vSAN Operations Guide

Recommendations for vSAN in VMware Cloud Foundation 9.0

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vmware by Broadcom

Table of Contents

Introduction

VMware vSAN provides enterprise-class storage that is robust, flexible, powerful, and easy to use. While vSAN-powered clusters share many similarities to vSphere clusters in a three-tiered architecture, the unique abilities and architecture of vSAN means that some operational practices and recommendations may be different than that of traditional environments.

This document provides practical guidance in the day-to-day operations of vSAN-powered clusters. It augments the step-by-step instructions found in Broadcom TechDocs, knowledge articles, and other detailed guidance found in vSAN blogs and other vSAN content on the VMware Resource Center. **This operations guide is not intended to be "how-to" documentation**. It offers general guidance and recommendations applicable to a large majority of environments. Requirements unique to a specific environment may dictate slightly different operational practices, thus the reason for no single "best practice." New topics may be added periodically. Please check to ensure the latest copy is used.

The guidance provided in this document reflects recommendations in accordance with the latest version of vSAN at the time of this writing. Some of the guidance will apply exclusively to the Original Storage Architecture (OSA) of vSAN, exclusively to the Express Storage Architecture (ESA) first introduced in vSAN 8. Efforts have been made to clarify which architecture(s) the guidance applies to, New features in vSAN will often impact operational recommendations. When guidance differs based on recent changes introduced to vSAN, it will be noted. The guidance will not retain an ongoing history of practices for previous versions of vSAN.

Scope of Topics

The information provided in this document will assume the use of vSAN 9.0, and/or VMware Cloud Foundation (VCF) 9.0. VCF deployments may have additional requirements and support limitations that fall outside of the scope of this document.

Section 1: Cluster

Pre-Flight Checks Prior to Introducing Clusters into Production

Introducing a new vSAN cluster into production is a simple process. Features such as Cluster Quickstart and vSAN health checks help provide guidance to ensure proper configuration, while VM migrations to a production cluster can be transparent to the consumers of those VMs. Supplement the introduction of a new vSAN cluster into production with additional steps to ensure that, once the system is powering production workloads, you get the expected outcomes.

Preparation

Preparation helps reduce potential issues when VMs rely on the services provided by the cluster. It also helps establish a troubleshooting baseline. The following may be helpful in a cluster deployment workflow:

- **Have the steps in the "vSAN Performance Evaluation Checklist" in the Proof of Concept (PoC) guide been followed?** While this document focuses on adhering to recommended practices during the evaluation of the performance of vSAN during a PoC, it provides valuable guidance for any cluster entering into production.
- **Is your cluster using the OSA, or ESA?** The operational guidance may be quite different depending on the circumstances. For example, the Performance Recommendations for vSAN ESA may be very different than the OSA. For more information on the vSAN ESA, see our vSAN ESA dedicated landing page.
- **Will VMs in this vSAN cluster require different storage policies than are used in other clusters?** See "Using Storage Policies in Environments with More Than One vSAN Cluster" for more information. This is especially important for clusters using the OSA.
- **What is the intention of this cluster? And what data services reflect those intentions?** Are its VMs primarily focused on performance? Do VMs need to be encrypted on this cluster? Generally, cluster-wide data services are best enabled or disabled at the time the cluster is provisioned. This pertains primarily toward the OSA.
- **Has host count in cluster size been sufficiently considered?** Perhaps you planned on introducing a new 24-node cluster to the environment. You may want to evaluate whether a single cluster or multiple clusters are the correct fit, especially as they relate to network design, and operational objectives. While this can be changed later, evaluating

at initial deployment is most efficient. See “vSAN Cluster Design—Large Clusters Versus Small Clusters” on core.vmware.com.

Recommendation: Always run a synthetic test (HCIBench) as described in the vSAN Performance Evaluation Checklist prior to introducing the system into production. This can verify that the cluster behaves as expected and can be used for future comparisons should an issue arise, such as network card firmware hampering performance. See step 1 in the “Troubleshooting vSAN Performance” document for more information.

Maintenance Work for L2/L3 Switching in Production

Redundant configuration

VMware vSAN recommends configuring redundant switches and either NIC teaming or failover so that the loss of one switch or path does not permanently cause a switch outage.

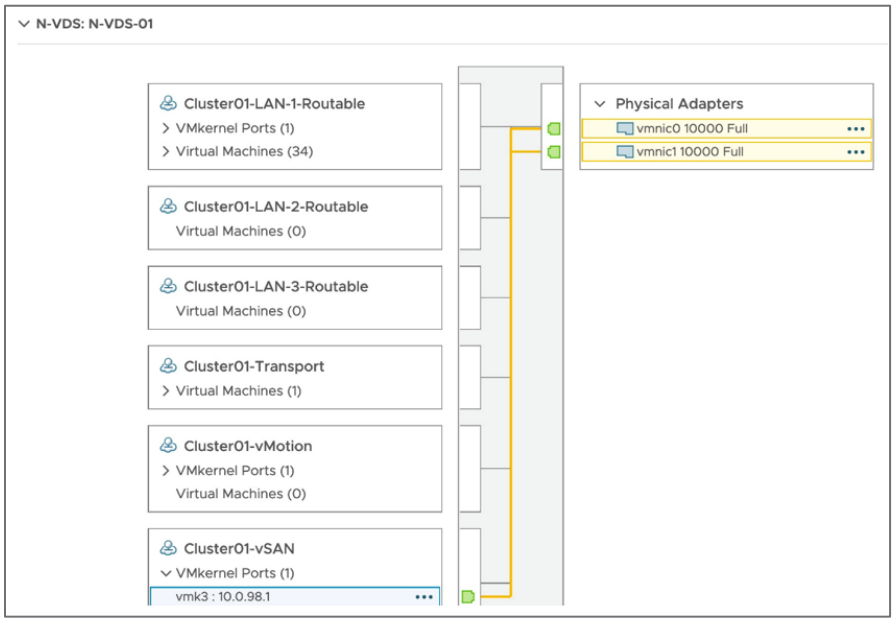


Figure. Virtual Switch and port group configuration

Health Findings

Prior to performing maintenance, review the vSAN networking health findings (renamed from "health checks" in vSphere 8 U1 and later). Health findings tied to connectivity, latency, or cluster partitions can help identify situations where one of the two paths is not configured correctly, or is experiencing a health issue.

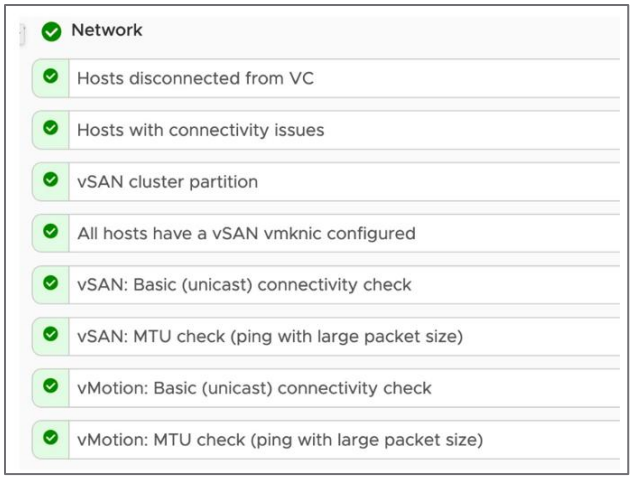


Figure. Network-related health checks in the vSAN health UI in vCenter

Understanding the nature of the maintenance can also help you understand what health alarms to expect. Basic switch patching can sometimes be performed non-disruptively. Switch upgrades that can be performed as an in-service software upgrade (ISSU) may not be noticeable, while physically replacing a switch may lead to a number of connectivity alarms. Discuss the options with your networking vendor.

Testing failure impacts

It is a good idea to simulate a path failure on a single host (disable a single port) before taking a full switch offline. If VMs on that host become unresponsive, or if HA is triggered, this may imply an issue with pathing that should be resolved prior to switch removal or reboot.

Controlled maintenance

If fault domains are used with multiple racks of hosts using different switches, consider limiting maintenance to a single fault domain and verify its health before continuing on. For stretched clusters, limit maintenance to one side at a time to reduce potential impacts.

Summary

In a vSAN environment, configuration of virtual switches, and the respective uplinks used follows practices commonly recommended in traditional three-tier architectures. With the added responsibility of serving as the storage fabric, ensuring that the proper configuration is in place will help the abilities of vSAN to perform as expected.

Configuring Fault Domains

Each host in a vSAN cluster is an implicit fault domain by default. vSAN distributes data across fault domains (hosts) to provide resilience against drive and host failure. This is sufficient to provide the right combination of resilience and flexibility for data placement in a cluster in the majority of environments. There are use cases that call for fault domain definitions spanning across multiple hosts. Examples include protection against server rack failure, such as rack power supplies and top-of-rack networking switches.

vSAN includes an optional ability to configure explicit fault domains that include multiple hosts. vSAN distributes data across these fault domains to provide resilience against larger domain failure—an entire server rack, for example.

Preparation

vSAN requires a minimum of three fault domains. At least one additional fault domain is recommended to ease data resynchronization in the event of unplanned downtime, or planned downtime such as host maintenance and upgrades. The diagram below shows a vSAN cluster with 24 hosts. These hosts are evenly distributed across six server racks.

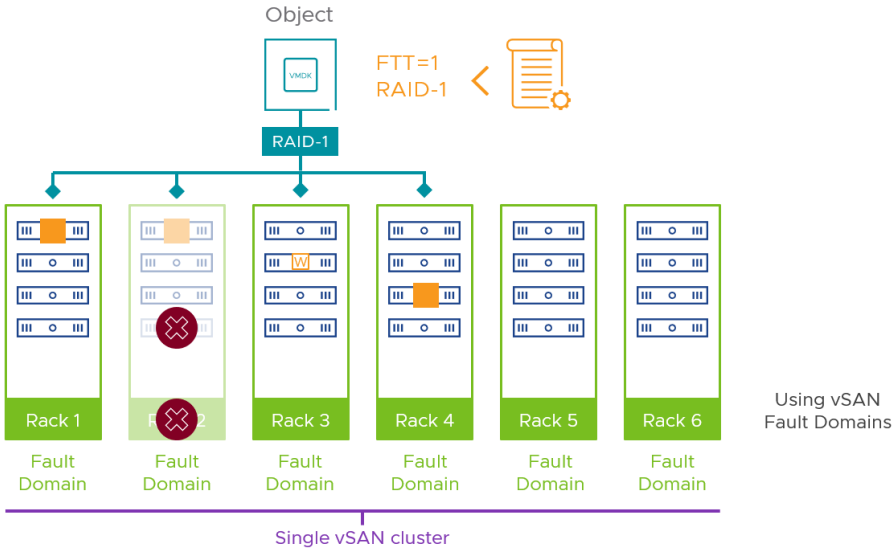


Figure. A conceptual illustration of a vSAN cluster using 24 hosts and 6 explicit fault domains

With the example above, you would configure six fault domains—one for each rack—to help maintain access to data in the event of an entire server rack failure. This process takes only a few minutes using the vSphere Client. The "Design and Operation Considerations When Using vSAN Fault Domains" post offers practical guidance for some of the most commonly asked questions when designing for vSAN fault domains. The post "Using Fault Domains in vSAN ESA" describes how the feature is different when using the ESA.

Recommendation: Prior to deploying a vSAN cluster using explicit fault domains, ensure that rack-level redundancy is a requirement of the organization. Fault domains can increase the considerations in design and management, thus determining the actual requirement up front can result in a design that reflects the actual needs of the organization.

vSAN is also capable of delivering multi-level replication or "nested fault domains." This is already fully supported with vSAN stretched cluster architectures. Nested fault domains provide an additional level of resilience at the expense of higher-capacity consumption. Redundant data is distributed across fault domains and within fault domains to provide this increased resilience to drive, host, and fault domain outages. Note that some features are not available when using vSAN's explicit fault domains. For example, the new reserved capacity functionality in the UI of vSAN 7 U1 is not supported in a topology that uses fault domains such as a stretched cluster, or a standard vSAN cluster using explicit fault domains.

Migrate to a Different vSAN Cluster Type

In some cases, an administrator may want to migrate VMs from one vSAN cluster to another. In most cases, performing a simple vMotion and storage vMotion will achieve the desired result. Some data services such as vSAN File Services and vSAN iSCSI target services may make this task more complex, but in most cases, the transition should be straightfoward.

Migrating from the OSA to ESA

As customers purchase new hardware that supports the ESA, questions arise in how best to migrate their environment to clusters running the ESA. For a detailed explanation on options available, see the post "Migrating to the Express Storage Architecture in vSAN 8"

Recommendation. Be cognisant the existing services used on the old cluster and the required services needed on the new cluster, and configure those services accordingly. This will help remove extra steps in the transition process, such as the data movement incured from turning on Data-at-Rest encryption after the transition has occurred.

Section 2: Network

Using NIOC for vSAN

vSphere Network I/O Control (NIOC) version 3 introduces a mechanism to reserve bandwidth for system traffic based on the capacity of the physical adapters on a host. It enables fine-grained resource control at the VM network adapter level, similar to the model used for allocating CPU and memory resources. NIOC is only supported on the VMware Distributed Switch (vDS) and is enabled per switch.

Planning

It is recommended to **not enable limits**. Limits artificially restrict vSAN traffic even when bandwidth is available. Reservations should also be avoided because reservations do not yield free bandwidth back for non-VMkernel port uses. On a 10Gbps interface uplink, a 9Gbps vSAN reservation would result in only 1Gbps of traffic available for VMs even when vSAN is not passing traffic. Limits also do not work well given that the ESA can utilize much more bandwidth if the guest VMs demand it, thus limits would not be very adaptable to these conditions. Reservations can also undermine desired outcomes, and are generally not recommended.

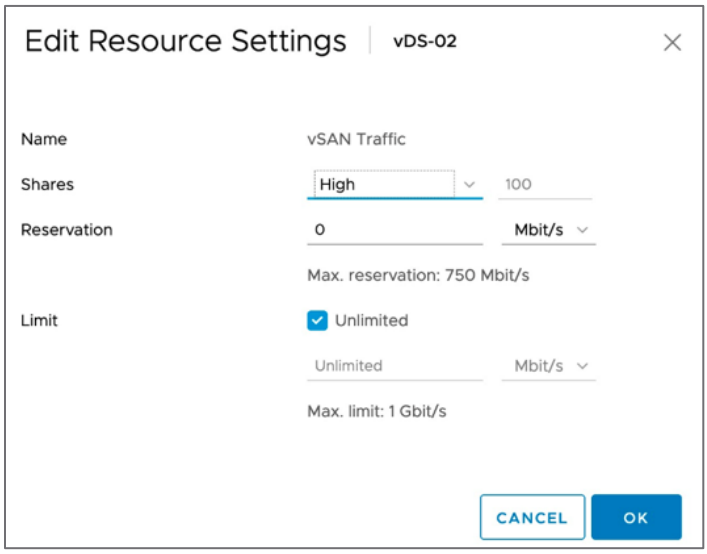
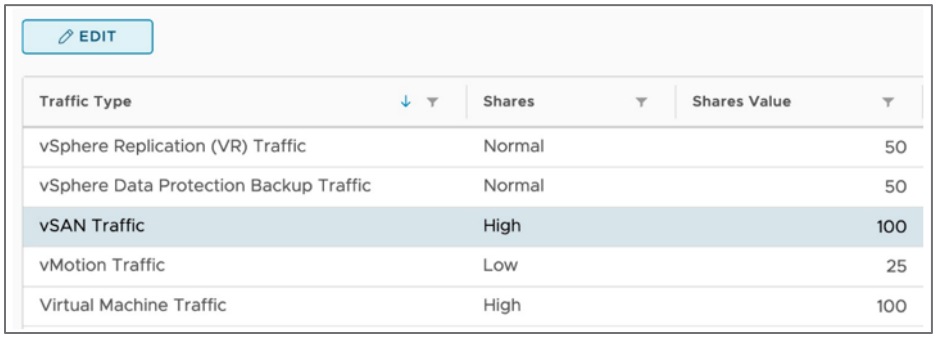


Figure. Setting shares in NIOC to balance network resources under contention

Under times of contention, such as a failed NIC in a vSAN host, **shares are the recommended way to prioritize traffic for VMware vSAN**. Raise the vSAN shares to "High."



Traffic Type	Shares	Shares Value
vSphere Replication (VR) Traffic	Normal	50
vSphere Data Protection Backup Traffic	Normal	50
vSAN Traffic	High	100
vMotion Traffic	Low	25
Virtual Machine Traffic	High	100

Figure. An example of a configuration of shares for a vSAN-powered cluster (OSA)

Other network quality of service (QoS) options

It is worth noting that NIOC only provides shaping services on the host's physical interfaces. It does not provide prioritization in switch-to-switch links and does not have awareness of contention caused by over saturated leaf/spine uplinks, or data center–to–data center links for stretched clustering. Tagging a dedicated vSAN VLAN with class of service or DSCP can provide end-to-end prioritization. Discuss these options with your networking teams, and switch vendors for optimal configuration guidance.

Using Large MTU Sizes with vSAN

Jumbo frames are Ethernet frames larger than 1,500 bytes of payload. The most common jumbo configuration is a payload size of 9,000, although modern switches can often go up to 9,216 bytes.

Planning

Consult with your switch vendor and identify if jumbo frames are supported and what maximum transmission units (MTUs) are available. If multiple switch vendors are involved in the configuration, be aware they measure payload overhead in different ways in their configuration. Also identify if a larger MTU is needed to handle encapsulation such as VxLAN. Identify all configuration points that must be changed to support jumbo frames end to end. If Witness Traffic Separation is in use, be aware that an MTU of 1,500 may be required for the connection to the witness.

Implementation

Start the changes with the physical switch and distributed switch. To avoid dropped packets, make the change last to the VMkernel port adapters used for vSAN.

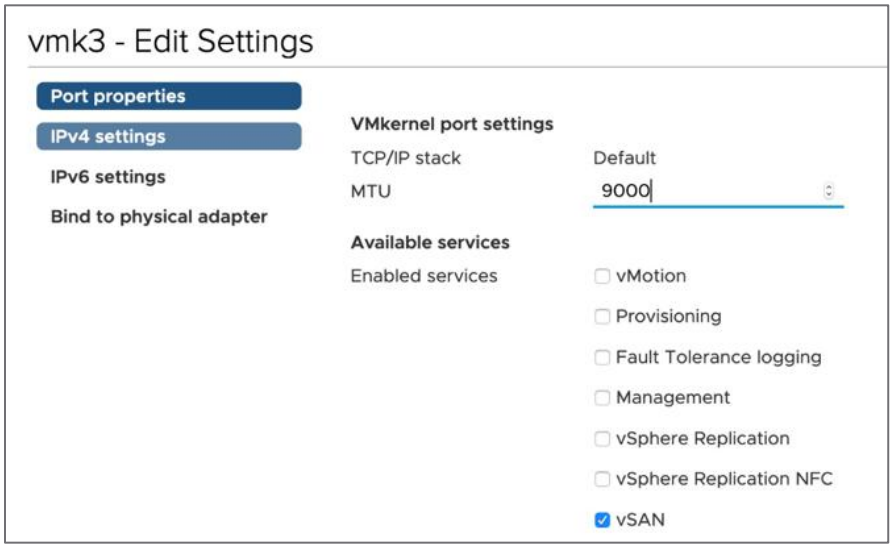


Figure. Changing the MTU size of virtual distributed switch (VDS)

Validation

The final step is to verify connectivity. To assist with this, vSAN: MTU check (ping with large packet size) will perform a ping test with large packet sizes from each host to all other hosts to verify connectivity end to end.

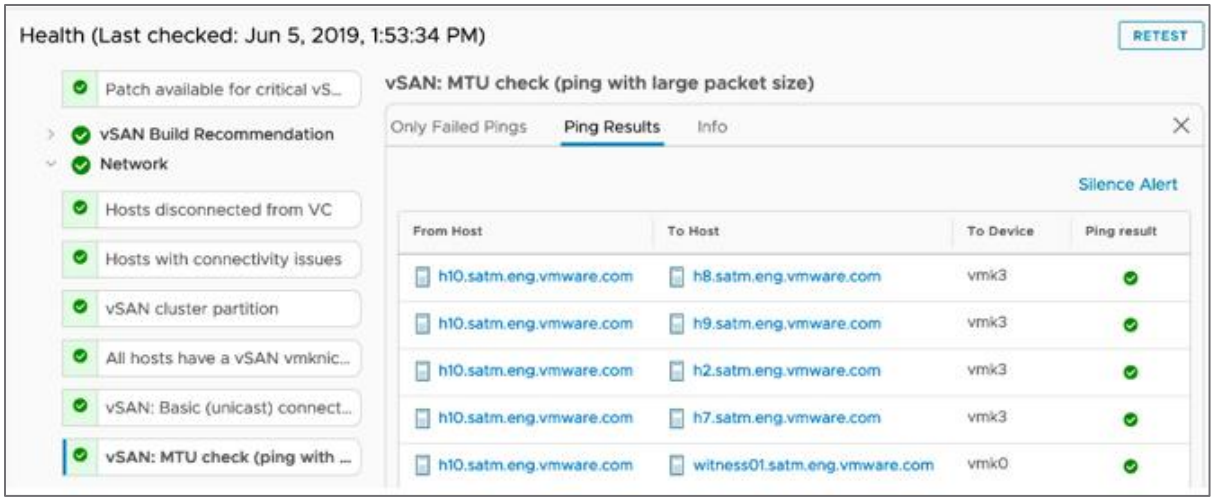


Figure. Verifying connectivity using the vSAN MTU check health check.

