" (No Single Point of Failure) when the selection is fully protected. NetApp FAS Storage offers choice by providing the ability to leverage system-defined hot spares or specific disks defined by the Storage Administrator. This can be viewed as an advantage or disadvantage of NetApp depending on the administrator's point of view.

A screen shot is provided below that illustrates the multiple storage data profiles that Oracle ZFS Storage is able to leverage. It shows the ease with which Oracle ZFS Storage provides an understanding of the benefits of each profile as the pool is built. The NSPF attribute is also shown during the provisioning process.



Oracle ZFS Storage : Storage Profile

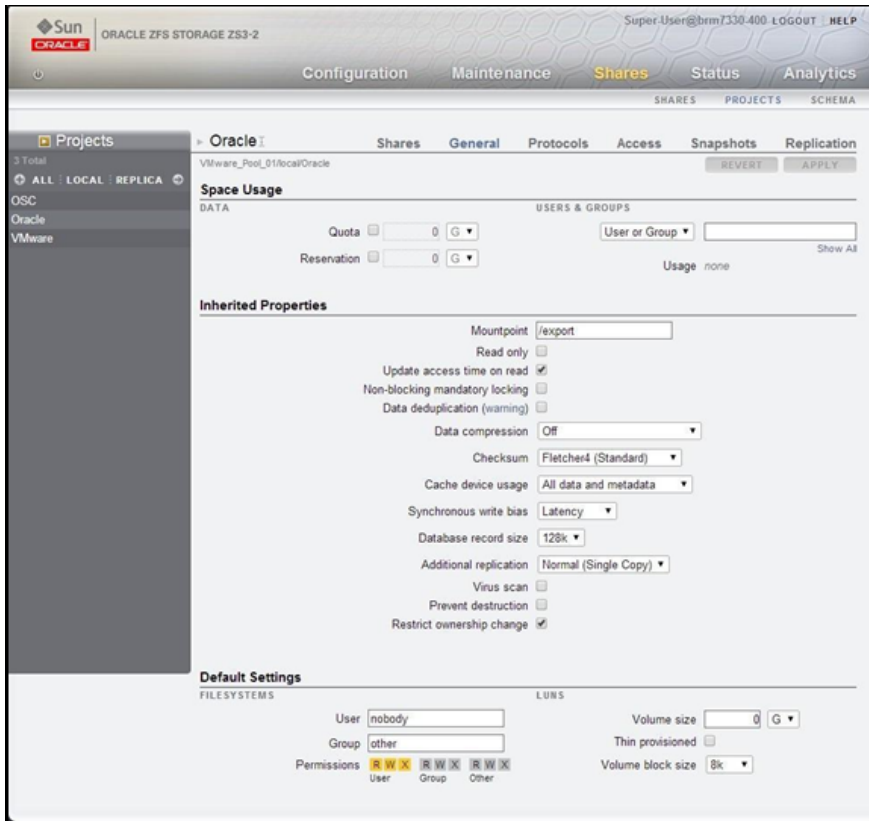


NetApp FAS Storage Appliance: RAID Type

## Creating a Project:

Oracle ZFS Storage simplifies the storage management process for administrators with the concept of a Project, The UI that is given for the creation of a Project groups all of the important characteristics of a Project into one screen for general setup, protocol access, access, snapshots, and replication options. The options selected at the Project level are then simply inherited for LUNs and FileSystems that are created within that Project. NetApp Flexvol lacks similar capability as it fails to provide the same level of granularity as ZFS Storage Project.

The screen shot below shows how Projects allow for all metrics available to LUNs and FileSystems to be centrally managed. It shows some of the general configuration options that are available including: mountpoints, deduplication, compression, virus scanning, and destruction.



## Creating LUNs and FileSystems:

Oracle ZFS Storage allows Storage Administrators to standardize LUN and FileSystem creations by ensuring that each setting/configuration within a given Project has consistent settings. The Oracle ZFS Storage platform distinguishes itself from NetApp FAS Storage when creating multiple LUNs/FileSystems because an administrator simply needs to create a LUN with no need to configure attributes such as De-dupe, Thin, AV, etc.; the Storage Administrator can simply add the LUN/FileSystem to a Project and be assured that each setting is configured appropriately. The Project also helps with LUNs/FileSystems created over time because again a Storage Administrator can simply add a LUN/FileSystem to a Project and know it is set up properly.

Table 5-1 shows the Oracle advantage over NetApp in the tasks that were executed and the tester's experience in terms of what functions and features contributed to this advantage. Table 5-1.1 shows the corresponding time savings achieved.

**Table 5-1: Storage Provisioning Feature Comparisons**

#	Task	Frequency of Use	Oracle ZFS Strength (+) or Weakness (-)	NetApp Strength (+) or Weakness (-)
1	Create Storage Pool with hot spares	Medium	<p>+ ZFS provisioning allows for 6 different protection (RAID) profiles (Double Parity, Mirrored, Single Parity, Striped, Triple Mirrored, Triple Parity).</p> <p>+ ZFS shows what protection scheme options may have single points of failure when creating storage pools.</p> <p>+ ZFS automates the hot spare creation process in order to lessen the workload on the Storage Administrator</p>	<p>+ Can leverage system or administrator defined hot spares</p> <p>-- NetApp takes a considerable amount of time for an aggregate to finalize its creation.</p> <p>-- NetApp offers only two different protection profiles (RAID 4 and RAID-DP)</p>
2	Create Project	Medium	<p>+ The concept of Projects helps to ensure a Storage Administrator can deliver like configurations for all LUNs/FileSystems for a given type of workload.</p> <p>Projects allow for a number of configuration options including:</p> <ul style="list-style-type: none"> <li>- Data Deduplication</li> <li>- Data Compression</li> <li>- Cache device usage</li> <li>- Database record size</li> <li>- AV Scan</li> <li>- Thin Provisioning</li> </ul> <p>Also allows for numerous access protocol configurations</p> <p>-NFS,SM B, HTTP,FTP,</p>	<p>-- While NetApp's FlexVol provides some similarities, it lacks the capability to deliver like configurations; it is a very manual and time consuming process</p>

#	Task	Frequency of Use	Oracle ZFS Strength (+) or Weakness (-)	NetApp Strength (+) or Weakness (-)
			SFTP, TFTP	
3	Create iSCSI Target Group		+ Can be set up with drag/drop interface	-- Drag and drop interface is not supported  -- Over 60% more complex and time consuming than Oracle ZFS storage solution
4	Creating LUN	Medium	+ Project concept ensures all LUN settings are standardized for a workload.  + Allows administrators to define a block size on a per LUN basis. This can be any power of 2 from 512 bytes to 1MB. This allows Storage Administrators to set the most appropriate block size for a given workload.	-- Once a LUN is created, NetApp FAS Storage does not allow an administrator to modify the LUN host operating system type.
5	Creating FileSystem	Medium	+ Project concept ensures all FileSystems settings are standardized for a workload.  Also allows for numerous access protocol configurations to be simply enabled/disabled.  - NFS, - SMB, - HTTP, - FTP, - SFTP, - TFTP	-- NetApp FAS Storage does not have a concept equivalent to Oracle ZFS Project hence 25% less efficient  +NetApp FAS Storage supports same protocols that are supported by Oracle ZFS Storage
6	Add Storage to a Pool	Low	+ Oracle ZFS Storage expands pool instantaneously	-- NetApp FAS Storage takes a considerable amount of time for an aggregate to finalize its additional storage.
7	Re-size LUN	Medium	+ Oracle ZFS has marginal advantage over NetApp in steps and time taken to perform this task	--Oracle ZFS has marginal advantage over NetApp in steps and time taken to perform this task



#	Task	Frequency of Use	Oracle ZFS Strength (+) or Weakness (-)	NetApp Strength (+) or Weakness (-)
8	Assign LUN to initiator group	Low	+Oracle ZFS Storage BUI (Browser User Interface) provides the ability to assign multiple LUNs to an initiator group in a single operation	--NetApp FAS Storage does not support assignment of multiple LUNs to the same initiator group in a single operation

**Table 5-1.1: Storage Provisioning Time Savings**

Task Areas	Oracle		NetApp	
	Time in Seconds	Steps	Time in Seconds	Steps
Create Storage Pool with hot spares	25	8	28*	10
Create Project	47	15	N/A	N/A
Create iSCSI Target Group	4	8	13	5
Creating LUN	20	7	50	12
Creating FileSystem	15	6	20	8
Add Storage to a Pool	19	4	20	6
Re-size LUN	10	5	14	7
Assign LUN to initiator group	14	7	14	7

	Oracle		NetApp	
<b>Total Storage Provisioning</b>	107	45	159	55
<b>Oracle Advantage (Oracle – NetApp)</b>	-52	-10		
<b>Percentage Oracle Advantage</b>	33% Less Time,	19% Fewer Steps		

\* This does not account for the time for an aggregate to zero the disks in NetApp FAS Storage. The process of zeroing the disks was approximately 3 hours.

## 5.2 Data Protection

Data continues to become increasingly important to businesses, and the capabilities that a storage platform offers must align with the needs of the business. A storage platform must be capable of protecting data via methods such as snapshots, cloning, and replication; this duplicated or protected data must also be quickly available for a business to run data reporting and analytics or provide for disaster avoidance. The ability to manage data in this manner can give an organization a tactical advantage by protecting against data loss in a disaster situation or a strategic advantage by providing the ability to use the data for offline reporting purposes or to quickly allow for testing of data changes in a test environment against production ready data.

The primary advantages of Oracle over NetApp for data protection can be summarized as follows:

### Create Snapshot:

Both Oracle ZFS Storage and NetApp FAS Storage provide the ability to take snapshots, but the Oracle ZFS Storage allows for an unlimited number of snapshots per volume, while NetApp FAS Storage allows for 255 snapshots per volume.

### Schedule Automatic Snapshots:

Oracle ZFS Storage takes advantage of its Project level configurations to ensure that Storage Administrators are not required to configure scheduled snapshots on a per Volume, LUN, or FileSystem basis. The Project configuration for scheduled snapshots only needs to be configured one time and all LUNs/ FileSystems in the Project will inherit the same settings. This single configuration leads to consistent settings as well as significantly reducing the workload on a Storage Administrator. NetApp FAS Storage would have been faster and with fewer steps, if Oracle didn't utilize Project functionality, but with Project global setting Oracle ZFS Storage uses zero time and steps, this makes Oracle ZFS Storage administration simple and consistent.

### **Clone/Restore Snapshot:**

In Oracle ZFS Storage, all tasks involved in managing the clone/restore/update of snapshots follow very similar processes. This makes administration simpler for administrators. As for other data protection tasks, the Project global configuration and reusability provide administrators the confidence of consistency.

Oracle ZFS Storage allows a clone to be created with a zero storage footprint increase, while ZFS and NetApp's snapshots and clone do not require additional space (other than small metadata). NetApp FAS Storage provides a similar feature, but is 22%, in clone snapshot, and 7%, in clone restore, more efficient than Oracle ZFS Storage

### **Create/Configure Replication:**

Oracle ZFS Storage takes advantage of its Project level configurations to ensure that Storage Administrators are not required to configure replication on a per LUN or FileSystem basis. The Project configuration for replication only needs to be configured one time and all LUNs/FileSystems in the Project will inherit the same settings. This single configuration will lead to both consistent settings as well as significantly reducing the workload on a Storage Administrator.

NetApp FAS Storage offers similar functionality except that it takes 39% more on replication creation and 100% more on replication configuration than Oracle ZFS Storage.

### **Set Snapshot Retention Policy:**

Oracle ZFS Storage takes advantage of its Project level configurations to ensure that Storage Administrators are not required to configure scheduled snapshots retention policies individually. The Project configuration for scheduled snapshot retention only needs to be configured one time and all LUNs/FileSystems in the Project will inherit the same settings. This single configuration will lead to consistent settings as well as significantly reducing the workload on a Storage Administrator. NetApp FAS Storage provides this configuration only at the time of snapshot creation which results in 100% inefficiency when compared to Oracle ZFS Storage effort.

### **Clone from Replica:**

Oracle ZFS Storage tasks involved in managing the clone/restore/update of replicas follows very similar processes. This makes administration simpler for administrators. NetApp FAS Storage provides similar functionality to perform Clone from Replica and it is 50% more efficient than Oracle ZFS Storage.

### **Sync Replica with Source – Manual:**

Oracle ZFS Storage tasks involved in managing the clone/restore/update of replicas follows very similar processes. This makes administration simpler for administrators.

Like Oracle ZFS Storage, NetApp FAS Storage replication functions are embedded in one interface. This makes it easy to configure replication automatically or on demand.

### **Sync Replica with Source - Continuous:**

Oracle ZFS Storage takes advantage of its Project level configurations to ensure that Storage Administrators are not required to configure replication synchronization on a per LUN or FileSystem basis. The Project configuration for replication only needs to be configured one time and all LUNs/FileSystems in the Project will inherit the same settings. This single configuration will lead to both consistent settings as well as significantly reducing the workload on a Storage Administrator. NetApp FAS Storage provides similar functionality but is 100% less efficient than Oracle ZFS Storage because of the Oracle Project reusability functionality.

Table 5-2 shows the Oracle advantage over NetApp in the tasks that were executed and the tester's experience in terms of what functions and features contributed to this advantage. Table 5-2.1 shows the corresponding time savings.

**Table 5-2: Data Protection Comparison**

#	Task	Frequency of Use	Oracle ZFS Strength (+) or Weakness (-)	NetApp FAS Strength (+) or Weakness (-)
1	Create Snapshot	Medium	+ Oracle ZFS Storage allows for unlimited snapshots	-- NetApp FAS Storage allows for only 255 snapshots
2	Schedule Automatic Snapshots	Medium	+ Use of Projects standardizes configurations  + Use of Projects reduces Storage Administrator overhead, by only requiring a single configuration.	-- While NetApp's FlexVol provides some similarities, it lacks the capability to deliver like configurations; it is a very manual and time consuming process, hence it is 100% less efficient
3	Clone from Snapshot	Medium	+ Clones use zero disk space upon creation	+The clone has no dependency on the original data.  + Clones use zero disk space upon creation
4	Restore from Snapshot	Medium	+ The tasks for managing the clone/restore of snapshots follow the same processes	+ Comparatively less steps when compared to Oracle ZFS storage
5	Create Replication Target	Medium	+ Configuring replication target is easy and it is 40% more efficient than NetApp  + Capable of performing replication to the same Storage Array.	-- NetApp FAS Storage doesn't provide the ability for administrators to create just the replication target with System Manager, but forces them to complete the entire replication process  -- NetApp FAS Storage takes 56% more steps when compared to Oracle ZFS storage

#	Task	Frequency of Use	Oracle ZFS Strength (+) or Weakness (-)	NetApp FAS Strength (+) or Weakness (-)
6	Configure Replication	Medium	<ul style="list-style-type: none"> <li>+ Use of Projects standardizes configurations</li> <li>+ Use of Projects reduces Storage Administrator overhead, by only requiring a single configuration.</li> <li>+ Capable of performing replication to the same Storage Array. Additional hardware not a requirement for replication.</li> </ul>	-- While NetApp's FlexVol provides some similarities, it lacks the capability to deliver like configurations; it is a very manual and time consuming process, hence it's 100% less efficient
7	Set Snapshot Retention Policy	Medium	<ul style="list-style-type: none"> <li>+ Use of Projects standardizes configurations</li> <li>+ Use of Projects reduces Storage Administrator overhead, by only requiring a single configuration.</li> <li>+ Capable of setting long term retentions on snapshots taken on daily basis or longer</li> </ul>	-- While NetApp's FlexVol provides some similarities, it lacks the capability to deliver like configurations; it is a very manual and time consuming process, hence it's 100% less efficient
8	Clone from Replica	Medium	+ There is no increase in storage requirements for the clone that is created from a replica	+ NetApp FAS Storage is 50% more efficient than Oracle ZFS
9	Sync Replica with Source – Manual	Medium	+ For both NetApp and Oracle ZFS, time and step variance are marginal	+ For both NetApp FAS and Oracle ZFS, time and step variance are marginal

#	Task	Frequency of Use	Oracle ZFS Strength (+) or Weakness (-)	NetApp FAS Strength (+) or Weakness (-)
10	Sync Replica with Source - Continuous	Medium	<p>+ Use of Projects standardizes configurations</p> <p>+ Use of Projects reduces Storage Administrator overhead by only requiring a single configuration.</p>	<p>-- While NetApp's FlexVol provides some similarities, it lacks the capability to deliver like configurations; it is a very manual and time consuming process, hence it's 100% less efficient</p>
11	Sever Replica from Source	Medium	<p>-- Process does not follow the same workflow as other snapshot / clone tasks</p>	<p>-- NetApp FAS Storage is 79% more efficient than Oracle ZFS</p>