Create and Manage Broadcast Domains for Multiple vSAN Clusters

It is recommended, when possible, to **dedicate unique broadcast domains** (or collections of routed broadcast domains for Layer 3 designs) for vSAN. Benefits to unique broadcast domains include:

- Fault isolation. Spanning tree, configuration mistakes, entering duplicate IP address, and other failures can cause a broadcast domain to fail, or failures to propagate across a broadcast domain.
- Security. While vSAN hosts have automatic firewall rules created to reduce attack surface, data over the vSAN network is not encrypted unless by higher-level solutions (VM encryption, for example). To reduce the attack surface, restrict the broadcast domain to only contain VMkernel ports dedicated to the vSAN cluster. Dedicating isolated broadcast domains per cluster helps ensure security barriers between clusters.

Planning

There are several ways to isolate broadcast domains. The most basic is physically dedicated and isolated interfaces and switching. The most commonly chosen is to tag VLANs onto the port groups used by the vSAN VMkernel ports. Prior to this, configure the switches between the hosts to carry this VLAN for these ports. Other encapsulation methods for carrying VLANs between routed segments (ECMP fabrics, VxLAN) are supported. NSX-V may not be used for vSAN or storage VMkernel port encapsulation. NSX-T may be used with VLAN backed port groups. (subject to versions. NSX-T 2.2 offers notable improvements in support of vSAN environments.)

Implementation

The first step is to configure the VLAN on the port group. This can also be set up when the VDS and port groups are created using the Cluster Quickstart.

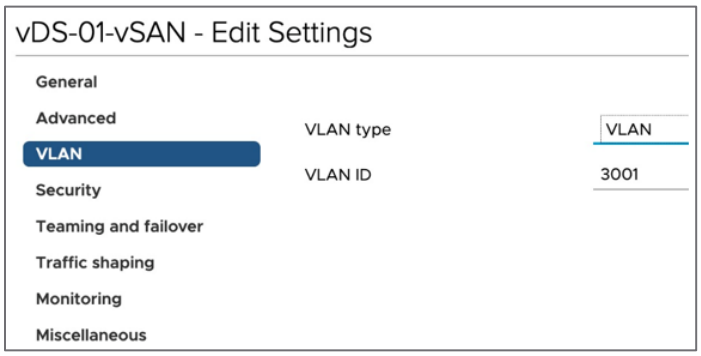


Figure: Configuring a port group to use a new VLAN

Validation

A number of built-in health checks can help identify if a configuration problem exists, preventing the hosts from connecting. To ensure proper functionality, all vSAN hosts must be able to communicate. If they cannot, a vSAN cluster splits into multiple partitions (i.e., subgroups of hosts that can communicate but not to other subgroups). When that happens, vSAN objects might become unavailable until the network misconfiguration is resolved. To help troubleshoot host isolation, the vSAN network health checks can detect these partitions and ping failures between hosts.

Recommendation: VLAN design and management does require some levels of discipline and structure. Discuss with your network team the importance of having discrete VLANs for your vSAN clusters up front, so that it lays the groundwork for future requests.

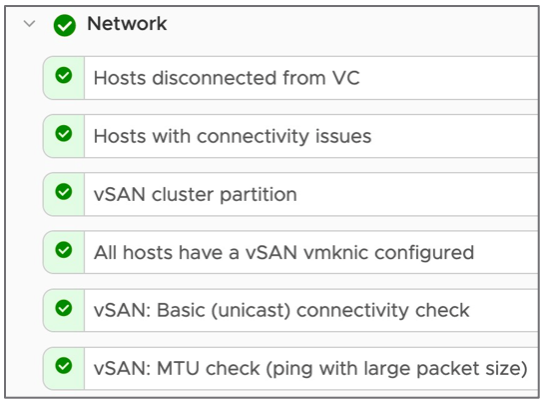


Figure. Validating that changes pass network health findings

Change IP Addresses of Hosts in a vSAN Cluster

vSAN requires networking between all hosts in the cluster for VMs to access storage and maintain the availability of storage. Operationally migrating IP addresses of storage networks need extensive care to prevent loss of connectivity to storage or loss of quorum to objects.

Planning

Identify if you do this as an online process or as a disruptive offline process (powering off all VMs). If disruptive, make sure to power off all VMs following the cluster shutdown guidance.

Implementation

If new VMkernel ports are used prior to removing old ones, a number of techniques can be used to validate networking and test hosts before removing the original VMkernel ports.

- Use vmkping to source pings between the new VMkernel ports.
- Put hosts into maintenance mode, or evacuate VMs before removing the original vSAN VMkernel port.
- Check the vSAN object health alarms to confirm that the cluster is at full health once the original VMkernel port has
- been removed.
- Once the host has left maintenance mode, vSphere vMotion® a test VM to the host and confirm that no health alarms are alerting before continuing to the next host.

Note that in vSAN 7 U3 and newer, there is a Skyline health check for vSAN that will detect duplicate IP addresses.

Validation

Before restoring the host to service, confirm that networking and object health is returning normal health.

Migrate vSAN Traffic to Another VMkernel Port

There are cases where the vSAN network needs to be migrated from to a different segment. For example, the implementation of a new network infrastructure or the migration of vSAN standard cluster (non-routed network) to a vSAN stretched cluster (routed network). Recommendations and guidance on this procedure is given below.

Prerequisites

Check Skyline Health for vSAN to verify there are no issues. This is recommended before performing any planned maintenance operations on a vSAN cluster. Any issues discovered should be resolved before proceeding with the planned maintenance.

Set up the new network configuration on your vSAN hosts. This procedure will vary based on your environment. Consult "vSphere Networking" in the vSphere section of VMware Docs https://docs.vmware.com for the version of vSphere you are running.

Ensure that the new vSAN network subnet does not overlap with the existing one. vSphere will not allow the vSAN service to run simultaneously on two VMkernel ports on the same subnet. Attempting to do this using esxcli will produce an error like the one shown below.

```
esxcli vsan network ip add -i vmk2

Failed to add vmk2 to CMMDS: Unable to complete Sysinfo operation. Please see the VMkernel log file for more details.

Vob Stack: [vob.vsan.net.update.failed.badparam]: Failed to ADD vmknic vmk2 with vSAN because a parameter is incorrect.
```

Note that you might see warnings in Skyline Health as you add new VMkernel adapters with the vSAN service--specifically, the "vSAN: Basic (unicast) connectivity check" and "vSAN: MTU check (ping with large packet size)" health checks, as shown below. This is expected if the vSAN service on one host is not able to communicate with other hosts in the vSAN cluster. These warnings should be resolved after the new VMkernel adapters for vSAN have been added and configured correctly on all hosts in the cluster. Use the "Retest" button in vSAN Skyline Health to refresh the health checks status.

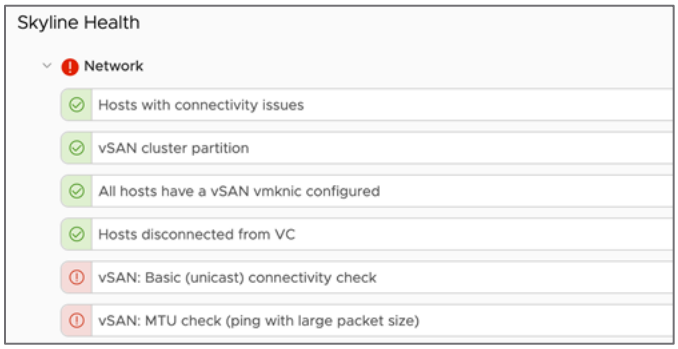


Figure. vSAN Skyline Health warnings

Use vmkping to verify the VMkernel adapter for the new vSAN network can ping the same VMkernel adapters on other hosts. This KB article provides guidance on using vmkping to test connectivity: https://knowledge.broadcom.com/external/article?legacyId=1003728

1. Shut down all running virtual machines that are using the vSAN datastore. This will minimize traffic between vSAN nodes and ensure all changes are committed to the virtual disks before the migration occurs.
2. After configuring the new vSAN network on every host in the vSAN cluster, verify the vSAN service is running on both VMkernel adapters. This can be seen in the UI by checking the Port Properties for both VMkernel adapters in the UI or by running esxcli vsan network list. You should see an output similar to the text below.

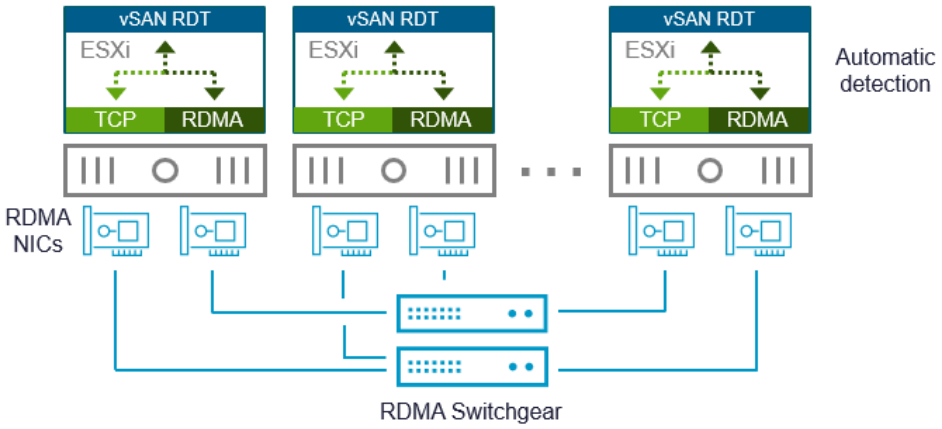
```
[root@host01:~] esxcli vsan network list Interface

VmkNic Name: vmk1

...

Traffic Type: vsan

Interface

VmkNic Name: vmk2

...

Traffic Type: vsan
```

1. Click the "Retest" button in vSAN Skyline Health to verify there are no warnings while the vSAN service is enabled on both VMkernel adapters on every host. If there are warnings, it is most likely because one of more hosts do not have the vSAN service enabled on both VMkernel adapters. Troubleshoot the issue and use the "Retest" option in vSAN Skyline Health until all issues are resolved.
2. Disable the vSAN service on the old VMkernel adapters.
3. Click the "Retest" button in vSAN Skyline Health to verify there are no warnings.
4. Power on the virtual machines.

Recommendation: While it is possible to perform this migration when VMs on the vSAN datastore are powered on, it is NOT recommended and should only be considered in scenarios where shutting down the workloads running on vSAN is not possible.

Introducing RDMA into a vSAN Environment

Running vSAN over RDMA introduces all new levels of capabilities in efficiency and performance. The support of RoCE v2 introduced in vSAN 7 U2 means that customers can explore this extremely fast method of network connectivity of vSAN hosts on a per cluster basis. **For clusters running the vSAN ESA, RDMA may provide even more beneficial**, as often times the bottleneck in an ESA environment is the network, and not the storage stack in a server.



TCP over Ethernet
Flexible and ubiquitous

RDMA over Converged Ethernet
Fast, consistent, and efficient

Figure. vSAN over RDMA

Recommendation: Ensure that a host added to a vSAN cluster running RDMA is in fact, fully compatible with RDMA. Adding a single host that is not compatible with RDMA will make the cluster fail back to using TCP over ethernet.

Introducing RDMA into an environment requires the use of certified hardware (RDMA NIC adapters and switches). See the BCG for vSAN RDMA Network Adapters for more information. vSAN clusters using RDMA may be subject to additional limitations of supported features or functionality, including, but not limited to:

- vSAN cluster sizes are limited to 32 hosts
- vSAN cluster must not be running the vSAN iSCSI services
- vSAN cluster must not be running in a stretched cluster configuration
- vSAN cluster must be using RDMA over Layer 2. RDMA over Layer 3 is not supported.
- vSAN cluster running vSAN over RDMA is not supported with disaggregated environments including vSAN storage clusters, or vSAN HCI with datastore sharing.
- vSAN cluster must not be using a teaming policy based on IP Hash or any active/active connection where sessions are balanced across two or more uplinks.

Section 3: Storage Devices

Both vSAN OSA and vSAN ESA have the ability to easily add and remove storage devices that contribute to the vSAN cluster. The management of these devices varies slightly between architectures, as noted below.

Adding and Removing Storage Devices in vSAN OSA

In order to add or "claim" storage devices in vSAN OSA, a "disk group" must be created. This disk group represents a unit of storage resources that is comprised of at least one cache device, and one to seven capacity devices. Typically, vSAN OSA hosts will have one to three disk groups, where the higher number of disk groups generally represents better potential performance.

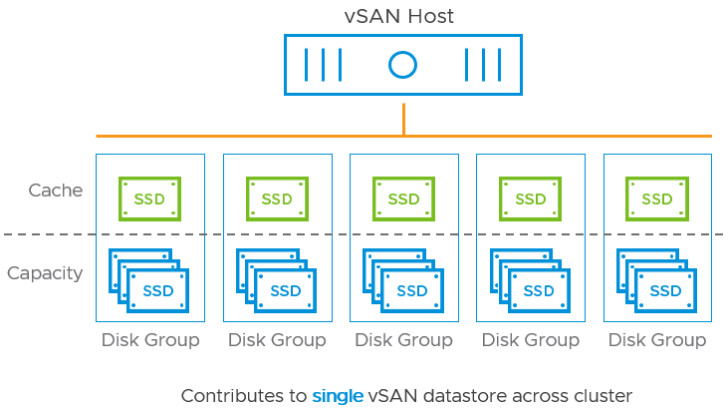


Figure. Disk groups in vSAN OSA.

The process of adding and removing disk groups and storage devices can be found by highlighting **Configure > vSAN > Disk Management**. Note that their will be restrictions and health checks in place to help safegaurd operations that may impact availability of data. For example, one cannot simply remove a cache device without removing the entire disk group, since it is the disk group that requires the cache device to be in place at all times.

Note that any abrupt device removal would cause an all-paths-down (APD) or permanent-device-loss (PDL) situation. In such cases, vSAN would trigger error-handling mechanisms to remediate the failure.

Adding and Removing Storage Devices in vSAN ESA

The claiming of devices in vSAN ESA is much more flexible, and easier. ESA removes the construct of a disk group. Instead, each host shows claimed devices in a "storage pool." There is only one storage pool per host, and it simply reflects the collection of storage devices claimed for use by vSAN. Claiming can be performed manually, automatically through "managed disk claim" or prescriptively through "prescriptive disk claim" capability introduced in vSAN 8 U2. For more information, see the post: "vSAN Prescriptive Disk Claim for the ESA in vSAN 8 U2."

With each storage device in vSAN ESA being its own boundary of failure and management, accomodation for these two conditions is much more efficient than in vSAN OSA. For more information, see the post: "The Impact of a Storage Device Failure in vSAN ESA versus OSA"

Recommendation: When removing any storage device permanently, use the "full data migration option." This ensures that objects remain compliant with the respective storage policies. Use LED indicators to identify the appropriate devices that needs to be removed from the server.

Secure Erase of Data on a Decommissioned vSAN Storage Device

Just as with many storage systems, discrete storage devices decommissioned from a storage system typically need an additional step to meet the National Insitute of Standards and Technology (NIST) to ensure that all data previously stored on a device can no longer be accessed. This involves a step often referred to as "secure erase" or "secure wipe." The goal of a secure wipe is to prevent data spillage, which could occur if a system or device was repurposed to a less sensitive

environment. It also plays a critical role in a declassification procedure, which may involve the formal demotion of the hardware to a less secure environment. The method discussed here achieves a properly and securely erased device for both of those purposes.

vSAN 7 U1 introduces a new approach to this secure wipe process. It can be achieved through API or PowerCLI, with the latter being a much more convenient option for administrators. It should be the final step in the decommissioning process if the requirements dictate this level of security. To ensure the protection of data occurring as a result of an inadvertent command, the wipe option will only be supported if the "Evacuate" all data" was chosen at the time of removing the disk from the disk group.

Recommendation: Be patient. The secure wipe procedure may take some time. Claiming the device in vSAN must wait for the secure wipe process to complete.

PowerCLI command Syntax

The PowerCLI commands for wiping a disk will include:

`Wipe-Disk – Given a list of disks, issues a wipe disk. Syntax: Wipe-Disk –Disk <Disk[]> -RunAsync`

`Query-Wipe-Status – Given a list of disks, returns a lists of wipe disk status. Syntax: Query-Wipe-Status <Disk[]>`

`Abort-Wipe-Disk – Given a list of disks, cancel the sanitization of them and return the status. Syntax: Abort-Wipe-Disk <Disk[]>`

The following image shows an example of these secure wipe commands.

```
1. login server

PS C:\windows\system32> Connect-VIServer '            ' -Username 'administrator@vsphere.local' -Pass

2. Get host

PS C:\windows\system32> $h = Get-VMHost

3. Query wipe status

PS C:\windows\system32> $s = Get-VsanWipeDiskStatus -VMHost $h[0] -CanonicalName ("mpx.vmhba0:C0:T3:L0
```

Figure. Example of the secure wipe commands

The disk wipe activity log will capture:

- Date/time wipe initiated
- Date/time wipe completed
- Status of job.
- Relevant information as to which host and cluster the activity occurred
- Status of success or failure

Support and Compatibility

There is a heavy reliance on system and device capabilities in order to support the above commands and capabilities. Therefore, some older generations of hardware/servers may not be capable of supporting the capability. Please check the VMware Compatibility Guide (VCG) for vSAN to determine which ReadyNodes support the feature. Secure wipe may only be applicable to some systems using NVMe, SATA, and SAS based devices. The support of a secure wipe is limited to flash devices only. This functionality does not apply to spinning disks.

Section 4: vSAN Datastore

Capacity Management Guidance

Managing capacity in a distributed system like vSAN is a little different than that of a three-tier architecture. vSAN uses a set of discrete devices across hosts and presents it as a single vSAN datastore. The vCenter Server UI also abstracts the complexities of where the data is placed and presents capacity utilization as a single datastore, which simplifies the capacity management experience of vSAN.

Overview

vSAN uses free space for the purposes of **transient activities** such as accommodating data placement changes and the rebalancing or repair of data. Free capacity is also used in the event of a **sustained host failure**, where the provided by the failed host must be reconstructed somewhere else in the cluster.

The "Reserved Capacity" in vSAN is a capacity management feature provided a dynamic calculation of the estimated free capacity required for transient operations, and host rebuild reserve capacity, and will adjust the UI to reflect these thresholds. It also allows vSAN to employ safeguards and health checks to help prevent the cluster from exceeding critical capacity conditions. The capacity reserve feature is disabled by default This is to accommodate topologies that the feature does not support at this time, such as stretched clusters and clusters using explicit fault domains. The post: "Understanding Reserve Capacity Concepts in vSAN" provides more details on this topic.

The amount of capacity that the UI allocates for the host rebuild reserve and operations reserve is a complex formula based on several variables and conditions. vSAN makes this calculation for you. However, if you would like to understand "what if" scenarios for new cluster configurations, use the VMware vSAN Sizer tool, which includes all of the calculations used by vSAN for sizing new environments, and estimating the required amount of free capacity necessary for the operations reserve, and host rebuild reserve.

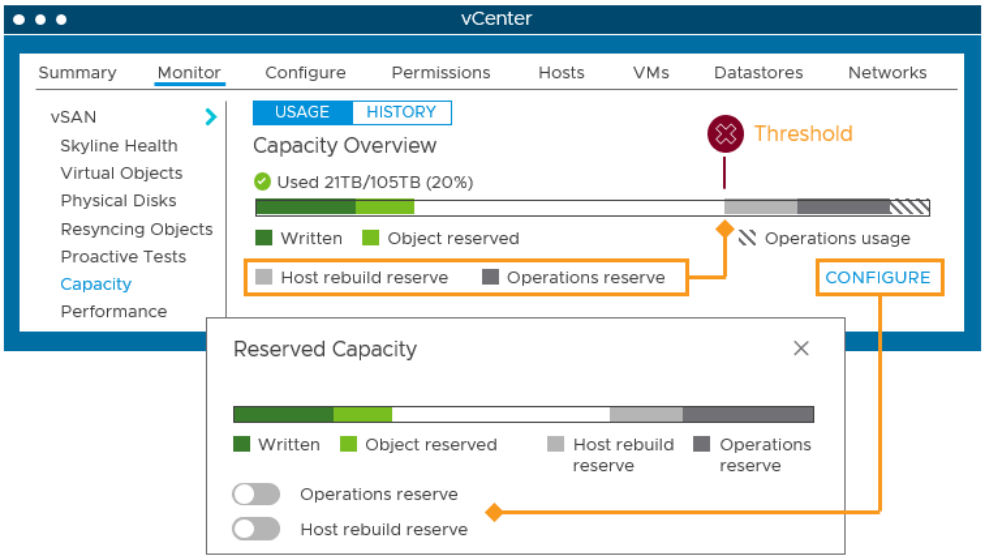


Figure. Accommodating for Reserved Capacity in vSAN.

The thresholds that the Reserved Capacity feature activate are designed to be restrictive but accommodating. **The thresholds will enforce some operational changes, but allow critical activities to continue.** For example, when the reserve capacity limits are met, health alerts will trigger to indicate the status, and provisioning of new VMs, virtual disks, clones, snapshots, etc will not be allowed when the threshold is exceeded. I/O activity for existing VMs will continue without issue.