Table 5-2.1: Data Protection Time Savings

Task Areas	Oracle		NetApp	
	Time in Seconds	Steps	Time in Seconds	Steps
Create Snapshot	16	8	13	5
Schedule Automatic Snapshots	33* 0**	11* 0**	26	7
Clone from Snapshot	22	9	18	7
Restore from Snapshot	16	8	15	6
Create Replication Target	23	7	38	16
Configure Replication	36* 0**	14* 0**	18	9

	Oracle		NetApp	
Task Areas	Time in Seconds	Steps	Time in Seconds	Steps
Set Snapshot Retention Policy	14* 0**	7* 0**	14	7
Clone from Replica	21	8	14	7
Sync Replica with Source – Manual	15	6	14	7
Sync Replica with Source - Continuous	36* 0**	9* 0**	24	8
Sever Replica from Source	25	8	14	7
<b>Total Data Protection</b>	138	54	208	86
<b>Oracle Advantage (Oracle – NetApp)</b>	-70	-32		
<b>Percentage Oracle Advantage</b>	34% Less Time, 37% Fewer Steps			

\* Accounts for a using a manual configuration

\*\* Accounts for using the Project level configuration

### 5.3 Storage Management Comparison

**Overview:** Through a storage platform’s life cycle there are numerous demands on a Storage Administrator to ensure disks are reclaimed as business applications are retired or performance



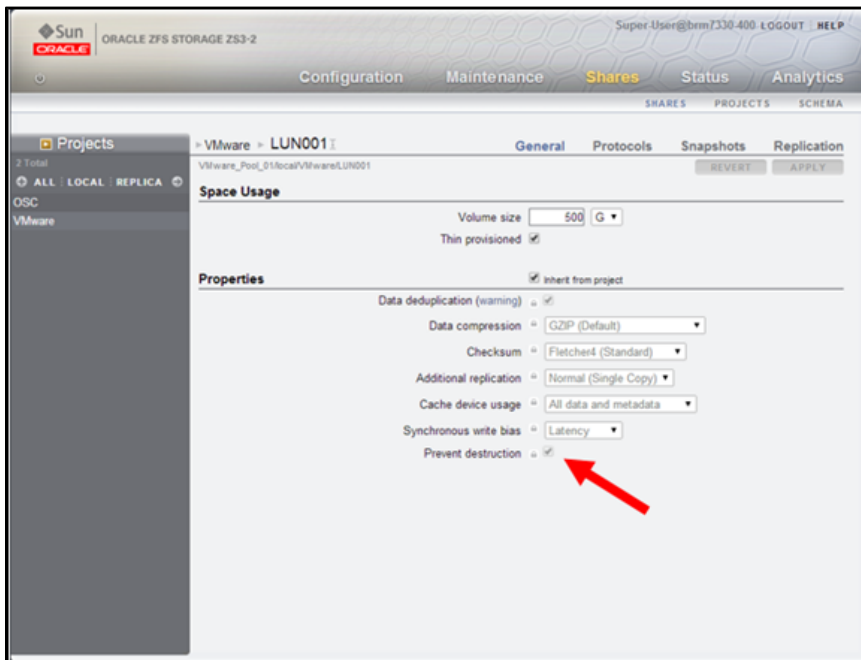
requirements for applications change. These require Storage Administrators to be able to simply and safely return disks to the device while leveraging higher cost cache disks for the appropriate purposes. Storage Administrators must also be able to quickly and easily diagnose real-time storage array performance issues as well as trend performance over time in order to reliably predict storage costs in accordance with budget cycles.

The primary advantages of Oracle over NetApp for medium and high priority storage management tasks can be summarized as follows:

### Prevention of Storage Deletion:

The process of decommissioning a pool is a standard process for Storage Administrators. Oracle ZFS Storage ensures that administrators do not inadvertently destroy production data, by allowing them to define LUN, FileSystems, and Projects with a “Prevent Destruction” attribute. This attribute protects an organization's data by ensuring an Administrator has to remove this flag before a Pool can be removed. Compared to the removal process of an aggregate on the NetApp FAS platform, the removal of an Oracle ZFS Storage pool is a much faster technical process.

The screen shot below illustrates the ability of Oracle ZFS Storage to prevent the destruction of LUNs or Filesystems on an individual or Project basis; even if there is an attempt to destroy the parent Pool.



### Destroy Project:

The concept of “Project” in NetApp is not supported at the same granular level as Oracle ZFS Storage. Oracle ZFS Storage continues to use common data protection methodologies in the process of destroying a Project. Oracle ZFS Storage ensures that administrators do not inadvertently destroy production data, by allowing them to define Projects with a “Prevent Destruction” attribute.

This attribute protects an organization's data by ensuring an administrator has to remove this flag before a Project can be removed.

#### **Destroy LUN:**

Oracle ZFS Storage ensures that administrators do not inadvertently destroy production data, by allowing them to define LUNs with a “Prevent Destruction” attribute. This attribute protects and organizations data by ensuring an Administrator has to remove this flag before a LUN can be removed. NetApp LUNs can be destroyed with no system protection processes in place.

#### **Reassign LUN to another Project:**

Again, NetApp FAS Storage does not have the concept of a Project to compare against. Oracle ZFS Storage allows administrators to easily reassign a LUN to a different Project by simply “dragging and dropping” the LUN to the appropriate Project. Allowing Administrators to reassign a LUN to a new Project gives them the ability to change the configurations of a LUN (or FileSystem) to match the configurations of a new Pproject, which will ensure the configurations are aligned with other LUNs in the new Project. This process eases an administrator's duties.

#### **Destroy FileSystem:**

Oracle ZFS Storage utilizes common data protection methodologies in the process of destroying a FileSystem. Oracle ZFS Storage ensures that administrators do not inadvertently destroy production data, by allowing them to define FileSystems with a “Prevent Destruction” attribute. This attribute protects an organization’s data by ensuring an administrator has to remove this flag before a FileSystem can be removed.

#### **Migrate data to new FileSystem:**

Oracle ZFS Storage provides the ability to copy the data from a FileSystem to a new FileSystem while keeping the data intact on the original FileSystem using Shadow Migration, a built-in local data migration tool . This allows Storage Administrators to set up copies of FileSystems for testing purposes. The process also makes it very simple to allow administrators to move FileSystems to new sets of disks as deemed necessary by business units or administrators. NetApp System Manager does not support migration of data to a new FileSystem.

#### **Set Cache device usage policy:**

Oracle ZFS Storage provides the ability for a Storage Administrator to define how Write Cache will be used in a given LUN basis. This flexibility allows Storage Administrators to best leverage the cache depending on the workload type, including the ability to disable for non-heavy workloads. This policy is not supported by NetApp FAS storage.

#### **Monitor performance: CPU usage, throughput and several other attributes**

Oracle ZFS Storage provides all key aspects of array performance and these are easily identified from a single screen which can be customized based on an administrator's requirements. Oracle ZFS Storage allows an administrator to see historical performance metrics (CPU, Disk, Network, FC, iSCSI, FC, FTP and NFS) across different time intervals allowing the administrator to trend performance over time or to troubleshoot performance issues in real-time. NetApp FAS Storage does not provide the capability to see differing performance metric time-lines.

Table 5-3 shows the Oracle advantage over NetApp in the tasks that were executed, and the tester's experience in terms of which functions and features contributed to this advantage. Table 5-3.1 shows the corresponding time savings.

**Table 5-3: Storage Management Comparison**

#	Task	Frequency of Use	Oracle ZFS Strength (+) or Weakness (-)	NetApp FAS Strength (+) or Weakness (-)
1	Un-configure Pool	Low	+ Process can be prevented if LUNs or FileSystems are marked as "Prevent Destruction"	-- No option "Prevent Destruction" option available
2	Destroy Project	Low	+ Process can be prevented if LUNs or FileSystems are marked as "Prevent Destruction"	-- Not Supported
3	Destroy LUN	Medium	+ Process can be prevented if LUNs are marked as "Prevent Destruction"	-- No option "Prevent Destruction" option available
4	Reassign LUN to another Project	Medium	+ Can be done using drag-and-drop feature in the GUI  + Allows Storage Administrator to change LUN attributes to match that of other FileSystems in the Project	-- Not Supported
5	Reassign FileSystem to another Project	Medium	+ Can be done using drag-and-drop feature in the GUI  + Allows Storage Administrator to change FileSystem attributes to match that of other FileSystems in the Project	-- Not Supported
6	Destroy FileSystem	Low	+ Process can be prevented if FileSystems are marked as "Prevent Destruction"	-- No "Prevent Destruction" option available

#	Task	Frequency of Use	Oracle ZFS Strength (+) or Weakness (-)	NetApp FAS Strength (+) or Weakness (-)
7	Migrate data to new FileSystem	Low	+ Process is integrated into the new FileSystem creation process	-- Not possible within the single administration tool system manager
8	Set Cache device usage policy	Medium	+ Can enable or disable on a per LUN basis + Only requires a single checkbox to be enabled / disabled	-- No option to set cache policy
9	Monitor performance: CPU usage, throughput and several other metrics (CPU, Disk, Network, FC, iSCSI, FC, FTP and NFS))	High	+ Can be configured to show up to 10 different "indicators" depending on thresholds set by the administrator + Allows administrator to see data over different periods of time (0-60 Min, 1-24hr, 1-7days)	-- Does not have capability to drill down into granular intervals of time
10	Monitor capacity: Available storage per pool, aggregate, FileSystem, deduplication ratio, compression	High	+ All Pool summary information is shown in a single location: Used, Available, Compression ratio, Deduplication ratio + Information is readily shown in both graphical and numerical format + Can show different pools with single click - Does not contain historical information	+ Detailed up to date (Used and Available in terms of percentage) information is provided for Storage Capacity, Aggregates, Volumes and Disks + Clicking on individual metric takes the user to the detailed graphical and numerical interface (metrics provided in percentage as well as absolute numbers) including deduplication and compression
11	Enable / Disable different protocols and services on FileSystem	Low	+ Capable of supporting 6 different protocols for FileSystems + Services can be enabled and disabled from a single location with one click per protocol.	-- NetApp FAS provides the same functionality as Oracle ZFS Storage except that it is 50% less efficient from a time and steps perspective

#	Task	Frequency of Use	Oracle ZFS Strength (+) or Weakness (-)	NetApp FAS Strength (+) or Weakness (-)
12	License Management	Low	+ There is no need for license management with ZFS	-- NetApp requires licenses to be installed and managed for each capability that is added to the array.

**Table 5-3.1: Storage Management Time Savings**

Task Areas	Oracle		NetApp	
	Time in Seconds	Steps	Time in Seconds	Steps
Un-configure Pool	8	4	14	6
Destroy Project	8	4	N/A	N/A
Destroy LUN	10	5	24	9
Reassign LUN to another Project	6	3	N/A	N/A
Reassign FileSystem to another Project	6	3	N/A	N/A
Destroy FileSystem	8	4	14	6
Migrate data to new FileSystem	21	6	N/A	N/A
Set Cache device usage policy	12	6	N/A	N/A
Monitor performance: CPU usage, throughput	6	2	4	2

	Oracle		NetApp	
Task Areas	Time in Seconds	Steps	Time in Seconds	Steps
Monitor capacity: Available storage per pool/aggregate, FileSystem, deduplication ratio, compression	6	2	4	2
Enable / Disable different protocols and services on FileSystem	4	2	8	4
License Management	0	0	6	3
<b>Total Storage Management</b>	<b>42</b>	<b>19</b>	<b>74</b>	<b>32</b>
<b>Oracle Advantage (Oracle – NetApp)</b>	<b>-32</b>	<b>-13</b>		
<b>Percentage Oracle Advantage</b>	<b>43% Less Time,</b>	<b>41% Fewer Steps</b>		

### 5.4 General Management Features Comparison

Overview: Businesses are expecting IT departments to deliver extremely high SLA's (Service Level Agreement's) in today's world. Considering the business drivers, the ability to manage a storage platform's health is a critical aspect of an array's capabilities. Storage Administrators must be able to simply and effectively have a proactive understanding that a problem exists before the issues begin to hamper production performance or before leading to production downtime.

The primary advantages of Oracle over NetApp for high priority general management tasks can be summarized as follows:

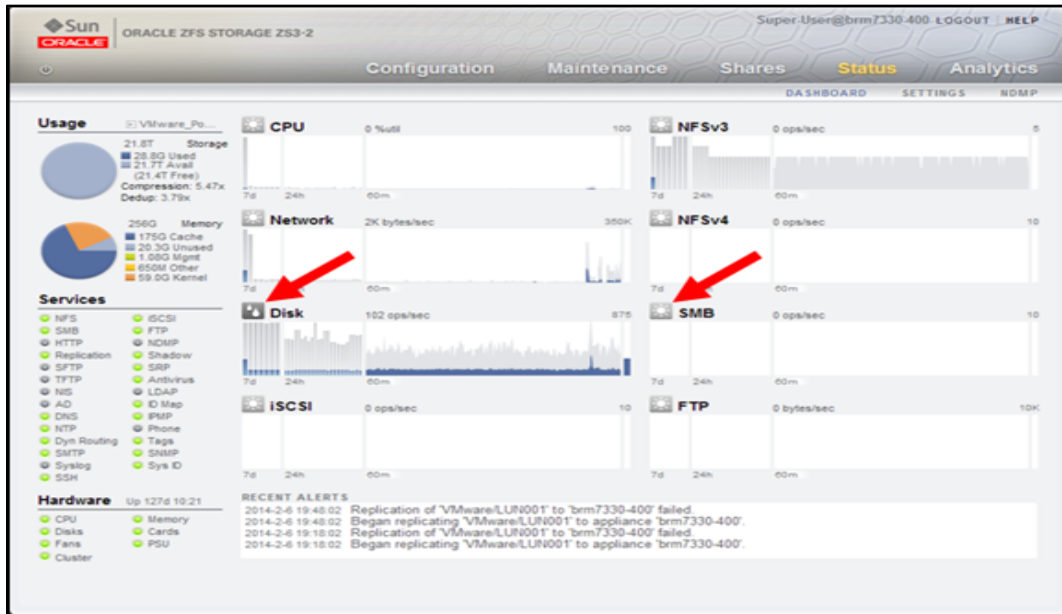
### Determining the health of the array:

Oracle ZFS Storage has numerous options available for outlining the physical health or stability of the array. Oracle allows this to be found directly from a status page by giving Storage Administrators the details needed to troubleshoot including: Type (major, minor), impact, affected components, if automated response was available, recommended actions, date/time of the event, and notifications taken.

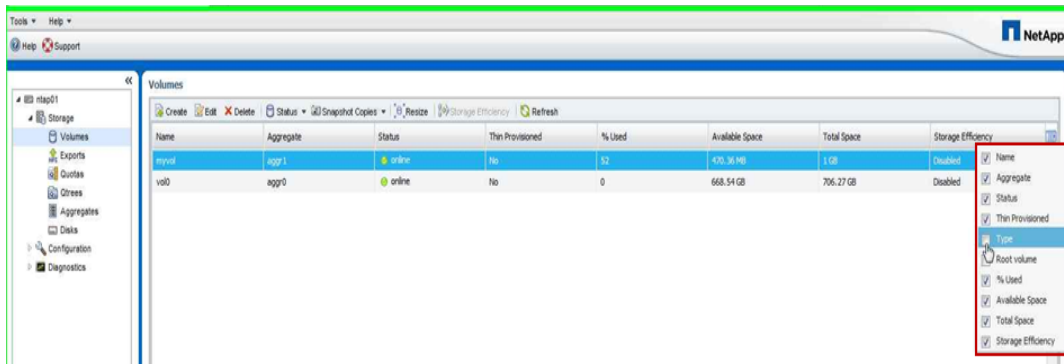
### Customization of views within the UI:

The UI within Oracle ZFS Storage allows a Storage Administrator a vast array of abilities to customize the monitoring views within the array. The administrator can define thirteen different metrics within the monitoring view. The view can be further customized by defining specific icons to metrics as outlined by business or technical need. Oracle ZFS Storage also allows Storage Administrators to create views with combinations of drill-down metrics and save the views for future use, creating additional efficiencies in the array. NetApp FAS Storage provides limited customization only at the individual component level such as Volume view. The NetApp FAS Storage dashboard provides no UI customization.