If an environment is using cluster-based deduplication and compression, or the compression-only service, vSAN will calculate the free capacity requirements off of the effective savings ratios in that cluster.

Capacity consumption is usually associated with bytes of data stored versus bytes of data remaining available. There are other capacity limits that may inhibit the full utilization of available storage capacity. vSAN has a soft limit of no more than 200 VMs per host, and a hard limit of object components of no more than 9,000 components per host. Certain topology and workload combinations, such as servers with high levels of compute and storage capacity that run low capacity VMs may run into these other capacity limits. Sizing of these capacity considerations should be a part of a design and sizing exercise. For more information on capacity reporting, see the post: "Demystifying Capacity Reporting in vSAN."

The monitoring of capacity generally remains the same between vSAN OSA and vSAN ESA. The latter does provide a few improvements, as capacity overheads in vSAN ESA are calculated differently than in vSAN OSA. For more information, see the post: "Improved Capacity Reporting in VMware Cloud Foundation 5.1 and vSAN 8 U2."

Automatic Rebalancing in a vSAN Cluster

vSAN provides an ability to automatically rebalance data across a vSAN cluster to optimize the use of resources across the cluster. For more extensive information on this capability, see the post: "Should Automatic Rebalancing be Enabled in a vSAN Cluster?"

In most cases, it is recommended to enabled the cluster-based toggle. This will help distribute the data for an optimal level of resource utilization across the cluster.

Managing Orphaned Objects in a Datastore

vSAN is an object-based datastore. The objects typically represent entities such as virtual machines, performance history database, iSCSI objects, Persistent volumes, and vSphere Replication Data. An object may inadvertently lose its association with a valid entity and become orphaned. Objects in this state are termed as orphaned or unassociated objects. While orphaned objects do not critically impact the environment, they contribute to unaccounted capacity and skew reporting.

Common causes for orphaned objects include but not limited to:

- Objects that were created manually instead of using vCenter or an ESXi host
- Improper deletion of a virtual machine such as deleting files through a command-line interface(CLI)
- Using vSAN datastore to store non-standard entities such as ISO images
- Manage files directly through vSAN datastore browser
- Residual objects caused by incorrect snapshot consolidation or removal by 3rd party utilities

Identification and Validation

Unassociated objects can be ascertained through command-line utilities such as Ruby vSphere Console(RVC) and Go-based vSphere CLI(GOVC). RVC is embedded as part of the vCenter Server Appliance(vCSA). GOVC is a single static binary that is available in GitHub and can be installed across different OS platforms.

Here are the steps to identify the specific objects,

RVC

Command Syntax: vsan.obj_status_report -t <pathToCluster>

Sample Command and Output:

```
>vsan.obj_status_report /localhost/vSAN-DC/computers/vSAN-Cluster/ -t

2020-03-19 06:05:29 +0000: Querying all VMs on vSAN .

Histogram of component health for possibly orphaned objects

+-------------------------------------+------------------------------+

|Num Healthy Comps / Total Num Comps | Num objects with such status |

+-------------------------------------+------------------------------+
```

```
+-------------------------------------+------------------------------+

Total orphans: 0
```

GOVC

```
Command Syntax: govc datastore.vsan.dom.ls -ds <datastorename> -l -o

Sample Command: govc datastore.vsan.dom.ls -ds vsanDatastore -l -o

<Command does not return an output if no unassociated objects are found>
```

Additional Reference to this task can be found at KB 70726

Recommendation: Contact VMware Technical Support to help validate and delete unassociated objects. Incorrect detection and deletion of unassociated objects may lead to loss of data.

Section 5: Storage Policies

The use of storage policies in vSAN provides substantial flexibility in perscribing defined outcomes to our data based on the requirements in your environment. While SPBM exists for both vSAN OSA and ESA, the unique capabilities of ESA (such as performance of RAID-1 using space efficient RAID-5/6, auto-policy management, etc.) make using SPBM in large environments much easier.

Approaches in Using SPBM

Overview

The flexibility of SPBM allows administrators to easily manage their data center in an outcome-oriented manner. The administrator determines the various storage requirements for the VM, and assigns them as rules inside a policy. vSAN takes care of the rest, ensuring compliance of the policy.

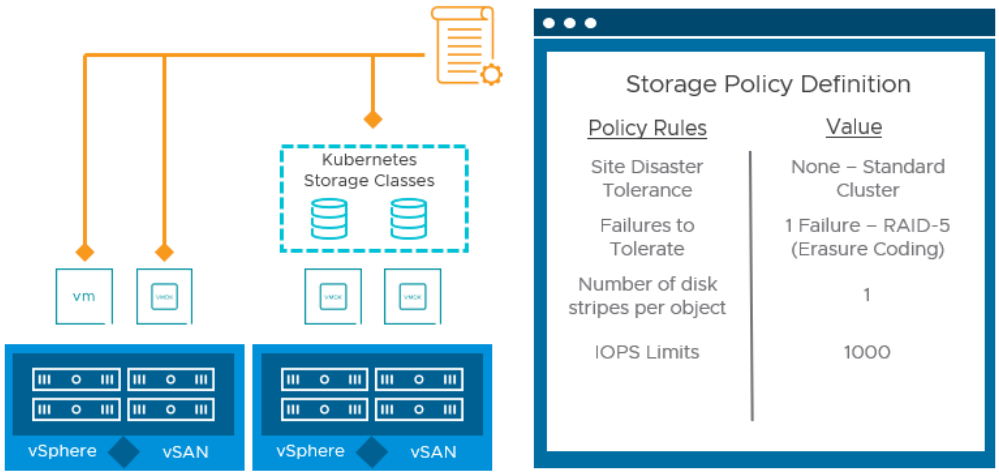


Figure. Multiple rules apply to a single policy, and a single policy applies to a group of VMs, a single VM, or a single VMDK

This form of management is quite different than commonly found with traditional storage. This level of flexibility introduces the ability to prescriptively address changing needs for applications. These new capabilities should be part of how IT meets the needs of the applications and the owners that request them.

When using SPBM for vSAN, the following guidance will help operationalize this new management technique in the best way possible.

- **Don't hesitate to be prescriptive with storage policies if needed (primarily OSA).** If an SQL server—or perhaps just the virtual machine disk (VMDK) of the SQL server—serving transaction logs needs higher protection, create and assign a storage policy for this need. The storage policy model exists for this very reason. **There is no need to use this approach with the ESA.** The the post "RAID-5/6 with the Performance of RAID-1 using the vSAN ESA" for more information.
- **Refrain from unnecessary complexity.** Take an "as needed" approach for storage policy rules. Storage policy rules such as limits for input/output operations per second (IOPS) allow you to apply limits to a wide variety of systems quickly and easily, but may restrict performance unnecessarily.
- **Be mindful of the physical capabilities of your hosts and network in determining what policy settings should be used as a default starting point for VMs in a cluster.** The capabilities of the hosts and network play a significant part in vSAN's performance. In an on-premises environment where hardware specifications may be modest, a more performance-focused RAID-1-based policy might make sense.
- **Be mindful of the physical capabilities of your cluster (primarily OSA).** Storage policies allow you to define various levels of resilience and space efficiency for VMs. Some higher levels of resilience and space efficiency may require

more hosts than are in the cluster. Review the cluster capabilities before assigning a storage policy that may not be achievable due to a limited number of hosts.

- **Monitor system behavior before and after storage policy changes.** With the vSAN performance service, you can easily monitor VM performance before and after a storage policy change to see if it meets the requirements of the application owners. This is how to quantify how much of a performance impact may occur on a VM. See the section "Monitoring vSAN Performance" for more information.

Recommendation: Do not change the vSAN policy known as the "default storage policy." It represents the default policy for all vSAN clusters managed by that vCenter server. If the default policy specifies a higher layer of protection, smaller clusters may not be able to comply.

Storage policies can always be adjusted without interruption to the VM. Some storage policy changes will initiate resynchronization to adjust the data to adhere to the new policy settings.

Storage policies are not additive. You cannot apply multiple policies to one object. Remember that a single storage policy is a collection of storage policy rules applied to a group of VMs, a single VM, or even a single VMDK.

Recommendation: Use some form of a naming convention for your storage policies. A single vCenter server houses storage policies for all clusters that it manages. As the usefulness of storage policies grows in an organization, naming conventions can help reduce potential confusion. See the topic "Managing a Large Number of Storage Policies."

Managing a Large Number of Storage Policies

Storage policies are a construct of a vCenter Server instance, not a cluster. A storage policy could be easily be used in one or more clusters. Depending on the need, an environment may require a few storage policies, or dozens. Before deciding what works best for your organization, let's review a few characteristics of storage policies with SPBM.

- A maximum of 1,024 SPBM policies can exist per vCenter server.
- A storage policy is stored and managed per server but can be applied to in one or more clusters.
- A storage policy can define one or many rules (around performance, availability, and space efficiency, for example).
- Storage policies are not additive. Apply only one policy (with one or more rules) per object.
- A storage policy can be applied to a group of VMs, a single VM, or even a single VMDK.
- A storage policy name can consist of up to 80 characters.
- A storage policy name is not the true identifier. Storage policies use a unique identifier for system management.

With a high level of flexibility, users are often faced with the decision of how best to name policies and apply them to their environments.

Storage policy naming considerations

Policy names are most effective when they include two descriptors: intention and scope.

- The **intention** is what the policy aims to achieve. Perhaps the intention is to apply high-performing mirroring using RAID-1, with an increased level of protection by using an FTT level of 2.
- The **scope** is where the policy will be applied. Maybe the scope is a server farm hosting the company ERP solution, or perhaps it is just the respective VMDKs holding databases in a specific cluster.

Note that in vSAN ESA, the "Auto-Policy Management" feature elliminates a lot of this complexity. It will simply create a cluster-specific storage policy that reflects the size of the cluster, the topology, and other capacity management settings. It is highly recommended to use the storage policy automatically created for vSAN ESA. For more information, see the post "Auto-Policy Management Capabilities with the ESA in vSAN 8 U1" and "Auto-Policy Management Remediation Enhancements for vSAN ESA in vSAN 8 U2."

Storage Policy Practices to Improve Resynchronization Management in vSAN

SPBM allows administrators to change the desired requirements of VMs at any time without interrupting the VM. This is extremely powerful and allows IT to accommodate change more quickly.

Some vSAN storage policy rules change how data is placed across a vSAN datastore. This change in data placement temporarily creates resynchronization traffic so that the data complies with the new or adjusted storage policy. Storage policy rules that influence data placement include:

- Site disaster tolerance (**any changes to the options below**)
  - None—Standard cluster
  - None—Standard cluster with nested fault domains
  - Dual site mirroring (stretched cluster)
  - None—Keep data on preferred (stretched cluster)
  - None—Keep data on non-preferred (stretched cluster)
  - None—Stretched cluster
- FTT (**any changes to the options below**)
  - No data redundancy
  - 1 failure—RAID-1 (mirroring)
  - 1 failure—RAID-5 (erasure coding)
  - 2 failures—RAID-1 (mirroring)
  - 2 failures—RAID-6 (erasure coding)
  - 3 failures—RAID-1 (mirroring)
  - Number of disk stripes per object

This means that if a VM's storage policy is changed, or a VM is assigned a new storage policy with one of the rules above different than the current policy rules used, it may generate resynchronization traffic so that the data can comply with the new policy definition. When a large number of objects have their storage policy adjusted, the selection order is arbitrary and cannot be controlled by the end user.

As noted above, the type of policy rule change will be the determining factor as to whether a resynchronization may occur. Below are some examples of storage policy changes and whether or not they impart a resynchronization effort on the system. Operationally there is nothing else to be aware of other than ensuring that you have sufficient capacity and fault domains to go to the desired storage policy settings.

Existing Storage Policy Rule	New Storage Policy Rule	Resynchronization?
RAID-1	RAID-1 with increased FTT	Yes
RAID-1	RAID-1 with decreased FTT	No
RAID-1	RAID-5/6	Yes
RAID-5/6	RAID-1	Yes
RAID-5	RAID-6	Yes
RAID-6	RAID-5	Yes
RAID-5 with stripe width=1	RIAD-5 with stripe width=2-4	No
RAID-5 with stripe width=4	RAID-5 with stripe width=5 or greater	Yes
RAID-6 with stripe width=1	RAID-6 with stripe width=2-6	No
RAID-6 with stripe width=6	RAID=6 with stripe width=7 or greater	Yes

Checksum enabled	Checksum disabled	No
Checksum disabled	Checksum enabled	Yes
Object space reservations (OSR) = 0	OSR > 0	Possible*
Object space reservations (OSR) >0	OSR=0	No

*OSR may not always initiate a resynchronization on increasing the value, but may depending on the fullness of the storage devices. An OSR is a preemptive reserve that may need to adjust object placement to accomodate for that new reserve assigned.

Other storage policy rule changes such as read cache reservations do not impart any resynchronization activities.

Recommendation: Use the VMs view in vCenter to view storage policy compliance. When a VM is assigned a new policy, or has its existing policy changed, vCenter will report it as "noncompliant" during the period it is resynchronizing. This is expected behavior.

Recommendations for policy changes for VMs

Since resynchronizations can be triggered by adjustments to existing storage policies, or by applying a new storage policy, the following are recommended.

- Avoid changing an existing policy, unless the administrator is very aware of what VMs it affects. Remember that a storage policy is a construct of a vCenter server, so that storage policy may be used by other VMs in other clusters. See the topic "Using Storage Policies in Environments with More Than One vSAN Cluster" for more information.
- If there are host failures, or any other condition that may have generated resynchronization traffic, refrain from changing storage policies at that time.

Visibility of resynchronization activity can be found in vCenter or Aria Operations. vCenter presents it in the form of resynchronization IOPS, throughput, and latency, and does so per disk group for each host. This can offer a precise level of detail but does not provide an overall view of resynchronization activity across the vSAN cluster.

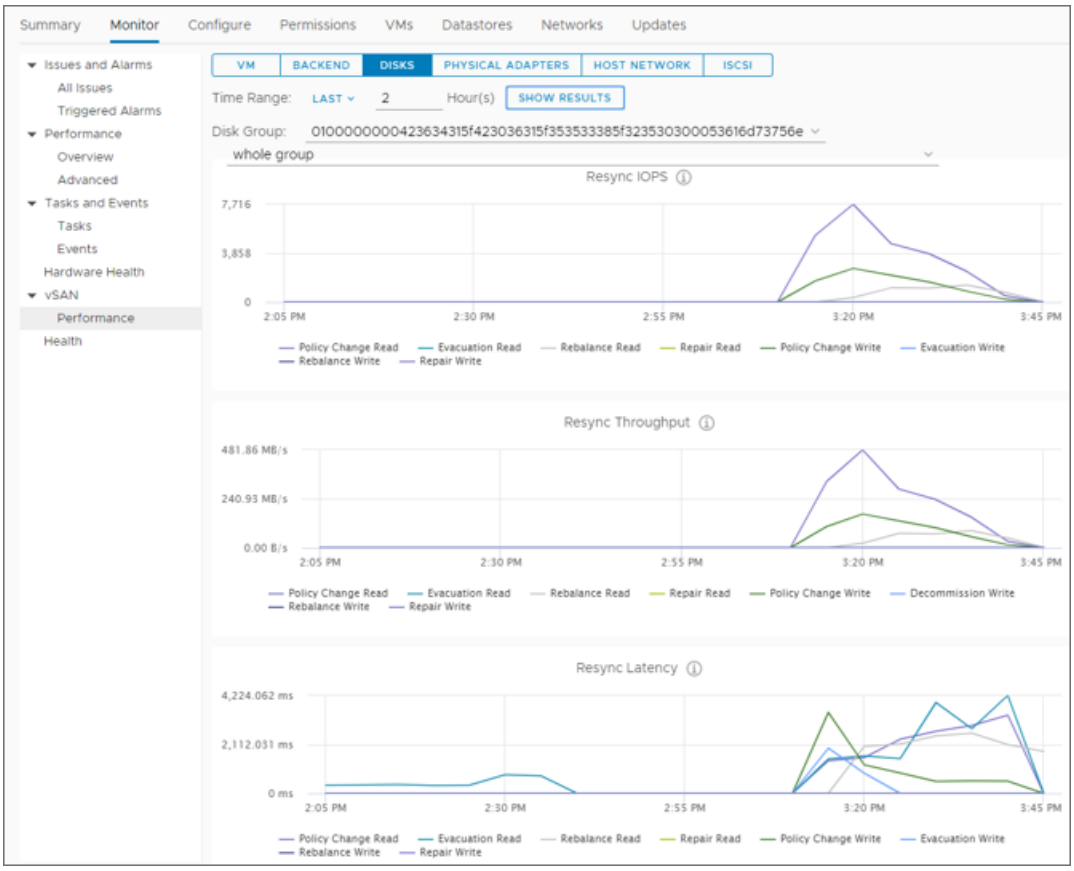


Figure. Resynchronization IOPS, throughput, and latency of a disk group in vCenter, courtesy of the vSAN performance service

VCF Operations can offer a unique, cluster-wide view of resynchronization activity by showing a burn down rate—or, rather, the amount of resynchronization activity (by data and by object count) that remains to be completed. This is an extremely powerful view to better understand the magnitude of resynchronization events occurring.

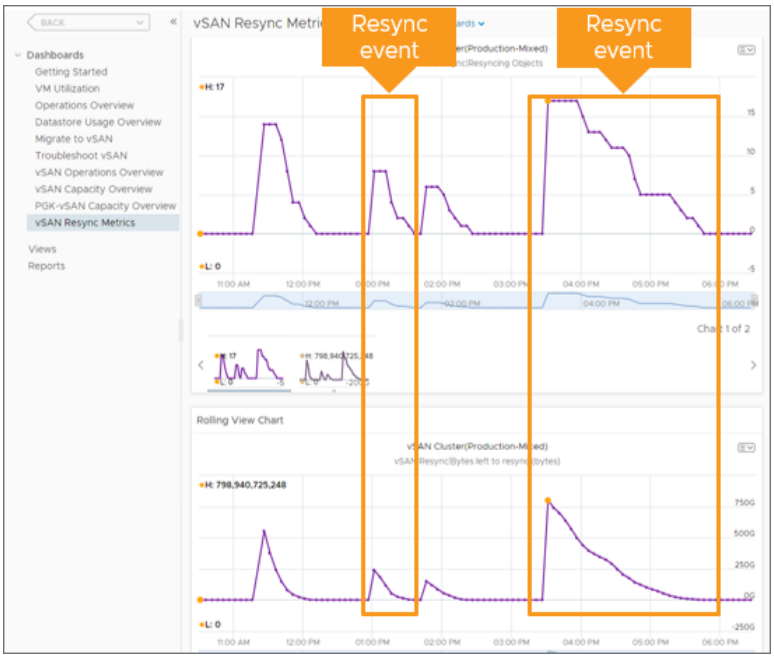


Figure. Resynchronization burn down rates across the entire vSAN cluster using a VCF Operations dashboard

Recommendation: Do not attempt to throttle resynchronizations using the manual slider bar provided in the vCenter UI found in older editions of vSAN. This is a feature that predates Adaptive Resync and should only be used under the advisement of GSS in selected corner cases. In vSAN 7 U1 and later, this manual slider bar has been removed, as Adaptive Resync offers a much greater level of granularity prioritization, and control of resynchronizations.

Using Workload Limiting Polies (IOPS Limits)

IOPS limits is one of the ways that administrators can reduce the potential impact of one VM consuming an abnormally large amount of resources. While it sound like an ideal solution for those situations, it does come with tradeoffs. To learn more about IOPS limits in vSAN, and when and when not to use them, see the post: "Performance Metrics when using IOPS Limits with vSAN – What you Need to Know."

Using Space-Efficient Policies with Clusters running DD&C in vSAN OSA

Overview

Two types of space efficiency techniques are offered for all-flash vSAN clusters running the OSA. Both types can be used together or individually and have their own unique traits. Understanding the differences between behavior and operations helps administrators determine what settings may be the most appropriate for an environment.

Note that **the following does NOT apply to the vSAN ESA**, as it's compression and erasure coding does not negatively impact performance.

DD&C and the "Compression-only" feature are opportunistic space efficiency features enabled as a service at the cluster level. The amount of savings is based on the type of data and the physical makeup of the cluster. vSAN automatically looks for opportunities to deduplicate and compress the data per disk group as it is destaged from the write buffer to the capacity tier of the disk group. DD&C and the "Compression-only" option could be best summarized by the following:

- Offers an easy "set it and forget it" option for additional space savings across the cluster
- Small bursts of I/O do not see an increase in latency in the guest VM
- No guaranteed level of space savings
- Comes at the cost of additional processing effort to destage the data

Recommendation: Since DD&C and the "Compression-only" feature is a cluster-based service, make the decision for its use per cluster. It may be suitable for some environments and not others.

RAID-5 and RAID-6 erasure codes are a data-placement technique that stripe the data with parity across a series of nodes. This offers a guaranteed level of space efficiency while maintaining resilience when compared to simplistic RAID-1 mirroring. Unlike DD&C, RAID-5/6 can be assigned to a group of VMs, a single VM, or even a single VMDK through a storage policy. RAID-5/6 could be best summarized by the following:

- Guaranteed level of space savings
- Prescriptive assignment of space efficiency where it is needed most
- I/O amplification for all writes, impacting latency
- May strain network more than RAID-1 mirroring
- Impacts when using the features together

The information below outlines considerations to be mindful of when determining the tradeoffs of using both space efficiency techniques together in a vSAN cluster using the OSA. The following is not applicable to the ESA.