The screen shot below shows the ability to change the representative icon in Oracle ZFS Storage based on administrator defined thresholds. Each metric can be configured with up to 10 different icon representations. It also shows the Pool disk usage, compression, and de-duplication ratios.



### Oracle ZFS: Dashboard Customization



### NetApp System Manager: Volume UI Customization

### Managing the physical system from the UI

The Oracle ZFS Storage platform allows the Storage Administrator to view all physical components of the storage array in a graphical representation. This allows the administrator to be certain where issues may lie when performing physical troubleshooting. Storage Administrators are also able to individually “beacon” independent disks to allow them to identify them when needed. NetApp FAS Storage does not offer a method to visualize the physical array from the NetApp management software.

The screen shot below shows that Oracle ZFS Storage allows all aspects of the hardware to be displayed. It also shows a specific disk shelf with each individual disk and its relevant information. Each disk shows a beacon icon to the right allowing the administrator to turn on or off each beacon light.

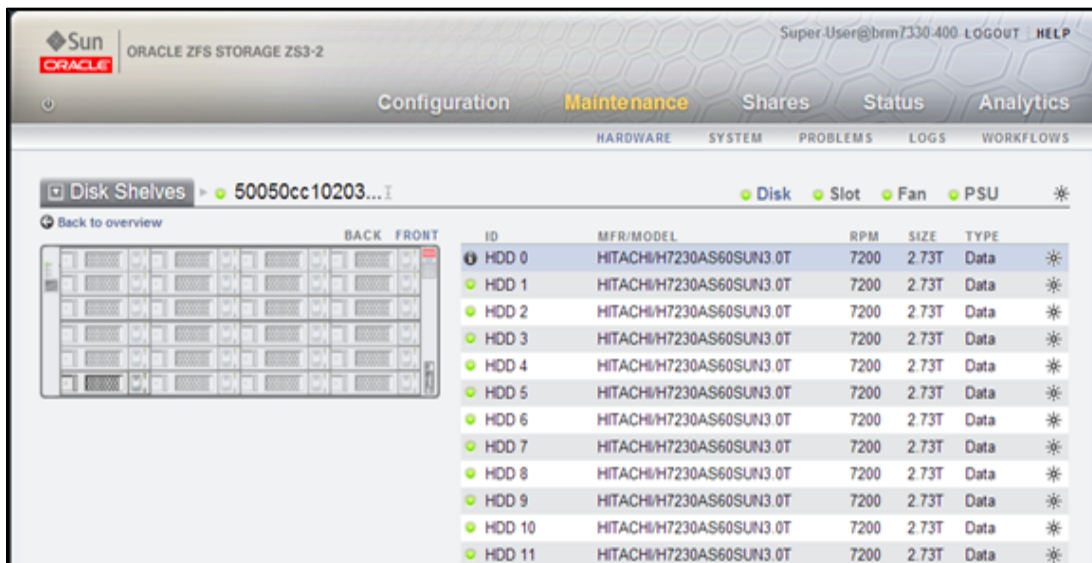


Table 5-4 shows the Oracle advantage over NetApp in the tasks that were executed and the tester’s experience in terms of what functions and features contributed to this advantage. Table 5-4.1 shows the corresponding Time Savings advantage.



**Table 5-4: General Management Comparison**

#	Task	Frequency of Use	Oracle ZFS Strength (+) or Weakness (-)	NetApp FAS Strength (+) or Weakness (-)
1	Determining the health of the array	High	<ul style="list-style-type: none"> <li>+ Errors are found on the "Maintenance" screen in real-time</li> <li>+ Notification alerts can be assigned to a workflow based on the threshold and duration of the event</li> <li>+ 7 key details provided are simple to understand and readily available</li> <li>Type (major, minor)</li> <li>Impact</li> <li>Affected components</li> <li>If automated response was available</li> <li>Recommended actions</li> <li>Date/Time of the event</li> <li>Notifications taken</li> </ul>	<ul style="list-style-type: none"> <li>-- Like Oracle ZFS "Recommended Actions" are not available to resolve any errors within NetApp System Manger 3.0</li> </ul>
2	Customization of views within the UI	High	<ul style="list-style-type: none"> <li>+ Allows the ability to define what attributes are monitored as well as define specific icons based on metrics</li> <li>+ Allows administrators to create specific views of metrics that can be re-used</li> </ul>	<ul style="list-style-type: none"> <li>-- The main dashboard at the system level is not customizable</li> <li>-- System Manager tool requires client installation and even though it is accessed using internet browser it still lacks the typical look and feel of a web client</li> </ul>

#	Task	Frequency of Use	Oracle ZFS Strength (+) or Weakness (-)	NetApp FAS Strength (+) or Weakness (-)
3	Managing the physical system from the UI	Medium	<ul style="list-style-type: none"><li>+ All aspects of the array allow drill-down functionality in a detailed representation of the physical array.</li><li>+ Allows the ability for an administrator to "beacon" a disk light.</li></ul>	<ul style="list-style-type: none"><li>-- Does not offer a physical view of the array</li></ul>

**Table 5-4.1: General Management Time Savings**

	Oracle		NetApp	
Task Areas	Time in Seconds	Steps	Time in Seconds	Steps
Determining the health of the array	4	2	49	4
Customization of views within the UI	32	8	17	10
Managing the physical system from the UI	4	2	N/A	N/A
<b>Total General Management</b>	<b>36</b>	<b>10</b>	<b>66</b>	<b>14</b>
<b>Oracle Advantage (Oracle – NetApp)</b>	<b>-30</b>	<b>-4</b>		
<b>Percentage Oracle Advantage</b>	<b>45% Less Time</b>	<b>29% Fewer Steps</b>		

### 5.5 Analytics Features Comparison

**Overview:** As the percentage of virtualized servers in data centers increase so does the importance of understanding the relationship of VM performance to storage performance. Today businesses have moved to virtualizing mission critical applications, not just Tier 2 and Tier 3 applications. The majority of VM performance issues are typically related to storage performance, making the ability to quickly and reliably troubleshoot issues critical. Storage Administrators must be able to identify and “root cause” issues around virtualization platforms in order to be successful.

The primary advantages of Oracle over NetApp for high priority general management tasks can be summarized as follows:

**Analyze, isolate and resolve workload problem in a Virtual environment with fifty VMs:**

Oracle ZFS storage provides Storage Administrators very robust yet simple to use capabilities for determining the storage performance characteristics of a Virtual Machine infrastructure deployment. Oracle ZFS Storage has directly integrated its DTrace performance monitoring tool that allows a Storage Administrator to drill down into the NFS stack for a virtual infrastructure in real-time as well as trending historical data. With the DTrace tool a Storage Administrator can determine which VM(s) is specifically generating the highest workload. As an example DTrace allows an Administrator to see a VM's I/O size, latency, and cache hit along with a number of other performance metrics.

The NetApp platform requires the use of an additional tool (On-Command Balance) in order to review VM performance data. The NetApp FAS Storage tool does offer a Storage Administrator the ability to see a number of VM performance details beyond storage, including CPU and Memory usage. The On-Command Balance tool leverages historical data to provide "Intelligent" monitoring capabilities and warnings of VM performance issues. The tool does not provide real-time data which can makes troubleshooting VM bottlenecks cumbersome as issues arise.

Table 5-5 shows the Oracle advantage over NetApp in the tasks that were executed and the tester's experience in terms of what functions and features contributed to this advantage. Table 5-5.1 shows the corresponding time savings.

**Table 5-5: Analytics Comparison**

#	Task	Frequency of Use	Oracle ZFS Strength (+) or Weakness (-)	NetApp FAS Strength (+) or Weakness (-)
1	Analyze, isolate and resolve workload problem in a Virtual environment with 50 VMs	Medium	<ul style="list-style-type: none"> <li>+ Provides for real-time data analytics for metrics</li> <li>+ Capable of drilling down between inter-related metrics with 2 clicks</li> <li>+ Capable of reviewing metrics over multiple time frames</li> <li>+ Directly integrated with the ZFS platform</li> </ul>	<ul style="list-style-type: none"> <li>+ Capable of monitoring Virtual Machine CPU and Memory usage</li> <li>+ The dashboard provides notification for any abnormal activities</li> <li>-- Requires use of an additional tool - OnCommand Balance, which requires installation of VM Appliance</li> <li>-- Requires the installation of a "Proxy" server for monitoring</li> <li>-- Requires log-on rights to virtual servers that are to be monitored</li> <li>-- Limited to 15 minute granularity</li> </ul>

**Table 5-5.1: Analytics Time Savings**

	Oracle		NetApp	
Task Areas	Time in Seconds	Steps	Time in Seconds	Steps
Analyze, isolate and resolve workload problems in a Virtual environment with 50 VMs	16	7	59	11
<b>Total Analytics</b>	16	7	59	11
<b>Oracle Advantage (Oracle – NetApp)</b>	43	4		
<b>Percentage Oracle Advantage</b>	73% Less Time	36% Fewer Steps		

## 6.0 Conclusions:

Oracle’s key differentiators over NetApp, such as the unified web based admin interface to perform all administration activities including monitoring, the reusable Project feature to set consistent policy across the enterprise to reduce risk and work load for administrators, result in efficiency and savings. NetApp FAS Storage requires multiple tools to perform the same tasks and lacks features at the granular level that Oracle ZFS StorageProject offers.

Oracle ZFS Storage zero install web client and the maturity of its web interface, with higher productivity features such as D-Trace Analytics, dashboard customization with drilldown capabilities, makes administration intuitive and less complex when compared to NetApp, which requires client installation and uses a primitive web interface.

In our view, Oracle ZFS Storage is clearly the better choice for customers seeking an Enterprise Storage Solution. Using ZFS Storage , Storage Administrators perform their jobs more efficiently, minimizing administrative overhead. As this study shows, this results in a time savings of over 30% in daily administrative tasks and over 70% savings in time taken to correct network problems resulting from a virtual environment.

## Appendix A: Test Configuration

**Table A: Test Configurations of Oracle and NetApp Storage Management Systems**

	Oracle	NetApp
Storage System	Oracle ZFS ZS3-2	NetApp FAS 3250
Software	ZFS Version 2013.06.05.0.0,1-1.7	OnTap Version 8.1.2 7 mode OnCommand Balance 4.1.0.2 System Manager 3.0

## Appendix B: Detailed Metrics Test Data

Table B1: Storage Provisioning Comparison Test Data

#	Tasks	Oracle ZFS Storage Clicks	NetApp FAS Storage Clicks	Variance (Oracle ZFS Storage Clicks – NetApp Clicks)
1	Create Storage Pool with hot spares	8	10	-2
2	Create Project	15	N/A	N/A
3	Create iSCSI Target Group	8	5	+3
4	Creating LUN	7	12	-5
5	Creating FileSystem	6	8	-2
6	Add Storage to a Pool	4	6	-2
7	Re-size LUN	5	6	+1
8	Assign LUN to initiator group	7	13	-6

**Table B1a: Storage Comparison Tasks**

#	Task	Frequency of Use	Why the Task is Important
1	<b>Create Storage Pool with hot spares</b>	Low	The administrator must frequently allocate storage for new applications. This can be time consuming and error prone if not done properly, and the cost of doing it incorrectly can be high in terms of performance, scalability, cost and on-going maintenance of the application. Appropriate provisioning of storage can save money and defer a storage purchase and other associated costs until a later date. This deferred purchase often results in lower costs and excess capacity that can be used for new projects.
2	<b>Create Project</b>	Medium	The administrator is typically required to ensure that LUNs and FileSystems for workloads that are similar have the exact same settings and configurations. Setting up Projects helps the administrator to ensure that the settings are properly set up without being required to verify each setting on all LUNs/FileSystems in a given Project.
3	<b>Create iSCSI Target Group</b>	Medium	This process is used to allow specific connectivity between the storage array and the specific hosts as required.
4	<b>Creating LUNs</b>	Medium	Storage is presented to the servers (where the business applications are hosted) in terms of LUNS. The LUNS are mapped to the specific Storage Pools to segregate the application data for better performance, security, scalability, data and maintenance efficiency. How long or how complex this process is directly impacts the productivity of IT staff.
5	<b>Creating FileSystems</b>	Medium	Storage can be presented to the users / servers in terms of FileSystems (or Exports). The FileSystems can be mapped to the Storage Pools to segregate the application data for better performance, security, scalability, data and maintenance efficiency. How long or how complex this process is directly impacts the productivity of IT staff.



#	Task	Frequency of Use	Why the Task is Important
6	<b>Add Storage to a Pool</b>	Low	Dynamic Pool expansion allows business / applications to work non-disruptively and helps minimize the need for storage maintenance.
7	<b>Re-size LUN</b>	Medium	Dynamic LUN and FileSystem expansion allows business / applications to work non-disruptively and helps minimize the need for storage maintenance.
8	<b>Assign LUN to initiator group</b>	Low	As servers are retired or decommissioned over time, there are often business requirements to move LUNs to new servers. The process of moving this data is important to Admins to allow them to ensure the LUNs can be moved without compromising the data.

**Table B2: Data Protection Comparison Test Data**

#	Tasks	Oracle ZFS Storage Clicks	NetApp FAS Storage Clicks	Variance (Oracle ZFS storage Clicks – NetApp Clicks)
1	<b>Create Snapshot</b>	8	5	3
2	<b>Schedule Automatic Snapshots</b>	11* 0**	7	4* -7**
3	<b>Clone from Snapshot</b>	9	7	2
4	<b>Restore from Snapshot</b>	8	6	2
5	<b>Create Replication Target</b>	7	16	-9
6	<b>Configure Replication</b>	14* 0**	9	+5 -9

#	Tasks	Oracle ZFS Storage Clicks	NetApp FAS Storage Clicks	Variance (Oracle ZFS storage Clicks – NetApp Clicks)
7	Set Snapshot Retention Policy	7* 0**	7	0 -7
8	Clone from Replica	8	7	+1
9	Sync Replica with Source - Manual	6	7	-1
10	Sync Replica with Source - Continuous	9* 0**	8	+1 -8
11	Sever Replica from Source	8	7	1

\* Accounts for a using a manual configuration

\*\* Accounts for using the Project level configuration

**Table B2a: Data Protection Comparison Tasks**

#	Task	Frequency of Use	Why the Task is Important
1	Create Snapshot	Medium	Storage Administrators need to be able to simply and quickly take a snapshot of data allowing Server or Database Administrators to perform upgrades while being provided a reliable rollback plan.
2	Schedule Automatic Snapshots	Medium	The ability to take scheduled snapshots protects application data in the event that a failure occurs, by allowing for a timely restore.

#	Task	Frequency of Use	Why the Task is Important
3	<b>Clone from Snapshot</b>	Medium	<p>The ability to clone a snapshot of production data can be used for presentation of data to test / development servers in order to allow development to occur on production-like systems, while minimizing the impact to production.</p> <p>This can also be used to allow for configuration for the replica data to be used on reporting servers to offload reporting capabilities from application oriented servers.</p>
4	<b>Restore from Snapshot</b>	Medium	<p>The ability to restore from a snapshot is more critical than the ability to take a snapshot. In the event of a failure Storage Administrators must be able to quickly restore data from snapshots that have been taken.</p>
5	<b>Create Replication Target</b>	Medium	<p>This will facilitate the remote replication of data to allow for data to be replicated to a separate physical hardware appliance. This replica can span data centers as a critical component of a business's Disaster Recovery Plans.</p>
6	<b>Configure Replication</b>	Medium	<p>This starts the process of remote replication of data to a separate physical hardware appliance. This replica can span data centers as a critical component of a business's Disaster Recovery Plans.</p>
7	<b>Set Snapshot Retention Policy</b>	Medium	<p>Storage Administrators should be allowed the ability to control how long snapshots are retained. This can ensure that they are retained for a duration long enough to meet restore needs based on business requirements.</p>
8	<b>Clone from Replica</b>	Medium	<p>The ability to clone a replica allows the configuration for the replica data to be used on reporting servers, to offload reporting capabilities from application oriented servers.</p> <p>The remote replica of data can also be used during a business's Disaster Recovery testing processes.</p>

#	Task	Frequency of Use	Why the Task is Important
9	<b>Sync Replica with Source - Manual</b>	Medium	Manually syncing a replica of a LUN/FileSystem to another location can be initiated to facilitate Disaster Recovery at a specific point in time.
10	<b>Sync Replica with Source - Continuous</b>	Medium	Continuously syncing a replica of a LUN/FileSystem to another location can be configured to ensure that Disaster Recovery sites have the most current data when a disaster occurs.
11	<b>Sever Replica from Source</b>	Medium	Allow Storage Administrators and data owners the ability to test or implement Disaster Recovery processes with the most current data possible.