- **Reduced levels of advertised deduplication ratios.** It is not uncommon to see vSAN's advertised DD&C ratio reduced when combining RAID-5/6 with DD&C, versus combining RAID-1 with DD&C. This is because data placed in a RAID-5/6 stripe is inherently more space efficient, translating to fewer potential duplicate blocks. Note that while one might find the advertised DD&C ratios reduced when using RAID-5/6 erasure coding, many times the effective overall space saved may increase even more. This is described in detail in the "Analyzing Capacity Utilization with Aria Operations" section of "VMware Aria Operations and Log Insight in vSAN Environments." This is one reason the DD&C ratio alone should not be looked used to understand space efficiency savings.
- **Hardware specification changes amount of impact.** Whether the space efficiency options are used together or in isolation, each method can place additional resources on the hardware. This is described in more detail below.
- **Workload changes amount of impact.** For any storage system, write operations are more resource intensive to process than read operations. The differences between not running any space efficiency techniques, to running both space efficiency techniques is highly dependent on how write intensive the workloads are. Sustained writes can be a performance challenge for any storage system. Space efficiency techniques add to this challenge and compound when used in combination. Infrastructure elements most affected by the features are noted below.
- **DD&C.** This process occurs during the destaging process from the buffer device to the capacity tier. vSAN consumes more CPU resources during the destaging process, slowing the destaging or drain rate. Slowing the rate for sustained write workloads effectively increases the buffer fill rate. When the buffer meets numerous fullness thresholds, it slows the rate of write acknowledgments sent back to the VM, increasing latency. Large buffers, multiple disk groups, and faster capacity devices in the disk groups can help reduce the level of impact.
- **RAID-5/6 erasure coding.** vSAN uses more CPU and network resources during the initial write from the guest VM to the buffer, as the I/O amplification increase significantly. The dependence on sufficient network performance increases when compared to RAID-1, as vSAN must wait for the completion of the writes to more nodes across the network prior to sending the write acknowledgment back to the guest. Physical network throughput and latency become critical. Fast storage devices for write buf fees (NVMe-based), multiple disk groups, and high-quality switchgear offering higher throughput (25Gb or higher) and lower latency networking can help alleviate this.

Recommendation: Observe the guest read/write I/O latency as seen by the VM after a VM or VMDK has had a change to a storage policy to/from RAID-5/6. This provides a good "before vs. after" to see if the physical hardware can meet some of the performance requirements. Be sure to observe latencies when there is actual I/O activity occurring. Latency measurements during periods of no I/O activity are not meaningful.

Moving your environment to vSAN ESA will elliminate the complexity of considerations when using space efficiency.

Using Number of Disk Stripes Per Object

The number of disk stripes per object storage policy rule aims to improve the performance of vSAN by distributing object data across more capacity devices. Sometimes referred to as "stripe width," it breaks the object components into smaller chunks on the capacity devices so I/O can occur at a higher level of parallelism. When it should be used, and to what degree it improves performance, depend on a number of factors.

Note that the number of disk stripes per object storage policy rule is **largely unnecessary when using the ESA**. For more information, see the post: "Stripe Width Storage Policy Rule in the vSAN ESA."

The stripe width policy rule can provide some performance improvement in vSAN OSA if the storage devices are the primary points of contention. As vSAN has evolved, so has the rule. For more information, see the post: "Stripe Width Improvements in vSAN 7 U1."

Recommendation: In vSAN OSA, keep all storage policies to a default number of disk stripes per object of 1. To experiment with stripe width settings, create a new policy and apply it to the discrete workload to evaluate the results, increasing the stripe width incrementally by 1 unit, then view the results. Note that changing the stripe width will rebuild the components, causing resynchronization traffic. If you are using vSAN ESA, disregard the rule completely, as it is no longer relevant.

Operational Impacts of Different Storage Policies

Using different types of storage policies across a vSAN cluster is a great example of a simplified but tailored management approach to meet VM requirements and is highly encouraged. Understanding the operational impacts of different types of storage policies against other VMs and the requirements of the cluster is important and described in more detail below.

What to look for (OSA only)

VMs using one policy may have a performance impact over VMs using another policy (OSA). For example, imagine a 6-node cluster using 10GbE networking and powering 400 VMs, 390 of them using a RAID-1 mirroring policy and 10 of them running a RAID-5 policy. This will only be a consideration in OSA clusters. ESA-based clusters will not have any negative impacts when using RAID-5/6 erasure coding.

At some point, an administrator decides to change 300 of those VMs to the more network-reliant RAID-5 policy. With 310 of the 400 VMs using the more network-intensive RAID-5 policy, this is more likely to impact the remaining 90 VMs running the less network-intensive RAID-1 policy, as it may run into higher contending conditions on that 10GbE connection. These symptom and remediation steps are described in detail in the "Troubleshooting vSAN Performance" document under "Adjust storage policy settings on non-targeted VM(s) to reduce I/O amplification across cluster" on core.vmware.com.

The attributes of a storage policy can change the requirements of a cluster. For example, in the same 6-node cluster described above, an evaluation of business requirements has determined that 399 of the 400 VMs can be protected with a level of FTT of 1, and the remaining VM needs an FTT of 3. The cluster host count can easily comply with the minimum host count requirements associated with policies using an FTT=1, but 6 hosts is not sufficient running a policy with an FTT=3. In this case, the cluster would have to be increased to 7 hosts to meet the absolute minimum requirement, or 8 hosts to meet the preferable minimum requirement for VMs using storage policies with an FTT=3. It only takes one object assignment.

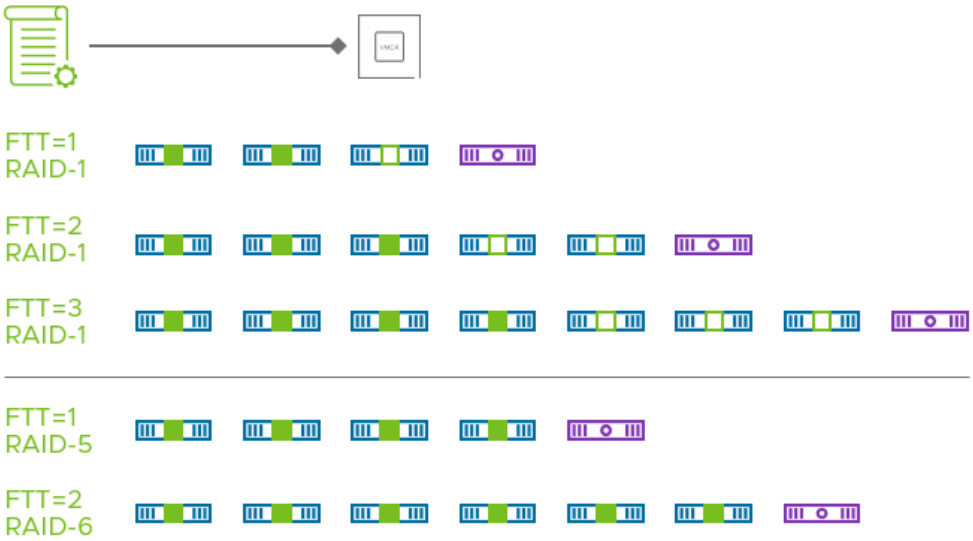


Figure. Minimum host requirements of storage policies (not including N+x sizing)

The above illustration **only applies to clusters running the OSA.** The vSAN ESA has different requirements for storage policies, and using a different, adaptive RAID-5 erasure coding technique.

Other less frequently used storage policy rules can also impact data placement options for vSAN. Stripe width is one of those storage policy rules. Using a policy with an assigned stripe width rule of greater than 1 can make object component placement decisions more challenging, especially if it was designed to be used in another vSAN cluster with different physical characteristics. See the topic "Using Number of Disk Stripes Per Object on vSAN-Powered Workloads" for more information.

The attributes of a storage policy can change the effective performance and capacity of the VMs running in the cluster. Changes in a data placement scheme (RAID-1, RAID-5, RAID-6) or Failures to Toleration (FTT=1, 2, or 3) can have a substantial impact on the effective performance and capacity utilization of the VM. For example, in a stretched cluster, changing that was simply protected across sites to one that introduces a secondary level of resilience at the host level can amplify the number of write operations substantially. See the post: "Performance with vSAN Stretched Clusters" (OSA) for more details. The post "Using the vSAN ESA in a Stretched Cluster Topology" addresses the benefits of using ESA in a stretched cluster topology.

Using Storage Policies with More Than One vSAN Cluster

vSAN storage policies are created and saved in vCenter, and a policy can be applied to any vSAN-powered VM or VMDK managed by that vCenter server. Since existing storage policies can be easily changed, the concern is that an administrator may be unaware of the potential impact of changing an existing policy used by VMs across multiple clusters.

Recommendation: If an administrator wants to change policy rules assigned to a VM or group of VMs, it is best to apply those VMs to a storage policy already created, or create a new policy if necessary. Changing the rules of an existing policy could have unintended consequences across one or more clusters. This might cause a large amount of resynchronizations as well as storage capacity concerns.

Improving operational practices with storage policies

In many cases, categorizing storage policies into one of three types is an effective way to manage VMs across larger environments (primarily for OSA-based clusters):

- **Storage policies intended for all vSAN clusters.** These might include simple, generic policies that could be used as an interim policy for the initial deployment of a VM.
- **Storage policies intended for a specific group of vSAN clusters.** Storage policies related to VDI clusters, for example, or perhaps numerous branch offices that have very similar needs. Other clusters may have distinctly different intentions and should use their own storage policies.
- **Storage policies intended for a single cluster.** These policies might be specially crafted for specific applications within a cluster—or tailored to the design and configuration of a specific cluster. This approach aligns well with the guidance found in the topic “Using Storage Policies in Environments with Both Stretched and Non-Stretched Clusters.” Since a stretched cluster is a cluster-based configuration, storage policies intended for standard vSAN clusters may not work with vSAN stretched clusters.

A blend of these offers the most flexibility while minimizing the number of storage policies created, simplifying ongoing operations.

The vSAN ESA no longer has negative performance impacts in many of it's storage policy rules. As a result, **using the ESA will result in a simpler strategy for storage policy management.** The ESA in vSAN 8 U1 introduces an "Auto-Policy Management" feature that creates and manages a cluster-specific storage policy that is tuned specifically for the traits of the cluster. For more information, see the post: "Auto-Policy Management Capabilities with the ESA in vSAN 8 U1."

Section 6: Host and EMM Operations

What EMM Option to Choose for Host Maintenance

All hosts in a vSAN cluster contribute to a single shared vSAN datastore for that specific cluster. If a host goes offline due to any planned or unplanned process, the overall storage capacity for the cluster is reduced. From the perspective of storage capacity, placing the host in maintenance mode is equivalent to its being offline. During the decommissioning period, the storage devices of the host in maintenance mode won't be part of the vSAN cluster capacity.

Maintenance mode is mainly used when performing upgrades, patching, hardware maintenance such as replacing a drive, adding or replacing memory, or updating firmware. For network maintenance that has a significant level of disruption in connectivity to the vSAN cluster and other parts of the infrastructure, a cluster shutdown procedure may be most appropriate. Rebooting a host is another reason to use maintenance mode. For even a simple host restart, it is recommended to place the host in maintenance mode.

Placing a given host in maintenance mode impacts the overall storage capacity of the vSAN cluster. Here are some pre-requisites that should be considered before placing a host in decommission mode:

- It is always better to decommission one host at a time.
- Maintain sufficient free space for operations such as VM snapshots, component rebuilds, and maintenance mode.
- Verify the vSAN health condition of each host.
- View information about the number of objects that are currently being synchronized in the cluster, the estimated time to finish the resynchronization, the time remaining for the storage objects to fully comply with the assigned storage policy, and so on.

A pre-check simulation is performed on the data that resides on the host so that vSAN can communicate to the user the type of impact the EMM will have, all without moving any data. If the pre-check results show that a host can be seamlessly placed in maintenance mode, decide on the type of data migration. Take into account the storage policies that have been applied within the cluster. Some migration options might result in a reduced level of availability for some objects. Let's look at the three potential options for data migration:

Full data migration—Evacuate all components to other hosts in the cluster.

This option maintains compliance with the FTT number but requires more time as all data is migrated from the host going into maintenance mode. It usually takes longer for a host to enter maintenance mode with Full data migration versus Ensure accessibility. Though this option assures the absolute availability of the objects within the cluster, it causes a heavy load of data transfer. This might cause additional latency if the environment is already busy. When it is recommended to use Full data migration:

- If maintenance is going to take longer than the rebuild timer value.
- If the host is going to be permanently decommissioned.
- If you want to maintain the FTT method during the maintenance.

Ensure accessibility (default option)—Instructs vSAN to migrate just enough data to ensure every object is accessible after the host goes into maintenance mode.

vSAN searches only for data with RAID-0 and move/regenerate them on a host different than the one entering in maintenance mode. All the other objects with RAID-1 and higher, should already have at least one copy residing on different host within the cluster. Once the host comes back to operational, the data components left on the host in maintenance mode update with changes that have been applied on the components from the hosts that have been available. Keep in mind the level of availability might be reduced for objects that have components on the host in maintenance mode.

This maintenance mode is intended to be used for software upgrades or node reboots. Ensure accessibility gives the opportunity to avoid needless Full data migration, since the host will be back to operational in a short time frame. It is the most versatile of all EMM options

No data migration—No data is migrated when this option is selected.

A host will typically enter maintenance mode quickly with this option, but there is a risk if any of the objects have a storage policy assigned with FTT=0. When it is recommended to use No data migration:

- This option should be applied while some network changes are to be applied. In that specific case, all the nodes from the cluster should be placed in maintenance mode, selecting the "No data migration" option.
- This option is best for short amounts of planned downtime where all objects are assigned a policy with FTT=1 or higher, or where downtime of objects with FTT=0 is acceptable.

Our recommendation is to always build a cluster with the minimum number of hosts n + 1. This configuration allows vSAN to self-heal in the event of a host failure or a host entering in maintenance mode.

There is no need to keep a host in maintenance mode in perpetuity to achieve an N+1 or hotspare objective. vSAN's distributed architecture already achieves this. To ensure a cluster is properly sized for N+1 or greater failures, use the vSAN Sizer, and follow the recommendations in the vSAN Design Guide.

Restarting a Host

For typical host restarts with ESXi, most administrators get a feel for roughly how long a host takes to restart, and simply wait for the host to reappear as "connected" in vCenter. This may be one of the many reasons why out-of-band host management isn't configured, available, or a part of operational practices. However, hosts in a vSAN cluster can take longer to reboot than non-vSAN hosts because they have additional actions to perform during the host reboot process. Many of these additional tasks simply ensure the safety and integrity of data. Incorporating out-of-band console visibility into your operational practices can play an important role for administering a vSAN environment.

Note that **restarting hosts in clusters configured for the vSAN ESA will not take as long as hosts residing in a vSAN OSA cluster**. While host restarts are much faster, it is still recommended to have a out of band management interface to monitor the boot status of a host.

Looking at the Direct Console User Interface (DCUI) during a host restart reveals a few vSAN-related activities. The most prominent message, and perhaps the one that may take the most time in vSAN OSA is "vSAN: Initializing SSD… Please wait…" similar to the image below.

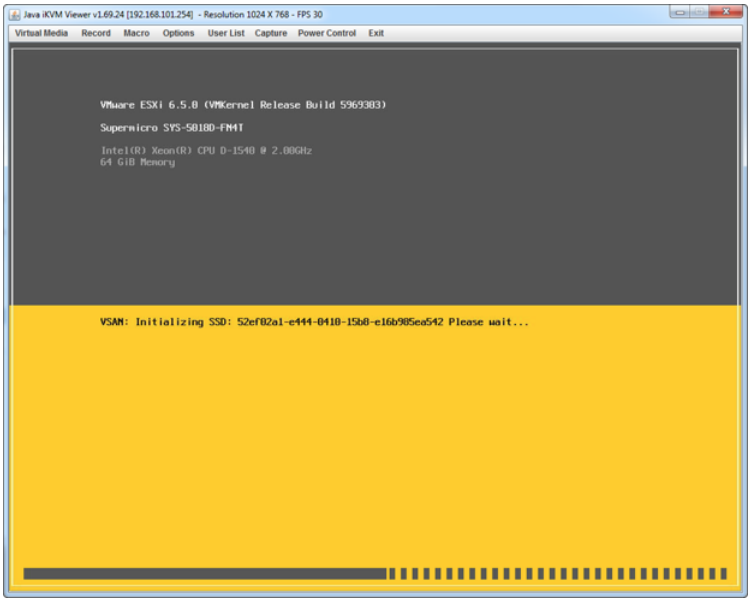


Figure. DCUI showing the "Initializing SSD" status

During this step, vSAN is processing data and digesting the log entries in the buffer to generate all required metadata tables (OSA only). More detail on a variety of vSAN initialization activities can be exposed by hitting ALT + F11 or ALT + F12 in the DCUI. For detailed information, read the blog post on monitoring vSAN restarts using DCUI.

Recommendation: Use out-of-band management to view vSphere DCUI during host restarts.

Cluster Shutdown and Power-Up

Occasionally a graceful shutdown of a vSAN cluster may need to occur. Whether it be for server relocation, or for a sustained power outage where backup power cannot sustain the cluster indefinitely. Since vSAN is a distributed storage system, care must be taken to ensure that the cluster is shut down properly. The guidance offered here will be dependent on the version of vSAN used.

The recommendations below assume that guest VMs in the cluster are shut down gracefully before beginning this process. The order that guest VMs are powered down is dependent on the applications and requirements of a given customer environment and is ultimately the responsibility of the administrator.

vSAN provides a guided workflow built right into vCenter Server makes a cluster power down and power up process easy, predictable, and repeatable. This feature is a management task of the cluster. It is available in the vCenter Server UI when highlighting a given vSAN cluster, and selecting **vSAN > Shutdown Cluster**.

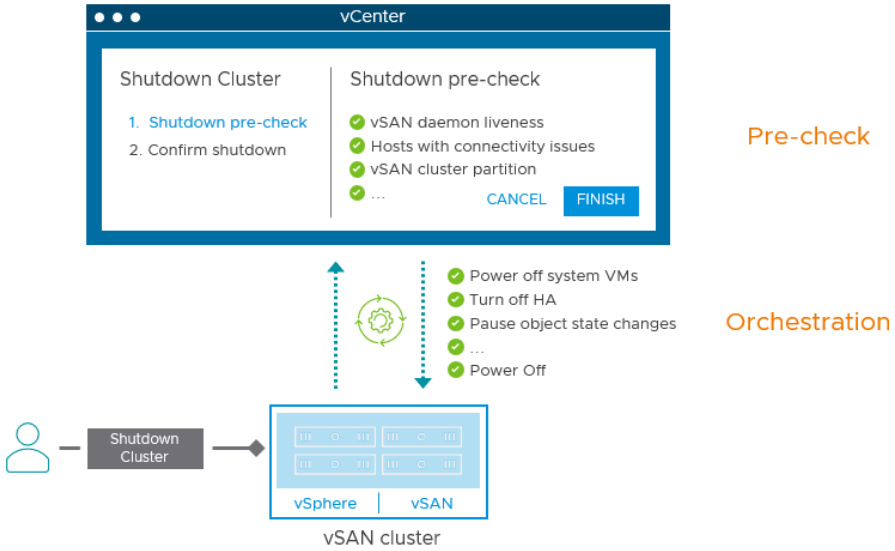


Figure. The logic of the new cluster shutdown workflow.

Note that **in vSAN 8, the Shutdown Cluster orchestration was enhanced to provide improved robustness** under a variety of conditions, and in vSAN 8 U1, the Shutdown Cluster workflow can be executed using PowerCLI.

The workflow accommodates for vSAN clusters that are powering the vCenter Server. The process elects an orchestration host that assists in this cluster shutdown and startup process once the vCenter Server VM is powered off. The selection of the orchestration host is arbitrary, but if the cluster powers a vCenter Server, it will typically elect the host that the vCenter Server VM is associated with.

Powering down the cluster will be orchestrated by this new built-in workflow. A high-level overview of the steps includes:

- Pre-validation health checks (e.g. is HA disabled, and all VMs powered off, etc.). The workflow will be halted if it does not pass.
- Hosts sets a new flag so vSAN's object manager will pause all change control processes.

- If vCenter server resides in the same cluster, vCenter will shut down and management of subsequent tasks will be delegated to the orchestration host.
- All hosts enter maintenance mode using “no action” option to prevent unnecessary data migration.
- Hosts are shut down.

Powering up the cluster will also be orchestrated by the new built-in workflow. A high-level overview of the steps includes:

- Administrator powers on ALL hosts in the cluster (using OOB management like IPMI, iDRAC, ILO, etc.)
- The orchestration host will set the flag in vSAN's object manager back to its original state to accept CCPs.
- If vCenter Server is within the cluster that was shut down, it will be automatically powered on.
- vCenter Server will perform a health check to verify the power state and alert of any issues.
- The administrator can power on VM’s.

The workflow also supports stretched cluster and 2-node topologies, but will not power down the witness host appliance, as this is an entity that resides outside of the cluster, and may also be responsible for duties with other clusters. The feature will also be available when the ESXi host lockdown mode is enabled on the hosts in the cluster.

Some system VMs such as VCLS may be automatically managed during the shutdown process, while others may not. Examples of other system-related VMs that will need to be managed manually include:

- File Services. No prechecks or automation workflows are included at this time.
- VKS pod VMs. These must be manually shut down.
- NSX management VMs. These must be manually shut down.

Recommendation: Regardless of the version of vSAN used, become familiar with the shutdown cluster process by testing it in a lab environment. This will help ensure that your operational procedures are well understood for these scenarios.

Powering up a vSAN cluster

A commonly overlooked step in the powering up of a vSAN cluster is to **ensure all hosts in the cluster are powered on and fully initialized prior to powering on guest VMs**. This is different than a vSphere cluster using a traditional three-tier architecture where a host that was powered on and initialized would not necessarily need to wait for other hosts to be powered on before VMs could be started. Since vSAN provides the storage resources in a distributed manner, A VM hosted on one host may have its data reside on other hosts, thus the need to ensure that all hosts are ready prior to powering on guest VMs.

Section 7: Guest VM Operations

Configuring TRIM/UNMAP in vSAN

vSAN supports thin provisioning, which lets you use just as much storage capacity as currently needed in the beginning and then add the required amount of storage space at a later time. Using the vSAN thin provisioning feature, you can create virtual disks in a thin format. For a thin virtual disk, ESXi commits only as much storage space as the disk needs for its initial operations. To use vSAN thin provisioning, set the SPBM policy for Object Space Reservation (OSR) to its default of 0.

One challenge to thin provisioning is that VMDKs, once grown, will not shrink when files within the guest OS are deleted. This problem is amplified by the fact that many file systems always direct new writes into free space. A steady set of writes to the same block of a single small file eventually use significantly more space at the VMDK level. Previous solutions to this required manual intervention and migration with Storage vMotion to external storage, or powering off a VM. To solve this problem, automated TRIM/UNMAP space reclamation was created for vSAN 6.7U1.

Additional information can be found on the "UNMAP/TRIM space reclamation on vSAN" section of the vSAN Space Efficiency Technologies document. The post: "The Importance of Space Reclamation for Data Usage Reporting in vSAN" will also be of use in better understanding TRIM/UNMAP functionality.

Planning

If implementing this change on a cluster with existing VMs, identify the steps to clean previously non-reclaimed space. In Linux, this can include scheduling file system (FS).Trim to run by timer, or in Windows, running the disk optimization tools or the Optimize-Volume PowerShell command. Identify any operating systems in use that may not natively support TRIM/UNMAP.

UNMAP commands do not process through the mirror driver. This means that snapshot consolidation will not commit reclamation to the base disk, and commands will not process when a VM is being migrated with VMware vSphere Storage vMotion. To compensate for this, run asynchronous reclamation after the snapshot or migration to reclaim these unused blocks. This may commonly be seen if using VADP-based backup tools that open a snapshot and coordinate log truncation prior to closing the snapshot. One method to clean up before a snapshot is to use the pre-freeze script.

Identify any VMs that you wish to not reclaim space with. For these VMs you can use a VMX flag disk.scsiUnmapAllowed set to False.

Implementation

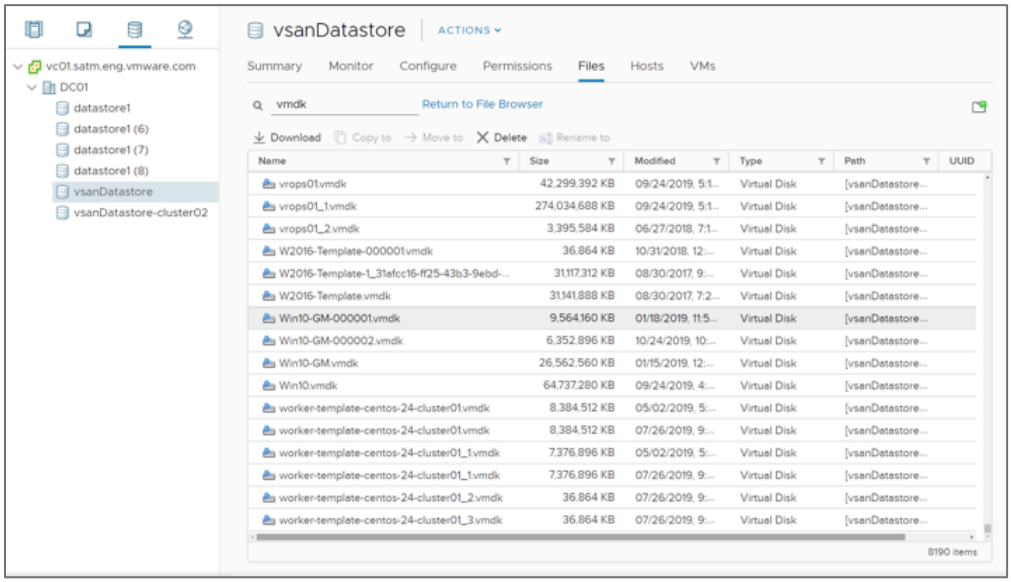


Figure. Viewing the size of a virtual disk within the vSANDatastore view of Center

Validation

After making the change, reboot a VM and manually trigger space reclaim. Monitor the backend UNMAP throughput and total free capacity in the cluster increasing.

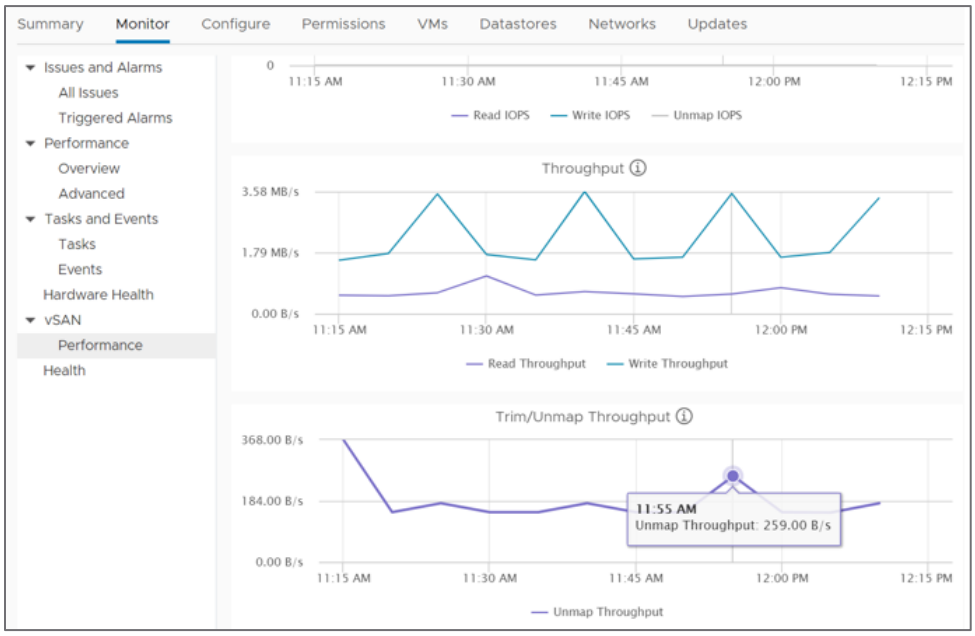


Figure. Viewing TRIM/UNMAP throughput on the host-level vSAN performance metrics

Tuning of Workloads after Migration to vSAN

In production environments, it is not uncommon to tune VMs to improve the efficiency or performance of the guest OS or applications running in the VM. Tuning generally comes in two forms:

- **VM tuning**—Achieved by adjusting the VM's virtual hardware settings (OSA and ESA), or vSAN storage policies (OSA).
- **OS/application tuning**—Achieved by adjusting OS or application-specific settings inside the guest VM.

The following provides details on the tuning options available, and general recommendations in how and when to make adjustments.

VM Tuning

VM tuning is common in traditional three-tier architectures as well as vSAN. Ensuring sufficient but properly sized virtual resources of compute, memory, and storage has always been important. Additionally, vSAN provides the ability to tune storage performance and availability settings per VM or VMDK through the use of storage policies. VM tuning that is non-vSAN-specific includes, but is not limited to:

- Virtual CPU
- Amount of virtual memory
- Virtual disks
- Type and number of virtual SCSI controllers
- Type and number of virtual NICs

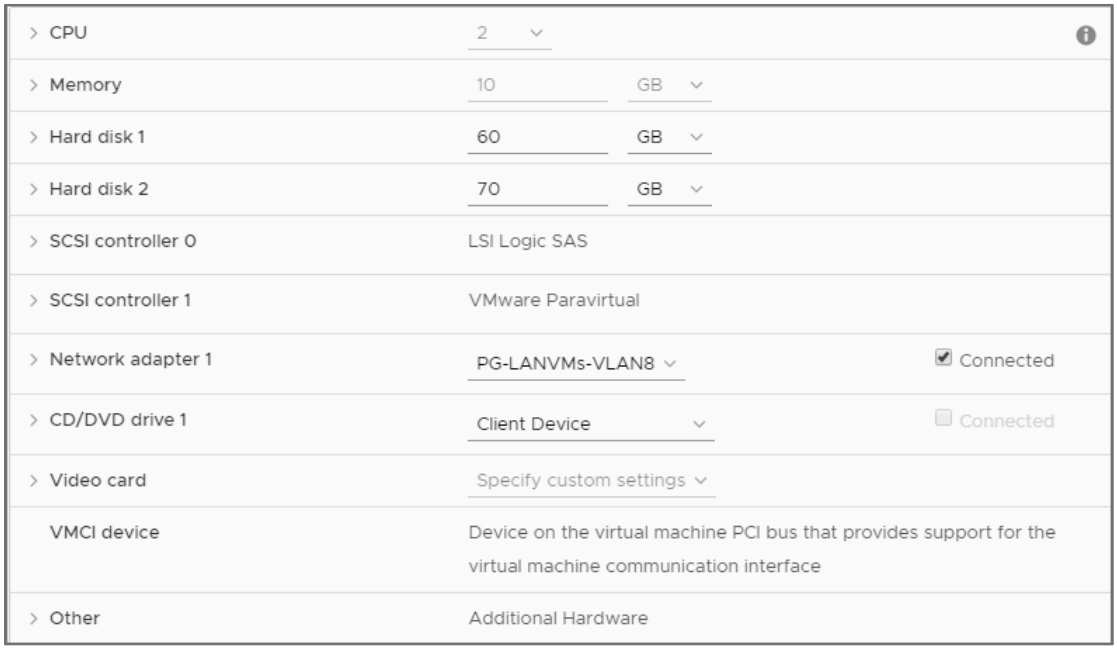


Figure. Virtual hardware settings of a VM

Determining the optimal allocation of resources involves monitoring the VM's performance metrics in vCenter Server, or augmenting this practice with other tools such as VMware Aria Operations to determine if there are any identified optimizations for VMs.

Recommendation: For VMs using more than one VMDK, use multiple virtual SCSI adapters. This provides improved parallelism and can achieve better performance. It also allows one to easily use the much more efficient and better performing Paravirtual SCSI controllers on these additional VMDKs assigned to a VM. See Page 38 of the "Troubleshooting vSAN Performance" document for more information.

VM tuning through the use of storage policies that are specific to vSAN performance and availability would include:

- Level of Failures to Tolerate (FTT)
- Data placement scheme used (RAID-1 or RAID-5/6). (only applicable in the OSA)
- Number of disk stripes per object (AKA "stripe width") (only applicable in the OSA)
- IOPS limit for object

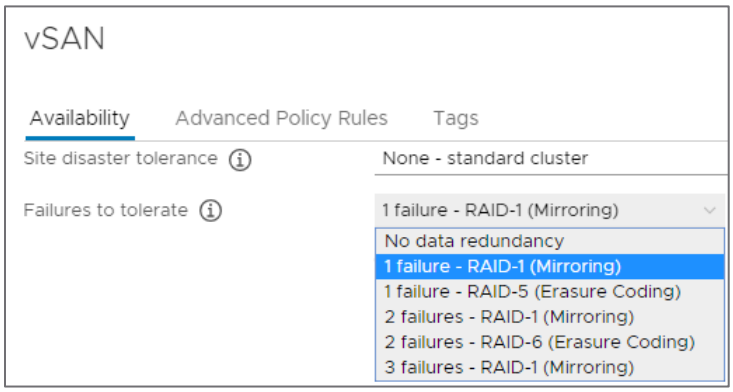


Figure. Defining the FTT level in a vSAN storage policy

Note that with the ESA, RAID-5/6 erasure coding is as fast, if not faster than RAID-1. For more information, see the post: "RAID-5/6 with the Performance of RAID-1 using the vSAN Express Storage Architecture."

Since all data lives on vSAN as objects, and all objects must have an assigned storage policy, vSAN provides a "vSAN Default Storage Policy" on a vSAN cluster as a way to automatically associate data with a set of rules defining availability and space efficiency. This is set to a default level of FTT=1, using RAID-1 mirroring, and offers the most basic form of resilience for all types of cluster sizes. In practice, an environment should use several storage policies that define different levels of outcomes, and apply them to the VMs as the requirements dictate. This is most important for clusters running the OSA. For ESA clusters, one can enable the optional Auto-Policy Management capability to simplify the process of providing an optimal storage policy setting for the cluster. See "Operational Approaches of Using SPBM in an Environment " for more details.

Determining the appropriate level of resilience and space efficiency needed for a given workload is important, as these factors can affect results. Setting a higher level of resilience or a more space-efficient data placement method may reduce the level of performance the environment delivers to the VM. This trade-off is from the effects of I/O amplification and other overhead, described more in "Troubleshooting vSAN Performance."

The recommendations for storage policy settings may be different based on your environment. For an example, let us compare a vSAN cluster in a private cloud versus vSAN running on VMC on AWS.

- **Private cloud**—The standard hardware specification for your hosts and network in a private cloud may be modest. The specification may not be able to meet performance expectations if one were to use the more space efficient but more taxing RAID-5/6 erasure coding. In those cases, it would be best to use a RAID-1 mirror as the default, and look for opportunities to apply RAID-5/6 case by case.
- **VMC on AWS**—The standard hardware specification for this environment is high, but consuming large amounts of capacity can be cost-prohibitive. It may make more sense to always start by using VM storage policies that use the more space-efficient RAID-5/6 erasure coding over RAID-1. Then, apply RAID-1 to discrete systems where RAID-5/6 is not meeting the performance requirements. As our cloud providers transition to the ESA, they will also be adjusting their operational behaviors, which would no longer follow the description above. Other storage policy rules that can impact performance and resilience settings are "Number of disk stripes per object" (otherwise known as "stripe width") and "IOPS limit for object." More details on these storage policy rules can be found in the "Storage Policy Operations" section of this document.

OS/application tuning

OS/application tuning is generally performed to help the OS or application optimize its behavior to the existing environment and applications. Often you may find this tuning in deployment guides by an application manufacturer, or in a reference architecture. Note: Sometimes, if the recommendations come from a manufacturer, they may not take a virtualized OS or application into account and may have wildly optimistic recommendations.

For high performing applications such as SQL server, **ensure the guest VM volumes use a proper disk/partition alignment.** Some applications such as SQL demand a highly efficient storage system to ensure that serialized, transactional updates can be delivered in a fast and efficient manner. Sometimes, due to how a guest OS volume or partition is created, I/O requests will be unaligned, causing unnecessary Read, Modify, Write (RMW) events, increasing I/O activity unnecessarily, and impacting performance . See the post "Enhancing Microsoft SQL Server Performance on vSAN (and VMC on AWS) with SQL Server Trace Flag 1800" for information on how to determine if there is I/O unalignment of your SQL Server VM, and how to correct it. In some circumstances, it can have a dramatic impact on performance. While the link above showcases the issue and benefit on Microsoft SQL Server running on Windows Server, it can can occur with other applications.

Recommendation: Avoid over-ambitious OS/application tuning unless explicitly defined by a software manufacturer, or as outlined in a specific reference architecture. Making OS and application adjustments in a non-prescriptive way may add unnecessary complexity and result in undesirable results. If there are optimizations in the OS and application, make the adjustments one at a time and with care. Once the optimizations are made, document their settings for future reference.

VM tuning, as well as OS/application tuning can sometimes stem from identified bottlenecks. The "Troubleshooting vSAN Performance" document on core.vmware.com provides details on how to isolate the largest contributors to an identified performance issue, and the recommended approach for remediation.

Section 8: Data Services

Deduplication and Compression (OSA): Enabling and Disabling

The Original Storage Architecture (OSA) in vSAN provides an opportunistic space-efficiency feature known as "Deduplication and Compression." It attempts to compress and deduplicate data in a manner that can store more data in a cluster than what the physical storage capacity may otherwise allow. Deduplication and Compression in vSAN OSA has its tradeoffs, as it can impact performance in some circumstances.

Since this feature is a cluster based option that changes the data layout on the devices that comprise the vSAN cluster, enabling or disabling it on an existing production cluster can introduce a lot of data movement and resource usage during the conversion.

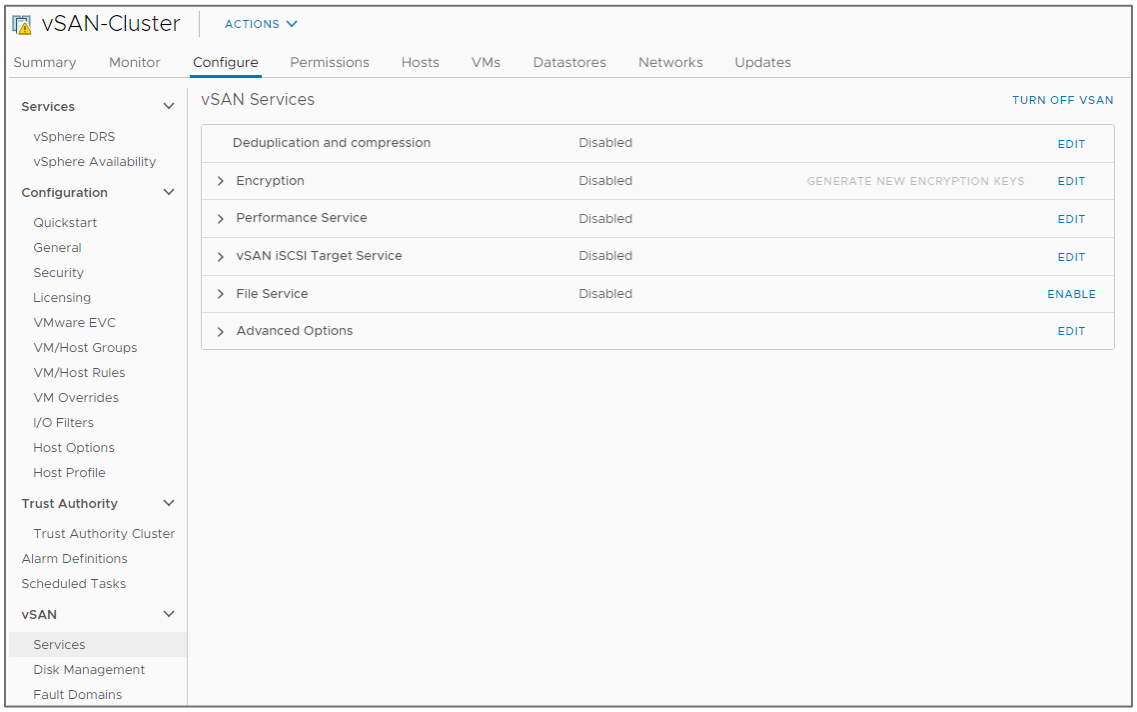


Figure. The Deduplication and Compression Service in vSAN.

Recommendation: If you are running a cluster using vSAN OSA, choose whether you want to use the Deduplication and Compression feature prior to migrating workloads onto the new cluster. A better long term strategy is to simply move to vSAN ESA, since it will provide much higher levels of performance while providing optimal space efficiency.

Further guidance on the Deduplication and Compression feature can be found on the post: "vSAN Design Considerations – Deduplication and Compression" as well as the "vSAN Space Efficiency Technologies" document. For OSA clusters that are more performance-oriented, one may wish to use the Compression-only option instead. For more information, see the post: "Space Efficiency using the new 'Compression only' Option in vSAN 7 U1."

Compression (ESA): Enabling and Disabling

The ESA in vSAN provides space efficiency in a much different way. Data compression is no longer a cluster-based service, but is applied as a storage policy rule. It is enabled by default. While it can be disabled, there is generally no need to do so. Note that changing the storage policy rule off and on will no retroactively compress or decompress the data, which is another reason to simply leave it enabled.

Compression ratios in vSAN ESA are much better as well. It has the ability to compress the data on a per 512 byte sector size, leading to a higher compression ratio of the data that is stored allows for it. It was not uncommon to see a compression ratio of about 1.2x in OSA, whereas we see compression ratios of 1.6x and above.

For more information on data compression in ESA, see the post: "vSAN 8 Compression – Express Storage Architecture."

Recommendation: Leave the compression feature enabled in vSAN ESA. The ESA compresses the data at the top of the storage stack, which means it can reduce the amount of data traversing the network.