**Table B3: Storage Management Comparison Test Data**

#	Tasks	Oracle ZFS Storage Clicks	NetApp FAS Storage Clicks	Variance (Oracle ZFS Storage Clicks – NetApp Clicks)
1	<b>Un-configure Pool</b>	4	6	-2
2	<b>Destroy Project</b>	4	N/A	N/A
3	<b>Destroy LUN</b>	5	9	-4
4	<b>Reassign LUN to another Project</b>	3	N/A	N/A
5	<b>Reassign FileSystem to another Project</b>	3	N/A	N/A
6	<b>Destroy FileSystem</b>	4	6	-2
7	<b>Migrate data to new FileSystem</b>	6	N/A	N/A

#	Tasks	Oracle ZFS Storage Clicks	NetApp FAS Storage Clicks	Variance (Oracle ZFS Storage Clicks – NetApp Clicks)
8	Set Cache device usage policy	6	N/A	N/A
9	Monitor performance: CPU usage, throughput	2	2	0
10	Monitor capacity: Available storage per pool, aggregate, FileSystem, deduplication ratio, compression.	2	2	0
11	Enable / Disable protocols and services on FileSystem	2	4	-2
12	License Management	0	3	-3

Table B3a: Storage Management Tasks

#	Task	Frequency of Use	Why the Task is Important
1	Un-configure Pool	Low	As business applications are retired, pools of storage resources can be given back to an array and leveraged for other business needs.
2	Destroy Project	Low	As the business application is retired, some Projects may no longer be necessary. In a Pool that contains multiple Projects, remove the Project associated with a retired Oracle application, while leaving other Projects intact.

#	Task	Frequency of Use	Why the Task is Important
3	<b>Destroy LUN</b>	Medium	As server side requirements are changed or decommissioned the ability to return storage to a pool creates flexibility on the storage platform.
4	<b>Reassign LUN to another Project</b>	Medium	The ability to modify a LUNs attributes to match that of a separate Project can ease Administration.
5	<b>Reassign FileSystem to another Project</b>	Medium	The ability to modify a FileSystems attributes to match that of a separate Project can ease Administration.
6	<b>Destroy FileSystem</b>	Medium	As FileSystem requirements are changed or decommissioned the ability to return storage to a pool creates flexibility on the storage platform.
7	<b>Migrate data to new FileSystem</b>	Medium	As new disks are made available to storage platforms, or workload requirements change for a FileSystem, admins may need to move an existing FileSystem from the current set of disks that it runs on to a new Pool of disks. This process must be accomplished non-disruptively to end-users and business applications.
8	<b>Set Cache device usage policy</b>	Medium	Controlling the use of Cache devices allows administrators to set types of data that may be cached to ensure that the devices are best leveraged for application or business need.
9	<b>Monitor performance: CPU usage, throughput</b>	High	Allow administrators to easily understand current performance metrics of storage array CPU, Memory, and Network to ensure applications are not incurring performance issues because of underlying array subsystems. This should also allow the administrator to trend performance metrics changes over time to forecast future needs.

#	Task	Frequency of Use	Why the Task is Important
10	<b>Monitor capacity: Available storage per pool, aggregate, FileSystem, deduplication ratio, compression.</b>	High	Storage Administrators should easily and quickly be able to determine the storage savings that are delivered by compression and deduplication as well as understand the free capacity of a pool. This can ensure that the Storage Administrator avoids capacity issues as well as showing storage efficiencies.
11	<b>Enable / Disable different protocols and services on FileSystem</b>	Medium	The ability to enable or disable the protocols that are served by a FileSystem can make a Storage Administrators job functions simpler, while providing more capabilities from a FileSystem.
12	<b>License Management</b>	Low	License management can be a cumbersome and time consuming task for Storage Administrators. Without proper licenses attached to an array Storage Administrators would be missing key functionality that may be required to ensure they can meet business expectations.

**Table B4: General Management Comparison Test Data**

#	Tasks	Oracle ZFS Storage Clicks	NetApp FAS Storage Clicks	Variance (Oracle ZFS Storage Clicks – NetApp Clicks)
1	<b>Determining the health of the array</b>	2	4	-2
2	<b>Customization of views within the UI</b>	8	10	-2
3	<b>Managing the physical system from the UI</b>	2	N/A	N/A

**Table B4a: General Management Tasks**

#	Task	Frequency of Use	Why the Task is Important
1	<b>Determining the health of the array</b>	High	Administrators need to be able to quickly determine the state of an array's health. If a problem arises an administrator needs the capability of determining the exact nature of an issue (Storage Processor, CPU, Memory, Network Connectivity or Disk Failure). Alerting should also be configurable, allowing different types of notification methods (SMTP, SNMP, and SMS).
2	<b>Customization of views within the UI</b>	Medium	Allow an administrator to create standardized dashboards that meet specific application or array needs.
3	<b>Managing the physical system from the UI</b>	High	Assess the physical status of all aspects of the array by leveraging the GUI. Should be capable of drilling down to individual disks in order to ensure an array is functioning properly.

**Table B5: Analytics Comparison Test Data**

#	Tasks	Oracle ZFS Storage Clicks	NetApp FAS Storage Clicks	Variance (Oracle ZFS Storage Clicks – NetApp Clicks)
1	<b>Analyze, isolate and resolve workload problems in a Virtual environment with 50 VMs</b>	7	11	-4



**Table B5a: General Management Tasks**

#	Task	Frequency of Use	Why the Task is Important
1	<b>Analyze, isolate and resolve workload problems in a Virtual environment with 50 VMs</b>	Medium	Virtual Machine performance is directly related to the performance of the underlying storage array. A Storage Administrator must be able to quickly identify storage causing contention on a VM in order to help IT ensure business related SLA's are being met.

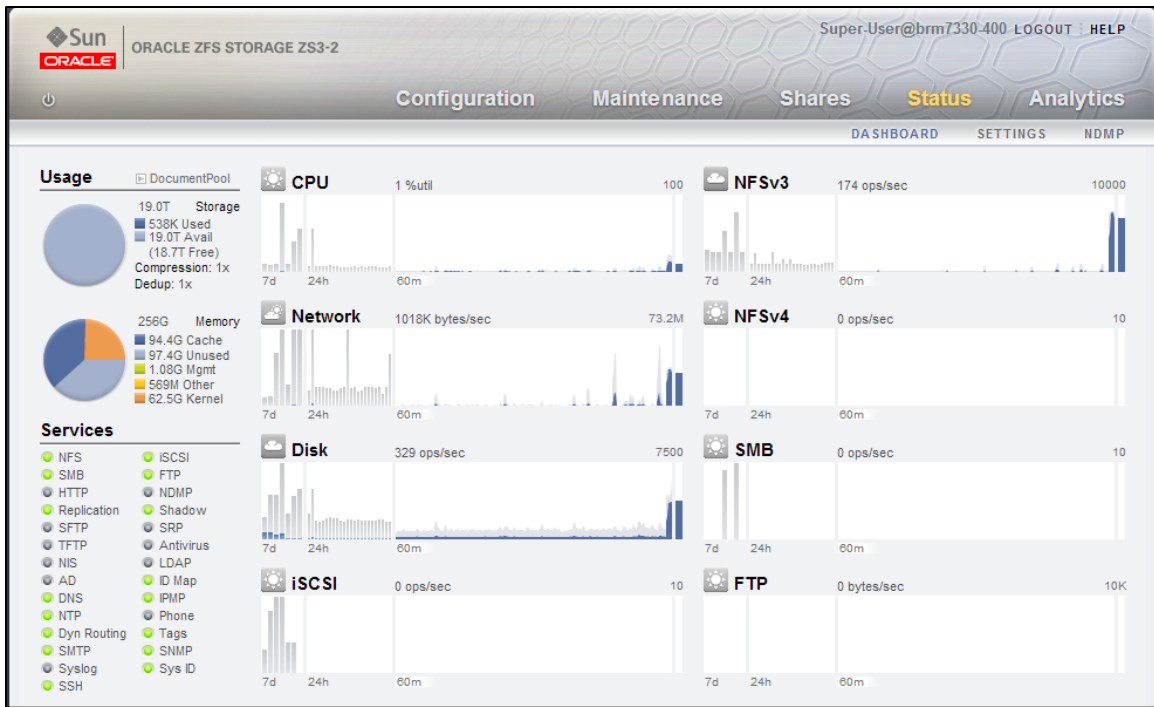
## Appendix C: Analytics on VM troubleshooting

**Overview:** The following screenshots outline the high-level processes that are used by the native Oracle ZFS Storage DTrace analytics tool vs. the NetApp On-Command Balance add-on utility.

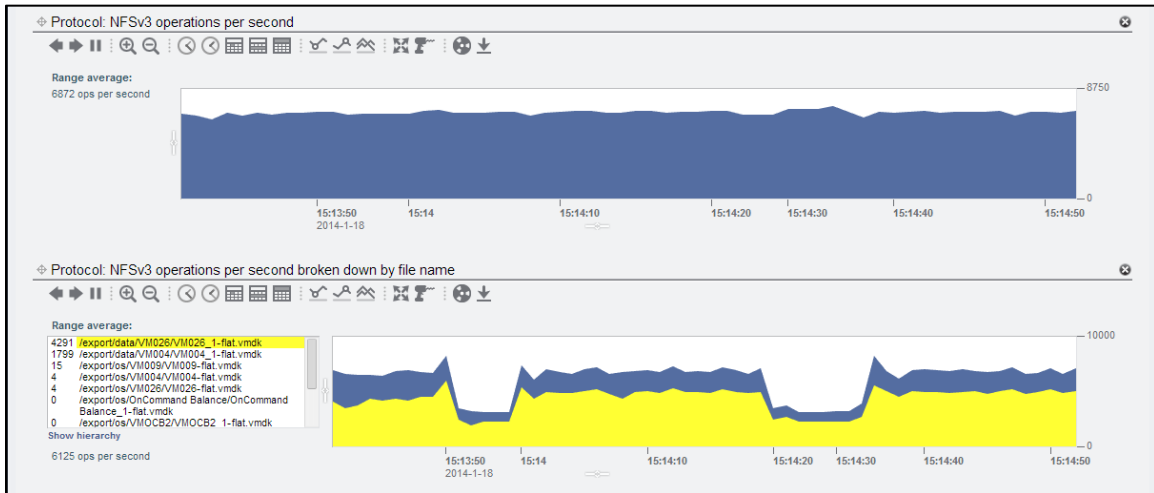
The Oracle ZFS platform allows Storage Administrators to troubleshoot performance of VM's in real-time versus NetApp OnCommand Balance's which show's VM performance metrics being delayed up to 45 minutes. Oracle ZFS allows an administrator in real time to see critical performance metrics such as network performance, cache hits and miss, network cache, block size of individual VM files

### Oracle ZFS Storage D-Trace Analytics:

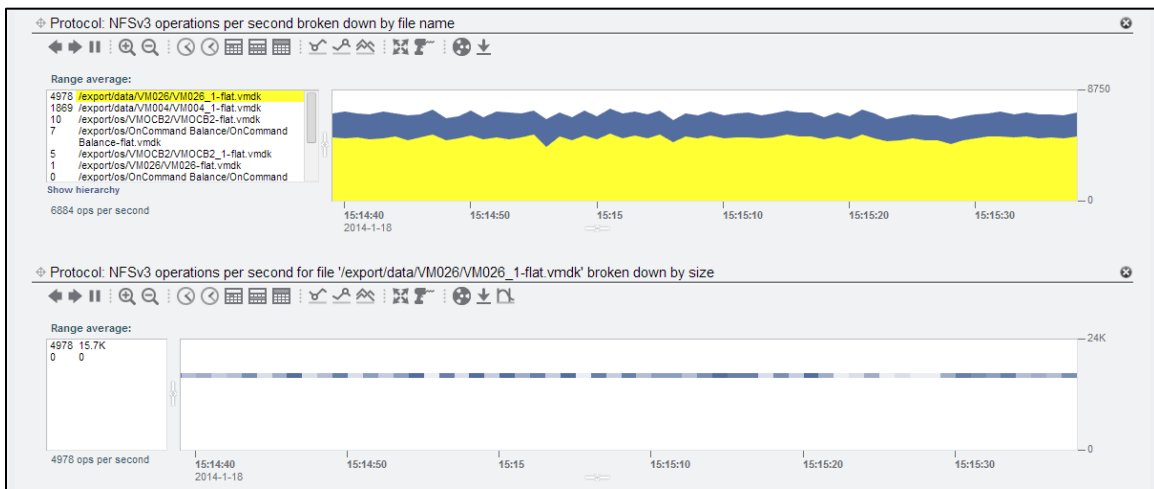
1) Log on to Oracle ZFS Storage and click "Status" section. Under NFSv3, click the right-hand side of the performance chart.



2) Click the “Drill Down” icon and select “By File Name”. Each VM’s filename on the NFS volume is now shown by highest NFS operations per second.



3) Click the “Drill Down” icon and select other relevant performance metrics needed for troubleshooting. This example shows the VM’s I/O size.



## NetApp OnCommand Balance:

### 1) Log on to NetApp On-Command Balance

The screenshot shows the NetApp OnCommand Balance dashboard. The top navigation bar includes Dashboard, Servers, Compute Clusters, Applications, Storage, Reports, Discovery, and Admin. The main content area is divided into several sections:

- Storage arrays:** A green checkmark indicates "No abnormal storage events on 1 storage array in the last 72 hours." A link "Add/monitor a new storage array..." is provided.
- VMs:** A green checkmark indicates "No performance issues on 25 VMs in the last 72 hours." A link "Add/monitor a new VM..." is provided.
- Virtual hosts:** A green checkmark indicates "No performance issues on 1 virtual host in the last 72 hours." A link "Add/monitor a new virtual host..." is provided.
- Monitor physical servers:** A link "Add/monitor your first physical server..." is provided.
- Monitored environment summary:** A table showing:
 

22 Windows, 1 Linux
21/25 guests monitored
<b>Monitor guests for more insight: ?</b>
4 guests. (Stand Alone)
1 Virtual host
0 grouped into 0 clusters, 1 unclustered
1 Array
1 NetApp
Total cap.: 4TB (12 disks)
- Additional Balance setup items:** A list of tasks:
  - Configure your vCenter Server - Using a single credential, you can choose which clusters/ESX hosts to monitor and import all of your VMs in a single step.
  - Configure physical servers - These will require individual setup. You will need IPs/FQDNs & credentials
  - Configure other resources - Fibre channel switches and SAN virtualization controllers can also be monitored.
  - Configure database applications - Balance provides special monitoring and reporting for databases so be sure to visit the applications page to set these up.
  - Add email recipients - receive emails on storage threshold reports, performance and predictor alerts.

### 2) Review VM's with the Highest Performance Index (PI)

The screenshot shows the NetApp OnCommand Balance Servers page, specifically the VMs section. The page displays a table of 25 VMs, sorted by their Performance Index (PI) for the host. The table columns are:

- Name
- DNS Name
- VM PI (with a dropdown arrow) | PI for host
- Current State
- Guest OS Collection
- Overall
- CPU
- Memory
- Storage

The table shows the following data for the first 10 VMs:

Name	DNS Name	VM PI	PI for host	Current State	Guest OS Collection	Overall	CPU	Memory	Storage
VM101	VM101	12	25	10.80.116.200	On	OK	■	■	■
VM001	WIN-6MVB24MAQKC	3	25	10.80.116.200	On	OK	■	■	n/a
VM002	VM002	2	25	10.80.116.200	On	OK	■	■	n/a
VMOCB03		2	25	10.80.116.200	On	Unmonitored	n/a	n/a	n/a
VM102	VM102	1	25	10.80.116.200	On	OK	■	■	■
VM103	VM103	1	25	10.80.116.200	On	OK	■	■	■
VM104	VM104	1	25	10.80.116.200	On	OK	■	■	■
VM106	VM106	1	25	10.80.116.200	On	OK	■	■	■
VM107	VM107	1	25	10.80.116.200	On	OK	■	■	■
VM108	VM108	1	25	10.80.116.200	On	OK	■	■	■
VM109	VM109	1	25	10.80.116.200	On	OK	■	■	■
VM110	VM110	1	25	10.80.116.200	On	OK	■	■	■

### 3) Review Disk Usage of VM with Highest Performance Index (PI)