As of vSAN 8 U3, the ESA does not have the deduplication. This is a feature that is expected in VCF 9. However, when we factor in ESA's improved compression ratios, and the ability to always store the data using RAID-5/6 erasure coding without any performance compromise, we find a much lower cost per Terabyte.

Global Deduplication (ESA): Enabling

vSAN in VCF 9.0 introduces global deduplication. This is a much more efficient and effective deduplication mechanism than what is found in vSAN OSA, and does not have many of the technical limitations that were associated with deduplication in vSAN OSA. Deduplication will initially be under limited availability in vSAN 9.0 P01. It will be be offered to customers via Broadcom's "Technical Qualification Request" (TQR). To submit a TQR, please contact vSAN Product Management.

Deduplication and Compression (OSA): View History of Capacity Savings

You can review the historical deduplication and compression rates, as well as actual storage consumed and saved, in two ways: one is with VCF Operations, and the other is right within the product itself. In VCF Operations, you will find the bundled "vSAN operations" dashboard. This lists a number of metrics and trends, some of those being space efficiency-related. You can view the ratio, the savings, and actual storage consumed as well as trends to predict time until cluster full and other useful metrics.

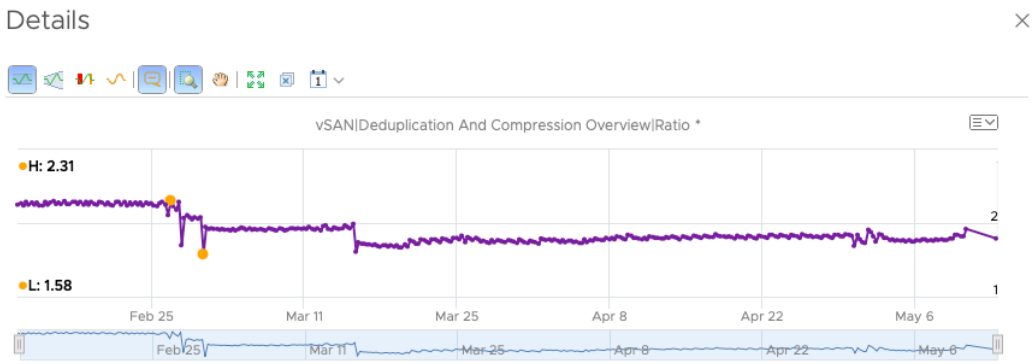


Figure. Using VCF Operations to view DD&C ratios over a long period of time

If you simply want to view some of this information in vCenter, navigate to the vSAN cluster in question and click Monitor → Capacity, then click the capacity history tab. This brings you to a UI that lets you change and view a number of things. The default is to look at the previous day's capacity trends, but this can be customized. You have two options to view the historical ratios and space savings here. One is the default, to use the current day as a reference and view the previous X days—where you define the number of days in the UI. The other option is to click the drop-down and choose Custom.

From here you can choose the reference date and the time period. For example, if you want to view the 30 days from 31 March, you would simply choose 31 March as your reference date and insert 30 as the number of days of history you want to view.

Figure. Viewing capacity utilization history of a vSAN cluster.

While the vSAN ESA offers compression on a storage policy rule basis, the effective compression ratio can also be viewed in the cluster capacity view.

Data-at-Rest Encryption: Enabling and Disabling

Enabling or disabling data at rest encryption on a vSAN cluster is relatively easy. When vSAN encryption is enabled or disabled, it performs a rolling reformat that copies data to available capacity on another node, removes the now-empty disk group, and then encrypts or decrypts each device in a newly recreated disk group.

Enabling or disabling encryption introduces a rolling reformat of the storage devices that are claimed by vSAN. This rolling reformat does not place the host into maintenance mode and simply reformats one disk group at a time in vSAN OSA, or one storage device at a time in vSAN ESA. **While the hosts are not placed into maintenance mode during the enabling or disabling of vSAN Data-at-Rest encryption, this rolling reformat may generate a substantial amount of data movement across the network during the transition.**

Data-at-Rest encryption is a cluster-based toggle, and much like the deduplication and compression feature, enabling or disabling the capability changes the data format. We recommend making this decision on its use prior to the deployment of a cluster running vSAN. Otherwise, the effort that it takes to roll through disk format process can be time consuming, and can impact performance. Once enabled, encryption services can impact the amount of processing required for storing data. For more information, see the post: "Performance when using vSAN Encryption Services (OSA)."

Recommendation: Use Data-at-Rest Encryption in your vSAN OSA cluster only if you have requirements to do so. This will reduce any unnecessary complexity for environments that do not need this additional layer of security.

For more information on Data-At-Rest Encryption, see the vSAN Encryption Services document.

Data-in-Transit Encryption: Enabling in-flight Encryption on a vSAN Cluster

Data-in-Transit Encryption allows for vSAN traffic to be securely transmitted from host to host in a vSAN cluster. Data-in-transit encryption provides a complete over the wire encryption solution that address host/member authentication, data

integrity/confidentiality, and embedded key management. It can be used on its own, or in conjunction with vSAN Data-at-Rest Encryption to provide an end-to-end encryption solution. Both capabilities use the same vSphere based FIPS 140-2 validated cryptographic modules.

Just like vSAN Data-at-Rest Encryption, Data-in-Transit Encryption is enabled and disabled at the cluster level. Unlike Data-at-Rest Encryption, it does not use an external key management server (KMS) which can make it extremely simple to operationalize. If a cluster uses both encryption features, the features will be independently responsible for its key management. Data-at-Rest Encryption will use an external KMS, while Data-in-Transit will manage its own host keys.

Health and Management of Data-in-Transit Encryption

The vSAN Skyline Health Services will periodically check the configuration state of the hosts that comprise the vSAN cluster. The Skyline Health Service will be the first place to check if there are difficulties with enabling Data-in-Transit Encryption.

Host BIOS settings and AES-NI Offloading

The vSphere cryptographic modules used for both methods of encryption can take advantage of AES-NI offloading to minimize the CPU consumption of the hosts. Modern CPUs are much more efficient with this offloading than older CPUs, so the impact of this offloading will depend on the generation of CPUs in the hosts

Recommendation: Prior to deployment, check the BIOS to ensure that AES offloading is enabled.

The Potential Impact on Performance

Data-in-transit encryption is an additional data service that as one might expect, demands additional resources. Performance considerations and expectations should be adjusted when considering these types of security features. The degree of impact will be dependent on the workloads and hardware specifications of the environment. This is addressed in more detail in the Data-at-Rest Encryption: Enabling on a New Cluster section. Data-in-Transit does have the potential to impact guest VM latencies, since all over-the-wire communication to synchronously replicate the data must be encrypted and decrypted in flight. For more information on this topic, see: Performance when using vSAN Encryption Services. The impact on performance of in-transit encryption will be less on vSAN ESA than it will be on vSAN OSA, but it should still be a consideration.

Data-at-Rest Encryption: Using vSAN and vSphere Encryption Together

vSphere provides FIPS 140-2 and 140-3 validated data-at-rest encryption when using per-VM encryption or vSAN datastore level encryption. These features are software-based, with the task of encryption being performed by the CPU. Most server CPUs released in the last decade include the AES-NI instruction set to minimize the additional overhead. More information on AES-NI can be found on Wikipedia.

These two features provide encryption at different points in the stack, and have different pros and cons for using each. Detailed differences and similarities are can be found in the Encryption FAQ. With VM encryption occurring at the VM level, and vSAN encryption occurring at a datastore level, enabling both results in encrypting and decrypting a VM twice. Having encryption performed multiple times is typically not desirable.

Skyline Health for vSAN reports when a VM has an encryption policy (for VM encryption) and also resides on an encrypted vSAN cluster. This alert is only cautionary, and both may be used if so desired.

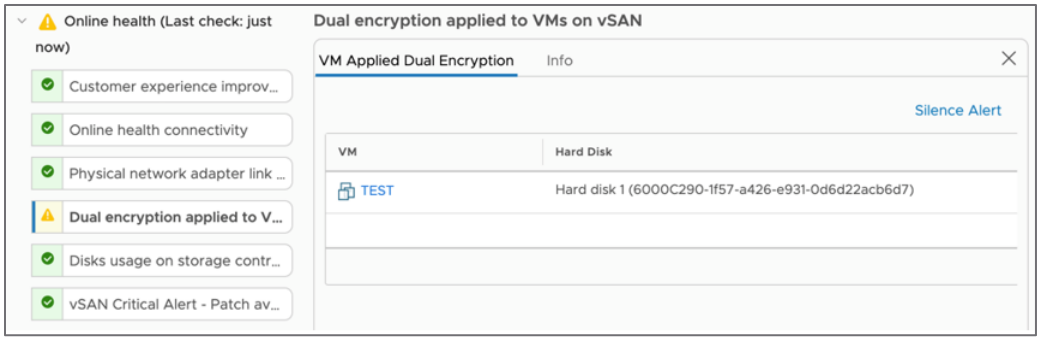


Figure. The vSAN health check reporting the use of multiple encryption types used together

The above alert is common when migrating a VM encrypted by VM encryption to a vSAN datastore. It is typically recommended to disable VM encryption for the VM if it is to reside on an encrypted vSAN cluster. The VM must be powered off to remove VM encryption. Customers wishing to prevent the VM from being unencrypted likely choose to remove VM encryption after it has been moved to an encrypted vSAN datastore.

Recommendation: With encryption being performed at multiple levels, only enable VM encryption on VMs residing on an encrypted vSAN cluster when there is an explicit requirement for it, such as, while migrating an encrypted VM to a vSAN cluster, or before moving a non-encrypted VM from a vSAN cluster

For clusters running the ESA, all vSAN traffic will inherently be encrypted in flight in addition to at-rest. However, to ensure the highest levels of security Data-in-Transit encryption remains as an available toggle in the cluster data services section. If this is enabled with Data-at-Rest Encryption in the ESA, it will encrypt each network packet uniquely so that so that identical data is not transmitted over the network. For more information, see the blog post: "Cluster Level Encryption with the vSAN Express Storage Architecture."

Data-at-Rest Encryption: Performing a Shallow Rekey

Key rotation is a strategy often used to prevent long-term use of the same encryption keys. When encryption keys are not rotated on a defined interval, it can be difficult to determine their trustworthiness. If the encryption keys have not been changed (or rotated), the the data could possibly be decrypted and recovered from the suspected failed storage device.

The process of performing a shallow rekey is very similar in vSAN OSA and vSAN ESA. When the checkbox below is left unchecked, this will perform a shallow rekey on the data living in the vSAN datastore. When the checkbox is checked, that will instruct vSAN to perform a deep rekey.

Shallow rekey operations are extremely light weight. All Disk Encryption Keys (DEK)s remain the same but are re-wrapped with a new KEK. Shallow rekey operations are very fast due to little to no data movement, and are the most common of the two key rotation methods.

Recommendation: Implement a KEK rotation strategy that aligns with organizational security and compliance requirements.

Data-at-Rest Encryption: Performing a Deep Rekey

Much like a shallow rekey, the process of a deep rekey is very similar when comparing vSAN OSA to vSAN ESA, although the assembly and handling of keys are fundamentally different between the two architectures. While vSAN ESA uses a cluster-wide Disk Encryption Key (DEK), the object data has object-specific keys that are used. This ensures that object data in VM

uses different keys than any other VM. Note however that a rekey operation will perform a rekey across all data on the cluster, and does not give a choice for rekeying discrete objects.

Deep rekey operations are a more resource intensive endeavor, and careful consideration should be taken when performing the action. For more information, see the post: "Key Rotation Options for vSAN ESA in vMware Cloud Foundation 5.1 and vSAN 8 U2."

Key Management Server (KMS) Options for vSAN

Key Management Server (KMS) solutions are used when some form of encryption is enabled in an environment. For vSphere and vSAN, a dedicated KMS is necessary for features such as vSphere VM Encryption, vSphere Encrypted vMotion and vSAN Data-at-Rest Encryption.

vSphere 7 U2 introduced the ability to provide basic key management services for vSphere hosts through the new vSphere Native Key Provider (NKP). This feature, not enabled by default, can simplify key management for vSphere environments using various forms of encryption. For more information, see the blog post: Introducing the vSphere Native Key Provider as well as the vSphere Native Key Provider Overview documentation.

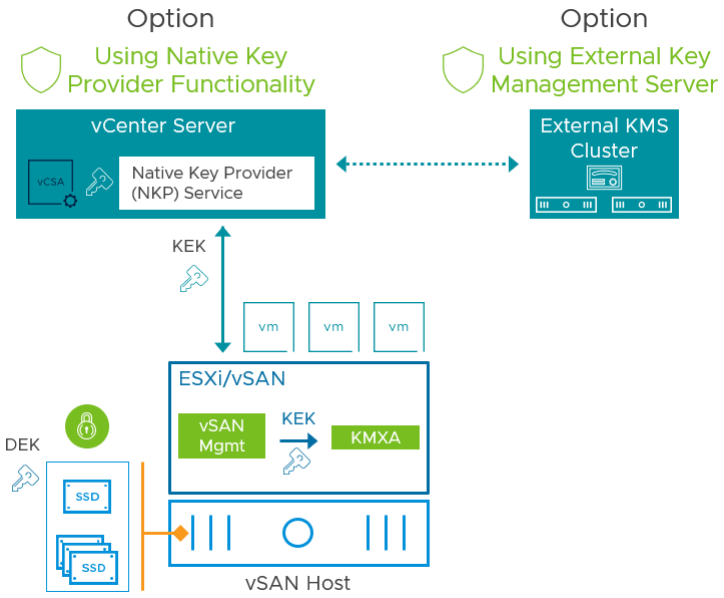


Figure. Key Management Services provided through the vSphere NKP, or an external KMS solution.

Key Management Services for vSAN 7 U2 and later can be provided in one of two ways:

- Using a 3rd party, External Key Management Server (KMS) solution
- Using the integrated vSphere NKP

Either one of these two will provide the key management services necessary for vSAN Data-at-Rest Encryption. The vSAN Data-in-Transit Encryption feature transparently manages its own keys across the hosts in a vSAN cluster and therefore does not need or use any other key management provider.

The use of the vSphere NKP versus an external, full featured KMS comes down to the requirements of an organization. The vSphere NKP is ideal for customers who have simple security requirements and need basic key management for vSphere and/or vSAN only. **It can only do so for vSphere related products.** It may be ideal for edge or small vSAN environments that may not have a full-featured KMS solution at their disposal.

Full-featured external KMS solutions may offer capabilities that are needed by an environment that cannot be met by the vSphere NKP. Clusters using where external KMS solutions can easily co-exist with other clusters using the vSphere NKP for key management. The vSphere NKP can also serve as an introductory key provider for an environment who may be interested in a full-featured external KMS solution. Transitioning from the vSphere NKP to an external KMS (and vice versa) is a simple matter.

vSAN 7 U3 introduced the ability to persist keys distributed to hosts through the use of a Trusted Platform Module (TPM) chip. This applies to environments running either the vSphere Native Key Provider, or an external KMS cluster. Should there ever be an issue with communication to the key provider, this will persistently cache the distributed keys to the TPM chip on the host. This cryptographically stored device will secure the key so that any subsequent reboots of the host will allow it to retrieve the assigned key without relying on the communication to the KMS.

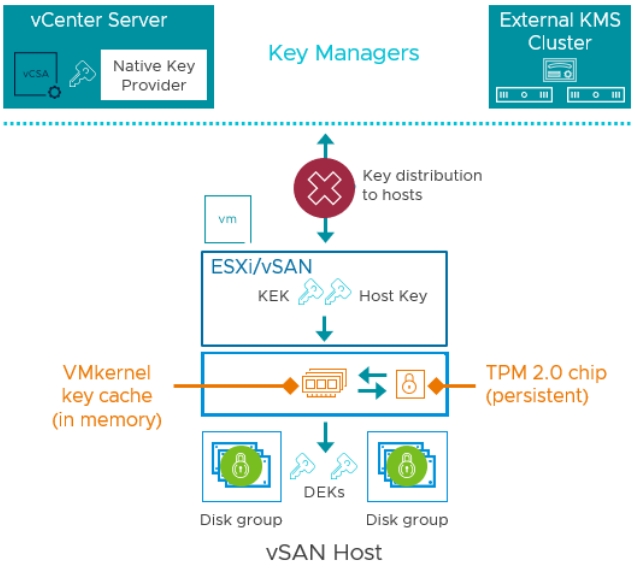


Figure. Using a TPM with the vSphere NKP, or an external KMS in vSAN 7 U3.

Recommendation: ALWAYS include a Trusted Platform Module (TPM) for each and every server purchased. This small, affordable device is one of the best ways to improve the robustness of your encrypted vSphere and vSAN environment.

The principles around operationalization of key management for secured environments will be similar regardless of the method chosen. When considering the role of a key provider, it is important to ensure operational procedures are well understood to help accommodate for planned and unplanned events.

OEM vendors of full featured KMS solutions will have their own guidance on how to operationalize their solution in an environment.

Recommendation: Test out the functionality of the vSphere NKP in a virtual or physical lab environment prior to introducing it into a production environment. This can help streamline the process of introducing the NKP into production environments

iSCSI: Identification and Management of iSCSI Objects in a vSAN Cluster

vSAN iSCSI objects can appear different than other vSAN objects in vSAN reports—usually reporting as "unassociated" because they aren't mounted directly into a VM as a VMDK—but rather via a VM's guest OS iSCSI initiator, into which vSAN has no visibility. If you use the vCenter RVC to query vSAN for certain operations, be aware that iSCSI LUN objects as well as vSAN performance service objects (both of which are not directly mounted into VMs) will be listed as "unassociated"—this does NOT mean they are unused or safe to be deleted.

So, how can you tell if objects are in use by the performance service or iSCSI? After logging in to the vCenter server, iSCSI objects or performance management objects could be listed and shown as unassociated when querying with RVC command vsan.obj_status_report.

These objects are not associated with a VM, but they may be valid vSAN iSCSI objects on the vSAN datastore and should not be deleted. If the intention is to delete some other unassociated objects and save space, **please contact the VMware GS team for assistance.** The following shows how to identify unassociated objects as vSAN iSCSI objects and verify from the vSphere web client.

Login to vCenter via ssh and launch the RVC, then navigate to the cluster:

```
root@sc-rdops-vm03-dhcp-93-66 [ ~ ]# rvc administrator@vsphere.local@localhost

Welcome to RVC. Try the 'help' command.

0 /

1 localhost/

> cd localhost/
```

Run the vSAN object status report in RVC:

```
/localhost> vsan.obj_status_report -t /localhost/VSAN-DC/computers/VSAN-Cluster/…

Histogram of component health for non-orphaned objects

+-------------------------------------+------------------------------+

| Num Healthy Comps / Total Num Comps | Num objects with such status |

+-------------------------------------+------------------------------+

| 3/3 (OK) | 10 |

+-------------------------------------+------------------------------+

Total non-orphans: 10

Histogram of component health for possibly orphaned objects

+-------------------------------------+------------------------------+

| Num Healthy Comps / Total Num Comps | Num objects with such status |

+-------------------------------------+------------------------------+

+-------------------------------------+------------------------------+

Total orphans: 0

Total v9 objects: 10

+-----------------------------------------+---------+---------------------------+

| VM/Object | objects | num healthy / total comps |

+-----------------------------------------+---------+---------------------------+

| Unassociated objects | | |
```

```
| a29bad5c-1679-117e-6bee-02004504a3e7 | | 3/3 |
| ce9fad5c-f7ff-9927-9f58-02004583eb69 | | 3/3 |
| a39cad5c-008a-7b61-a630-02004583eb69 | | 3/3 |
| d49fad5c-bace-8ba3-9c7a-02004583eb69 | | 3/3 |
| d09fad5c-1650-1caa-d0f1-02004583eb69 | | 3/3 |
| 66bcad5c-a7b5-1ef9-0999-02004504a3e7 | | 3/3 |
| 169cad5c-6676-063b-f29e-020045bf20e0 | | 3/3 |
| f39bad5c-5546-ff8d-14e1-020045bf20e0 | | 3/3 |
| 199cad5c-e22d-32d7-aede-020045bf20e0 | | 3/3 |
| 1d9cad5c-7202-90f4-0fbf-020045bf20e0 | | 3/3 |
+--------------------------------------+---------+--------------------------+
```

Cross-reference the “Unassociated objects” list UUIDs with the vSAN iSCSI objects, as well as the “iSCSI home object” and the “performance management object” in the vSphere web client under vSAN Cluster → Monitor → vSAN → Virtual Objects and compare the UUIDs under the “vSAN UUID” column with those in the “Unassociated objects” report from RVC. If UUIDs appear in both lists, they are NOT safe to remove.

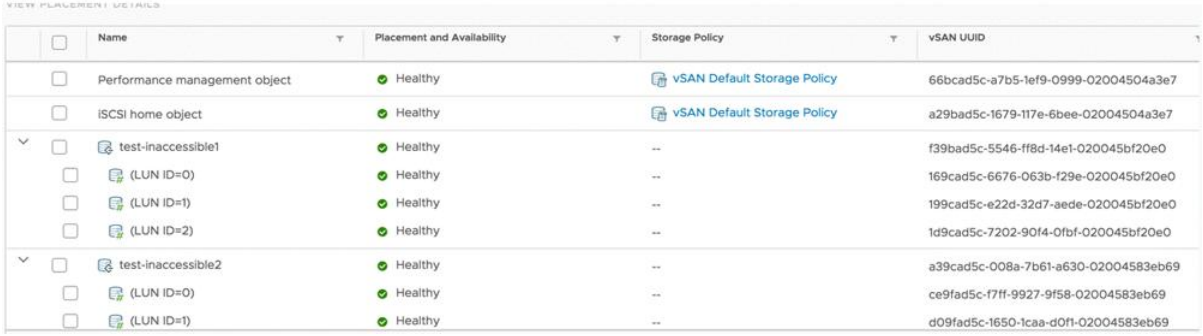


Figure. Enumerated objects, related storage policies, and vSAN UUIDs

Again, if in any doubt, **please contact the VMware GS team for assistance**.

File Services: Introducing it into an Existing Environment

vSAN File Services allows for vSAN administrators to easily deliver file services on a per cluster basis using any vSAN cluster. Providing both NFS and SMB file services in a manner that is native to the hypervisor allows for a level of flexibility and ease of administration that is otherwise difficult or costly to achieve with stand-alone solutions.

Enabling vSAN File Services in an environment introduces several operational considerations. vSAN File Services can be unique in that it may require additional considerations with the infrastructure that may or may not be related to the hypervisor. Some of those considerations include:

- Supported topology types
- Authentication options through Active Directory for SMB and Kerberos for NFS
- Supported protocol versions and how to connect clients to the shares

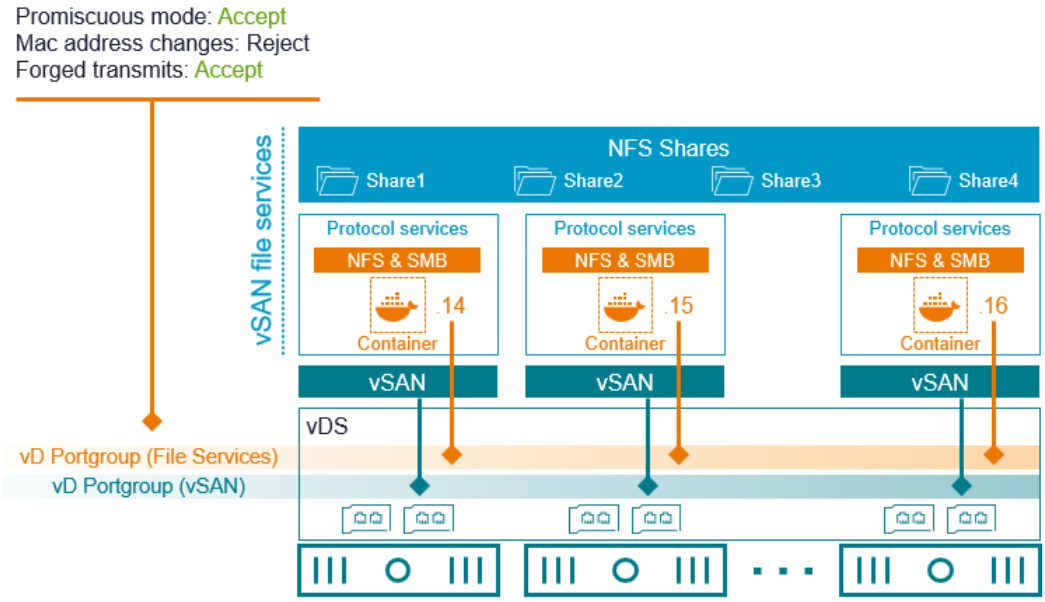
Note that in the VMware documentation and in the product UI, the term “share” may be used interchangeably with both SMB and NFS. The term "share" is used to simplify the language when discussing multiple protocols. Windows-based SMB

have historically referenced them as “shares” while Unix and Linux based systems typically refer to them as an “NFS export” that the NFS client will mount.

Recommendations on Introducing vSAN File Services into your environment

Since vSAN File Services is a relatively new feature, successfully introducing it into an environment can be achieved with preparation and familiarity.

- **Run the latest edition of vSAN**. File Services were introduced with vSAN 7, and has improved in performance and functionality in almost every version since. If you are interested in this feature, update the cluster to the latest version prior to enabling vSAN File Services.
- **Understand the limits.** vSAN File Services does not allow ESXi hosts to connect directly to File Services via NFS for the purpose of presenting storage for VMs. A share served by vSAN File Services can only be used for SMB, or NFS: Not both concurrently. The vSAN File Services FAQ and VMware Docs outline the common limits that you should be aware of prior to deployment.
- **Become familiar with the prerequisites required for the setup of vSAN file services.** Enabling and configuring vSAN File Services will require additional IP addresses for the respective protocol services containers (up to a maximum of 64 for clusters of cluster sizes of 64 running vSAN 7 U2) with forward and reverse DNS records.
- **Decide on the approach used for port group used by vSAN File Services.** The port group that is used for vSAN File Services will automatically enable promiscuous mode and forged transmits if those settings are not enabled already. If NSX-based networks are being used, ensure that similar settings are configured for the provided network entity from the NSX admin console, and all the hosts and File Services nodes are connected to the desired NSX-T network. An administrator may decide to put the IP addresses of protocol service container created by vSAN File Services on their own dedicated port group, or use another existing port group that previously did not have these settings enabled. Internal requirements (e.g. security) or other constraints may dictate the decision. Both approaches are supported.



- **Build out a test cluster to become familiar with the deployment process and configuration settings**. This will allow for easy experimentation to become familiar with the feature and the configuration. It can also serve as a way to test out the upgrade process, as well as review future editions of vSAN File Services.
- **Use the test cluster to ensure the proper configuration of Active Directory.** Configuration of Active Directory and Kerberos settings for vSAN File Services will be highly dependent on your organization's Active Directory Configuration. The deployment wizard also has guidance with this, including the requirements of a dedicated OU in Active Directory for use by vSAN File Services.

- **Set quotas.** vSAN file services can provide as much capacity for file shares as provided by the cluster. vSAN provides share warning thresholds as well as a hard quota to protect against the consumption of storage capacity beyond what is intended.
- **Become familiar with creating shares and their associated connection strings.** A connection string is the string of text an NFS or SMB client will use to establish a connection to the share. This connection string will be different for SMB, NFS v3, and NFS v4.1. Learn where to find these strings, and how to connect the clients.
- **Learn how to monitor.** vSAN provides the ability to monitor the activities of vSAN File Services. The share can be selected in the vSAN Performance Service to look at the demand on the share over a period of time. The Skyline Health checks also continuously check for various aspects of the cluster related to vSAN File Service health. The vCenter Server UI even allows you to see which objects make up the given file share. This can be found in the "Virtual Objects" view followed by clicking the "File Shares" icon to filter the object listing.

Recommendation: Do not use vSAN File Services as a location for important host logging, core dumps or scratch locations of the hosts that comprise the same cluster providing the file services. This could create a circular dependency and prevent the logging and temporary data from being available during an unexpected condition that requires further diagnostics.

Section 9: Stretched Clusters

See the vSAN Stretched Cluster Guide for more information on how to best operationalize vSAN when deployed as a stretched cluster.

Section 10: 2-Node Clusters

See the vSAN 2-Node Cluster Guide for more information on how to best operationalize vSAN when deployed as a 2-node cluster.

Section 11: vCenter Server Maintenance and Event Handling

Upgrade Strategies for vCenter Server Powering One or More vSAN Clusters

It is common for vCenter to host multiple vSAN clusters, these could be at different ESXi versions to each other, and as such, different vSAN versions. This is a fully supported configuration, but it is a good idea to ensure that your vCenter and ESXi versions are compatible with one-another.

Recommendation: When in doubt, simply run the very latest version of vCenter Server. The hosts that the vCenter Server manages do not need to match. This also sets up the environment well for upgrades, as vCenter Server is typically the first aspect to be upgraded.

Replacing vCenter Server on an Existing vSAN Cluster

There may be instances in which you need to replace the vCenter server that hosts some vSAN clusters. While vCenter acts as the interaction point for vSAN and is used to set it up and manage it, it is not the only source of truth and is not required for steady-state operations of the cluster. If you replace the vCenter server, your workloads will continue to run without it in place.

Replacing the vCenter server associated with a vSAN cluster can be done, but is not without its challenges or requisite planning. For more detailed information, see the blog post: "Replacing a vCenter Server for Existing vSAN Hosts."

Scenario: An all-flash vSAN OSA cluster on 7 U2 needs migrated to a new vCenter server with deduplication and compression enabled.

- Ensure the target vCenter server has the same vSphere version as the ESXi hosts, or higher (same is preferable).
- Create a new cluster on the new vCenter server with the same settings as the source cluster (vSAN enabled, DD&C, encryption, HA, DRS) and ensure the Disk Claim Mode is set to Manual.
- If you are using a Distributed Switch on the source vCenter server, export the vDS and import it into the new vCenter server, ensure "Preserve original distributed switch port group identifiers" is NOT checked upon import.

- Recreate all SPBM policies on the target vCenter server to match the source vCenter server.
- Disconnect all hosts from the source vCenter server.
- Remove hosts from the source vCenter server inventory.
- Add hosts into the new vCenter server.
- Drag the hosts into the new cluster.
- Verify hosts and VMs are contactable.
- Run esxcfg-advcfg -s 0 /VSAN/IgnoreClusterMemberListUpdates on all hosts.
- Configure hosts to use the imported vDS one by one, ensuring connectivity is maintained.
- Reconfigure a VM with the same policy as source—ensuring no resynchronization when the VM is reconfigured.
- For each SPBM policy, reconfigure one of each VM as a test to ensure no resynchronization is performed.
- Once verified, reconfigure all VMs in batches with their respective SPBM policies.

Recommendation: If you are not completely comfortable with the above procedure and doing this in a live environment, please open a ticket with GS and have them guide you through the procedure.

Protecting vSAN Storage Policies

Storage policy based management (SPBM) is a key component of vSAN. All data that is stored on a vSAN cluster: VM data, file services shares, first-class disks, and iSCSI LUNs are stored in the form of objects. Each one of the objects stored in a vSAN cluster have an assignment of a single storage policy that helps define the outcome that governs how the data is placed.

Storage policies are a construct of a vCenter server. Similar to vSphere Distributed Switches (vDS), they are defined and stored on a vCenter server, and can be applied to any supporting cluster that the vCenter server is managing. Therefore, when replacing a vCenter server in an already existing cluster (as described in "Replace vCenter server on existing vSAN cluster" in this sect ion of the operations guide), the storage policies will either need to be recreated, or imported from a previous time in which they were exported from vCenter.

Protecting storage policies in bulk form will simplify the restoration process, and will help prevent unnecessary resynchronization from occurring due to some unknown difference in the storage policy definition.

Procedures

The option of exporting and importing storage policies is not available in the UI, but a simple PowerCLI script will be able to achieve the desired result. Full details and additional options for importing and exporting policies using PowerCLI can be found in the PowerCLI Cookbook for vSAN.

```
Back up all storage policies managed by a vCenter server:

# Back up all storage policies

# Get all of the Storage Policies

$StoragePolicies = Get-SpbmStoragePolicy

# Loop through all of the Storage Policies

Foreach ($Policy in $StoragePolicies) {

# Create a path for the current Policy

$FilePath = "/Users/Admin/SPBM/"+$Policy.Name+".xml"

# Remove any spaces from the path

$FilePath = $FilePath -Replace (' ')
```

```
# Export (backup) the policy

Export-SpbmStoragePolicy -StoragePolicy $Policy -FilePath $FilePath

}

Importing or restoring all storage policy XML files that reside in a single directory

# Recover the Policies in /Users/Admin/SPBM/ $PolicyFiles = Get-ChildItem
"/Users/Admin/SPBM/" -Filter *.xml

# Enumerate each policy file found

Foreach ($PolicyFile in $PolicyFiles) {

# Get the Policy XML file path

$PolicyFilePath = $PolicyFile.FullName

# Read the contents of the policy file to set variables

$PolicyFileContents = [xml](Get-Content $PolicyFilePath)

# Get the Policy's name & description $PolicyName =
$PolicyFileContents.PbmCapabilityProfile.Name.'#text'

$PolicyDesc = $PolicyFileContents.PbmCapabilityProfile.Description.'#text'

# Import the policy

Import-SpbmStoragePolicy -Name $PolicyName -Description $PolicyDesc -FilePath $PolicyFile

}
```

When restoring a collection of storage policies to a newly built vCenter server, it will make most sense to restore them at the earliest possible convenience so that vSAN has the abilities to associate the objects with the respective storage policies.

Recommendation: Introduce some scripts to automate the process of regularly exporting your storage policies to a safe location, on a regular basis. It is a practice that is highly recommended for the vDS' managed by vCenter, and should be applied to storage policies as well.

Protecting vSphere Distributed Switches Powering vSAN

Virtual switches and the physical uplinks that are associated with them are the basis for connectivity in a vSAN powered cluster. Connectivity between hosts is essential for vSAN clusters since the network is the primary storage fabric, as opposed to three-tier architectures that may have a dedicated storage fabric.

VMware recommends the use of vSphere Distributed Switches (VDS) for vSAN. Not only do they provide additional capabilities to the hosts, they also provide a level of consistency, as the definition of the vSwitch and the associated port groups are applied to all hosts in the cluster. Since a vDS is a management construct of vCenter, it is recommended to ensure these are protected properly, in the event of unknown configuration changes, or if vCenter server is being recreated and introduced to an exist ing vSAN cluster.

Procedures

The specific procedures for exporting, importing, and restoring VDS configurations can be found at "Backing Up and Restoring a vSphere Distributed Switch Configuration." The process for each respective task is quite simple, but it is advised to become familiar with the process, and perhaps experiment with a simple export and restore in a lab environment to

become more familiar with the task. This will help minimize potential confusion for when it is needed most. Inspecting the data.xml file included in the zip file of the backup can also provide a simple way to review the settings of the vDS.

Recommendation: The VDS export option provides the ability to export just the vDS, or the vDS and all port groups. You may find it helpful to perform the export twice, using both options. This will allow for maximum flexibility in any potential restoration activities.

vDS can apply to more than one cluster. In any type of scenarios in which the VDS is restored from a backup, it will be important for the administrator to understand what clusters and respective hosts it may impact. Understanding this clearly will help minimize the potential impact of unintended consequences, and may also influence the naming/taxonomy of the vDS used by an organization, as the number of clusters managed by vCenter continues to grow.

Section 12: Upgrade Operations

Upgrading and Patching vSAN Hosts

Upgrading and patching vSAN hosts is very similar to the process for vSphere hosts using traditional storage. The unique role that vSAN plays means there are additional considerations to be included in operational practices to ensure predictable results.

vSAN is a cluster-based storage solution. Each ESXi host in the vSAN cluster participates in a manner that provides a cohesive, single storage endpoint for the VMs running in the cluster. Since it is built directly into the hypervisor, ESXi depends heavily on the expected interaction between hosts to provide a unified storage system. This can be dependent on consistency of the following:

- The version of ESXi installed on the host.
- Firmware versions of key components, such as storage controllers, NICs, and BIOS.
- Driver versions (VMware-provided "inbox" or vendor-provided "async") for the respective devices.

Inconsistencies between any or all of these may change the expected behavior between hosts in a cluster. Therefore, **avoid mixing vSAN/ESXi versions in the same cluster for general operation.** Limit inconsistency of versions on hosts to the cluster upgrade process, where updates are applied one host at a time until complete. The Knowledge Base contains additional recommendations on vSAN upgrade best practices.

Recommendation: Subscribe to the VCG Notification service in order to stay informed of changes with compatibility and support of your specified hardware and the associated firmware, drivers, and versions of vSAN.

Tips for using vLCM in an Existing Environment

The recommendations listed below will improve the transition to vLCM in your environment.

- **Download and install the latest vendor plugin(s).** This is the first step in establishing the intelligence between vLCM, the respective vendor repositories, VMware, and the hosts in your cluster. Depending on the server vendor, the configuration and operation of the plugin may vary slightly. VMware built this flexibility with the vendors in mind to best accommodate their repositories, and capabilities.
- **Ensure you have the server OEM's vLCM plugin/HSM downloaded and installed.** This will allow you to experience, and experiment with more complete lifecycle management of the host.
- **Build your desired image with multiple models (from the same vendor) in mind.** While vLCM (up to and including vSphere 8 U3) is limited to a single desired-state image per cluster, and this desired image can only be created by using one server manufacturer, the image can have drivers and firmware for different models from the server manufacturer. This approach will help ensure that all hosts in the cluster can be updated even if a cluster consists of hosts with some variations in device types or even an update specification of a ReadyNode.
- **Ensure your operational run-books for server updates are updated to reflect vLCM.** Make sure old procedures such as manually updating VIBs does not undermine the lifecycle management of the cluster. Since a vLCM enabled cluster manages this differently, applying those same practices may incorrectly introduce "drift" (move away from the desired state) into a cluster.

The benefits vLCM brings show up most when scale, consistency, and frequency of updates are top-of-mind. Clusters are managed by a single desired-state image which helps ensure consistency and reduces the obstacles typically associated with the lifecycle management process.

Recommendation: In some cases where there may be a variety of server vendors in the same environment, vSAN HCI with datastore sharing can be used to accommodate the transition of some clusters to vLCM. For example, in environments using VUM, a host from any vendor could be decommissioned from one cluster and moved over to another cluster using another vendor. With the current requirement for homogeneous configurations with vLCM, one could instead keep the clusters the same, but use vSAN HCI with datastore shring to borrow storage resources.

Upgrade Considerations for Different vSAN Topology Types

Lifecycle management using vLCM will be very similar regardless of the type of vSAN deployment, or topology.

- **2-Node topologies.** In 2-node clusters, for all clusters running vSAN 7 U1 or later, the witness host should be updated prior to upgrading the hosts in the cluster that use the witness host. In later versions of vSAN, vLCM will be able to update the virtual witness host appliance.
- **Stretched cluster topologies.** In stretched clusters, for all clusters running vSAN 7 U1 or later, the witness host should be updated prior to upgrading the hosts in the cluster that use the witness host. In later versions of vSAN, vLCM will be able to update the virtual witness host appliance.
- **vSAN storage clusters and/or vSAN HCI with datastore sharing**. In a disaggregated topology, the server cluster an generally maintain an independent lifecycle management from the client clusters that mount the datastore. While it is not required, it may be best to factor in the dependency or relationship to these clusters during upgrades. However, since vLCM will always update a vSAN cluster one host at a time per cluster, the impact should be minimal.

Multi-Cluster Upgrading Strategies

While VMware continues to introduce to vSAN all new levels of performance, capabilities, robustness, and ease of use, the respective vSAN clusters must be updated to benefit from these improvements. While the upgrading process continues to be streamlined, environments running multiple vSAN clusters can benefit from specific practices that will deliver a more efficient upgrade experience.

vCenter server compatibility

In a multi-cluster environment, vCenter server must be running the version equal to, or greater than the version to be installed on any of the hosts for the clusters it manages. Ensuring that vCenter server is always running the very latest edition will guarantee compatibility among all potential host versions running in a multi-cluster arrangement, and introduce enhancements to vCenter that independent from the clusters it is managing.

Recommendation: Periodically check that vCenter is running the latest edition. The vCenter Server Appliance Management Interface (VAMI) can be accessed using https://vCenterFQDN:5480.

Phasing in new versions of vSAN

As noted in the “Upgrading and Patching vSAN Hosts” section, vSAN is a cluster-based solution. Therefore, upgrades should be approached per cluster, not per host. With multi-cluster environments, IT teams can phase in a new version of vSAN per cluster to meet any of their own vetting, documentation, and change control practices. Similar to common practices in application maintenance, upgrades can be phased in on less critical clusters for testing and validation prior to rolling out the upgrade into more critical clusters.

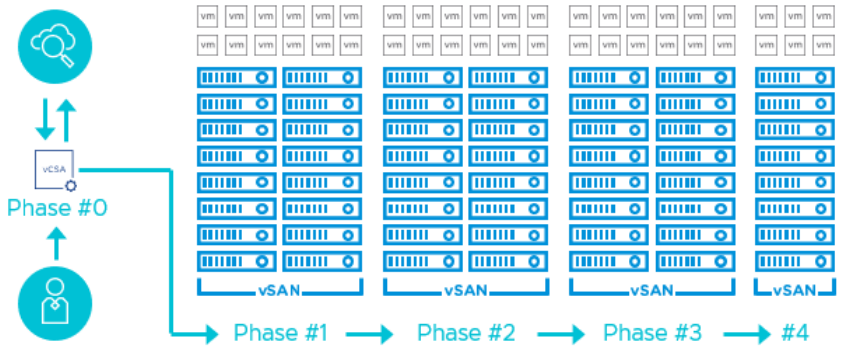


Figure. Phasing in new versions of vSAN per cluster

Cluster update procedures are not just limited to hypervisor upgrades, but should also include firmware and drivers for NICs, storage controllers, and BIOS versions. See "Upgrading Firmware and Drivers for NICs and Storage Controllers" and "Using VUM to Update Firmware on Selected Storage Controllers" for more detail. Recommendation: Update to the very latest version available. If a cluster is several versions behind, there is no need to update the versions one at a time. The latest edition has more testing and typically brings a greater level of intelligence to the product and the conditions it runs in.

Parallel upgrades

While vSAN limits the upgrade process to one host at a time within a vSAN cluster, cluster upgrades can be performed concurrently if desired. vLCM supports up to 64 concurrent cluster update activities. This can speed up host updates across larger data centers. Whether to update one cluster or multiple clusters at a time is at your discretion based on understanding tradeoffs and your procedural limitations.

Updating more hosts simultaneously should be factored into the vSAN cluster sizing strategy. More clusters with fewer hosts allows for more parallel remediation than fewer clusters with more hosts. For example, an environment with 280 hosts could cut remediation time in half if the design was 20 clusters of 14 hosts each, as opposed to 10 clusters of 28 hosts each.

Since a vSAN cluster is its own discrete storage system, administrators may find greater agility in operations and troubleshooting. "vSAN Cluster Design—Large Clusters Versus Small Clusters" discusses the decision process of host counts and cluster sizing in great detail.

Larger environments with multiple vSAN clusters may have different generations of hardware. Since drivers and firmware can cause issues during an update process, concurrent cluster upgrades may introduce operational challenges to those managing and troubleshooting updates. Depending on the age and type of hardware, a new version of vSAN could be deployed as a pilot effort to a few clusters individually, then could be introduced to a larger number of clusters simultaneously. Determine what level of simultaneous updates is considered acceptable for your own organization.

Recommendation: Focus on efficient delivery of services during cluster updates, as opposed to speed of update. vSAN restricts parallel host remediation. A well-designed and -operating cluster will seamlessly roll through updating all hosts in the cluster without interfering with expected service levels.

Why are vSAN clusters restricted to updating one host at a time? Limiting to a single host per cluster helps reduce the complexity of subtracting not only compute resources but storage capacity and performance. Factoring in available capacity in addition to compute resources is unique to an HCI architecture. Total available host count can also become important for some data placement policies such as FTT=2 using RAID-6 erasure coding. Limiting the update process to one host at a time per cluster also helps avoid this complexity, while reducing the potential need for data movement due to resynchronization.

Upgrading Large vSAN Clusters

Standard vSAN clusters can range from 3 to 64 hosts. Since vSAN provides storage services per cluster, a large cluster is treated in the same way as a small cluster: as a single unit of services and management. Maintenance should occur per cluster and is sometimes referred to as a "maintenance domain."

Upgrading vSAN clusters with a larger quantity of hosts is no different than upgrading vSAN clusters with a smaller quantity of hosts. In addition, those described in "Upgrading and Patching vSAN Hosts," there are a few additional host upgrade considerations to be mindful of during these update procedures.

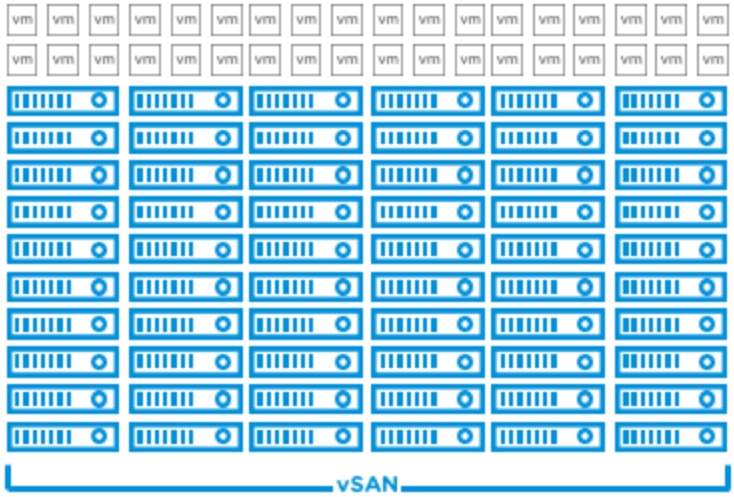


Figure. Visualizing the "maintenance domain" of a single large vSAN cluster

vLCM and VUM are limited to updating one host at a time in a vSAN cluster. The length of time for the cluster to complete an update is proportional to the number of hosts in a cluster. To upgrade more than one host at a time, reduce the size of the maintenance domain by creating more clusters comprising fewer hosts. This smaller maintenance domain will allow for more hosts (one per cluster) to perform parallel upgrades.

Designing an environment that has a modest maintenance domain is one of the most effective ways to improve operations and maintenance of a vSAN-powered environment. For more information on this approach, see the topic "Multi-Cluster Upgrading Strategies."

While no more than one host per vSAN cluster can be upgraded at a time, there are some steps that can be taken to potentially improve the upgrade speed.

- Use hosts that support the Quick Boot feature. This can help host restart times. Since hosts in a vSAN cluster are updated one after the other, reducing host restart times can significantly improve the completion time of the larger clusters.
- If a large cluster has relatively few resources used, an administrator may be able to place multiple hosts into maintenance mode safely without running short of storage and capacity resources. Updates will still occur one host at a time, but this may save some time placing the respective hosts into maintenance mode. This would only be possible in large clusters that are underused, and actual time savings may be negligible.

Recommendation: Focus on efficient delivery of services during cluster updates, as opposed to speed of update. vSAN restricts parallel host remediation of hosts. A well-designed and -operating cluster will seamlessly roll through updating all hosts in the cluster without interfering with expected service levels.

Larger vSAN clusters may better absorb reduced resources as a host enters maintenance mode for the update process. Proportionally, each host contributes a smaller percentage of resources to a cluster. Large clusters may also see slightly less data movement than much smaller clusters to comply with the "Ensure accessibility" data migration option when a host is entered into maintenance mode. For more information on the tradeoffs between larger and smaller vSAN clusters, see "vSAN Cluster Design—Large Clusters Versus Small Cluster"

Note that the ESA may be better at handling upgrades of large cluster sizes. This is due to a collection of enhancements that allow vSAN to complete the update process on each host faster on average than the hosts running the OSA.

Upgrading Firmware and Drivers for NICs and Storage Controllers

Outdated or mismatched firmware and drivers for NICs and Storage Controllers can impact VM and or vSAN I/O handling. While VUM handles updates of firmware and drivers for a limited set of devices, firmware and driver updates remain a largely manual process. Whether installed directly on an ESXi server from the command line or deployed using vLCM, ensure the correct firmware and drivers are installed, remain current to the version recommended, and are a part of the cluster lifecycle management process.

vLCM strives to simplify the coordination of firmware and driver updates for select hardware. It has a framework to coordinate the fetching of this software from the respective vendors for the purposed of building a single desired state image for the hosts.

Recommendation: Subscribe to the VCG Notification service in order to stay informed of changes with compatibility and support of your specified hardware and the associated firmware, drivers, and versions of vSAN.

Section 13: vSAN Capacity Management

Observing Storage Capacity Consumption Over Time

An increase in capacity consumption is a typical trend that most data centers see, regardless of the underlying storage system used. vSAN offers a number of different ways to observe changes in capacity. This can help with understanding the day-to-day behavior of the storage system, and can also help with capacity forecasting and planning.

Observing capacity changes over a period of time can be achieved in two ways: vCenter and VCF Operations.

Both provide the ability to see capacity usage statistics over time and the ability to zoom into a specific time window. Both methods were designed for slightly different intentions, and have different characteristics.

Capacity history in vCenter Server

- Natively built into the vCenter UI and easily accessible.
- Can show a maximum of a 30-day window.
- Data in performance service retained for 90 days, and this retention period is not guaranteed.
- Data will not persist if vSAN performance service is turned off then back on.

Capacity history in VCF Operations

- Much longer capacity history retention periods, per configuration of Aria Operations.
- While Aria Operations requires the vSAN performance service to run for data collection, the capacity history will persist if the vSAN performance service is turned off then back on.
- Able to correlate with other relevant cluster capacity metrics, such as CPU and memory capacity.
- Can view aggregate vSAN cluster capacity statistics.
- Breakdowns of capacity usage with and without DD&C.
- Requires Aria Operations Advanced licensing or above.

The vSAN capacity history in vCenter renders the DD&C ratio using a slightly different unit of measurement than found in the vSAN capacity summary in vCenter and in VCF Operations. The capacity summary in vCenter and VCF Operations displays the savings as a ratio (e.g., 1.96x) whereas the vSAN capacity history renders it at a percentage (e.g., 196%). Both are accurate.

Also note that vCenter's UI simply states, "Deduplication Ratio." The number presented actually represents the combined savings from DD&C.

Recommendation: Look at the overall capacity consumed after a storage policy change, rather than simply a DD&C ratio. Space efficiency techniques like erasure codes may result in a lower DD&C ratio, but actually increase the available free space.

Estimating Approximate "Effective" Free/Usable Space in vSAN Cluster

With the ability to prescriptively assign levels of protection and space efficiency through storage policies, the amount of capacity a given VM consumes in a vSAN cluster is subject to the attributes of the assigned policy. While this offers an impressive level of specificity for a VM, it can make estimating free or usable capacity of the VM more challenging. Recent editions of vSAN offer a built-in tool to assist with this effort.

The vSAN performance service provides an easy-to-use tool to help estimate available free usable capacity given the selection of a desired policy. Simply select the desired storage policy, and it will estimate the free amount of usable capacity with that given policy.

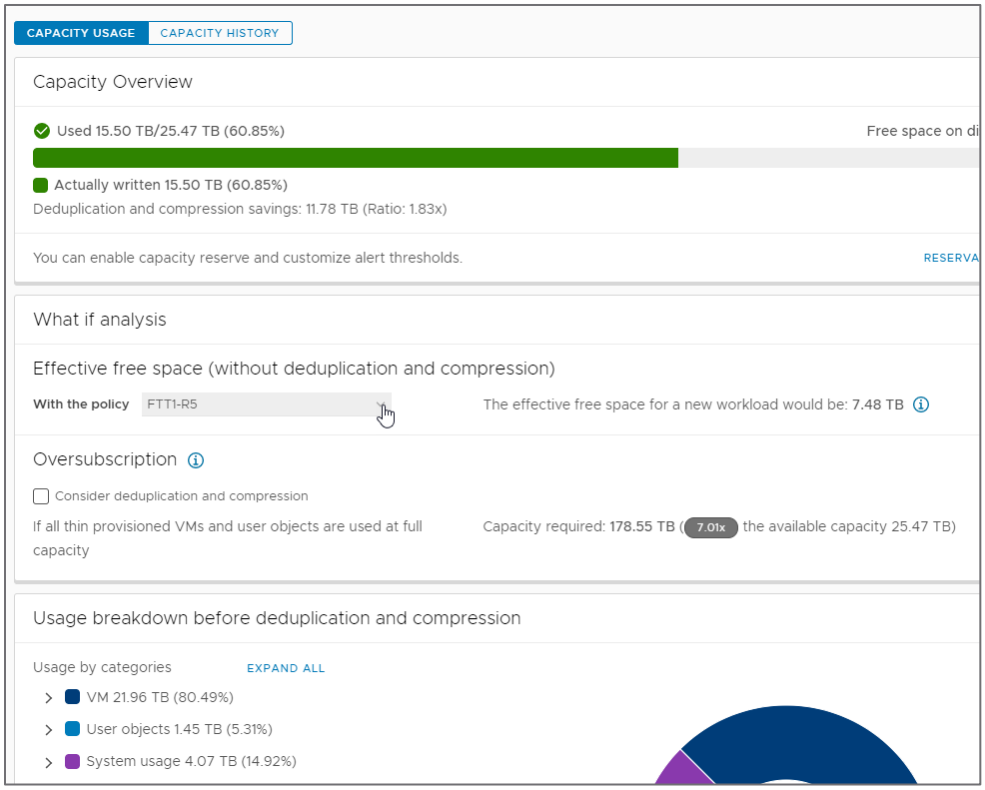


Figure. The free capacity with policy calculator in the vSAN UI found in vCenter

The tool provides a calculation for only the free raw capacity remaining. Capacity already consumed is not accounted for in this estimating tool. The estimator looks at the raw capacity remaining, and then applies the traits of the selected policy to determine the effective amount of free space available. Note that it does not account for the free space needed for slack space as recommended by VMware.

Recommendation: If you are trying to estimate the free usable space for a cluster knowing that multiple policies will be used, select the policy used that is the least space efficient. For example, if an environment will run a mix of FTT=1 protected VMs, but some use policies with RAID-1, while others use policies with the more space-efficient RAID-5, select the RAID-1 policy in the estimator to provide a more conservative number.

vSAN has the ability to see the "oversubscription" ratio. This helps the administrator easily understand the estimated capacity necessary for fully allocated capacity of thin provisioned objects. It factors in the storage policy used, and optionally, deduplication and compression. This can be extremely helpful for organizations who like to maintain a specific oversubscription ratio for their storage capacity.

As capacity utilization grows, administrators need to be properly notified when critical thresholds are met, with customizable alerts available to generate notifications. Clicking on the "Learn More" within the UI will direct you to a "About Reserved Capacity" which will describe the actions as a result of reaching these thresholds. These are considered “soft thresholds” meaning that they will enforce some operational changes, but allow critical activities to continue. When reservations are met, health alerts will be triggered to indicate the condition. Provisioning of new VMs, virtual disks, FCDs, linked and full clones, iSCSI targets, snapshots, file shares, etc. will not be allowed when the threshold has been exceeded. (note that thick provisioned disk will fail at the time of creation if it exceeds the threshold, where thin provision disks may prevent expansion). **I/O activity for existing VMs will continue** as the threshold is exceeded.

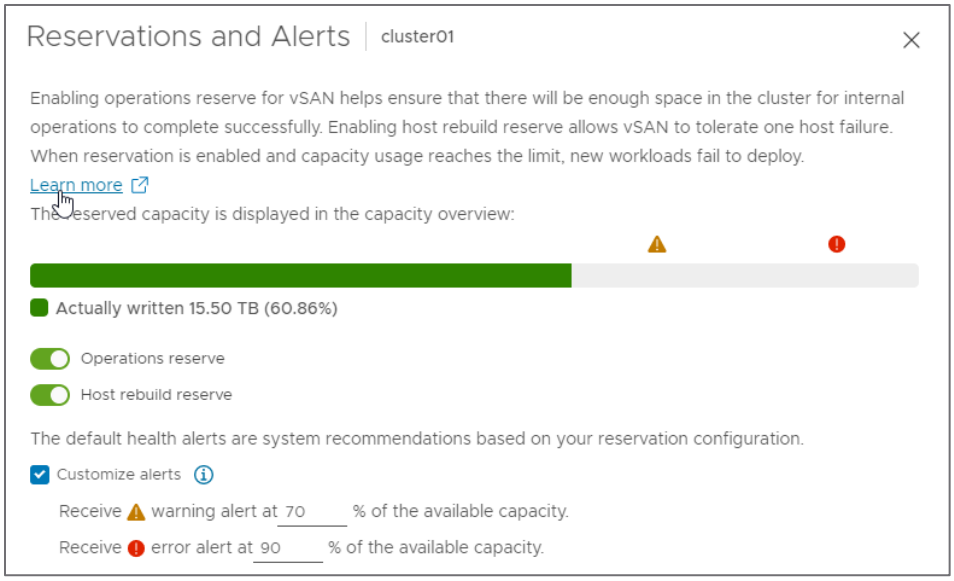


Figure. Alarm thresholds in vSAN

Capacity consumption is usually associated with bytes of data stored versus bytes of data remaining available. There are other capacity limits that may inhibit the full utilization of available storage capacity. vSAN OSA has a soft limit of no more than 200 VMs per host (500 VMs for ESA), and a hard limit of object components of no more than 9,000 components per host for OSA, and 27,000 components per host for ESA. Certain topology and workload combinations, such as servers with high levels of compute and storage capacity that run low capacity VMs may run into these other capacity limits. Sizing of these capacity considerations should be a part of a design and sizing exercise.

The new paradigm of Reserved Capacity in more recent editions of vSAN has been described extensively in the post: "Understanding Reserved Capacity Concepts in vSAN." Other helpful links on this topic include the posts: "Demystifying Capacity Reporting in vSAN" and "The Importance of Space Reclamation for Data Usage Reporting in vSAN."

Resize Custom Namespace Objects

The ability to resize custom namespace objects such as ISO directories and content libraries was introduced in vSAN 8 U1, supporting both ESA and OSA. This capability is not available in the UI, but is available via API, and through PowerCLI using multiple cmdlets. The example below demonstrates the ability to view and resize the desired namespace object.

After connecting to VI server,

```
PS C:\Users\User1> $services = Get-view 'ServiceInstance'

PS C:\Users\User1> $datastoreMgr = Get-view $services.Content.DatastoreNamespaceManager

PS C:\Users\User1> $datacenter = get-datacenter

PS C:\Users\User1>
$datastoreMgr.DeleteDirectory($datacenter.ExtensionData.MoRef,"/vmfs/volumes/vsan:526916282a8
ec9e1-95c4972ba093a2ec/6771b663-4b89-170b-f416-0200368ec988")

PS C:\Users\User1> $datastore = get-datastore

PS C:\Users\User1>
$datastoreMgr.CreateDirectory($datastore.ExtensionData.MoRef,"CodyTest2",$null,16777216)

/vmfs/volumes/vsan:526916282a8ec9e1-95c4972ba093a2ec/fa77b663-8748-3a1e-e9a6-0200368ec988
```

```
PS C:\Users\User1>
$datastoreMgr.QueryDirectoryInfo($datacenter.ExtensionData.MoRef,"/vmfs/volumes/vsan:526916282a8ec9e1-95c4972ba093a2ec/fa77b663-8748-3a1e-e9a6-0200368ec988")

Capacity Used

-------- ----

16777216 2223

PS C:\Users\User1> $datastoreMgr.IncreaseDirectorySize($datacenter.ExtensionData.MoRef,
"/vmfs/volumes/vsan:526916282a8ec9e1-95c4972ba093a2ec/fa77b663-8748-3a1e-e9a6-0200368ec988",
33554432)
```

Section 14: Monitoring vSAN Health

Remediating vSAN Health Alerts

The vSAN Skyline health UI provides an end-to-end approach to monitoring and managing the environment. Health finding alerts are indicative of an unmet condition or deviation from expected behavior.

The alerts can typically stem out of:

- Configuration inconsistency
- Exceeding software/hardware limits
- Hardware incompatibility
- Failure conditions

The ideal methodology to resolve a Skyline health alert is to correct the underlying situation. An administrator can choose to suppress the alert in certain situations.

vSAN 8 U1 introduced a new way to understand the severity and priority of triggered health checks in a vSAN cluster. Through a sophisticated set of relationships and weighting, Skyline health for vSAN can help you understand how severe the triggered health checks are, and what triggered health check is most important to remediate. For more information, see the post: "Skyline Health Scoring, Diagnostics, and Remediation in vSAN 8 U1."

Checking Object Status and Health during a Failure

An object is a fundamental unit in vSAN around which availability and performance are defined. This is done by abstracting the storage services and features of vSAN and applying them at an object level through SPBM. For a primer on vSAN objects and components, see the post: "vSAN Objects and Components Revisited."

At a high level, an object's compliance with the assigned storage policy is enough to validate its health. In certain scenarios, it may be necessary to inspect the specific state of the object, such as in a failure.

In the event of a failure, ensure all objects are in a healthy state or recovering to a healthy state. vSAN object health check provides a cluster-wide overview of the object's health and its respective states. This health check can be accessed by clicking on the vSAN cluster and viewing the Monitor tab. The data section comprises information specific to the object health check.

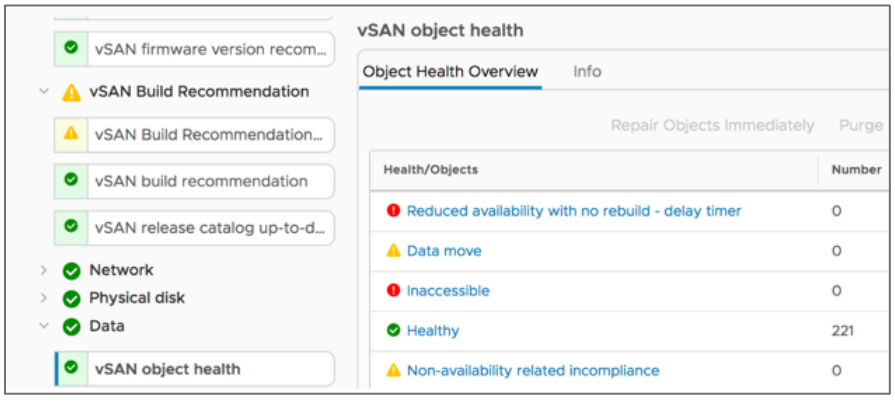


Figure. Viewing object health with the vSAN health checks.

On failure detection, vSAN natively initiates corrective action to restore a healthy state. This, in turn, reinstates the object's compliance with the assigned policy. The health check helps quickly assess the impact and validates that restoration is in progress. In certain cases, based on the nature of failure and the estimated restoration time, an administrator may choose to override or expedite the restoration.

Monitoring and Management of vSAN Object Components

VMware vSAN uses a data placement approach that is most analogous to an object store. VMs that live on vSAN storage are comprised of several storage objects - which can be thought of as a unit of data. VMDKs, VM home namespace, VM swap areas, snapshot delta disks, durability data, and snapshot memory maps are all examples of storage objects in vSAN. Object data is placed across hosts in the cluster in a manner that ensures data resilience. Resilience, space efficiency, security, and other settings related to a vSAN object are easily managed by the Administrator through the use of storage policies. For a primer on vSAN objects and components, see the post: "vSAN Objects and Components Revisited."

A vSAN object is comprised of one or more "components." Depending on the object size, applied storage policy, and other environmental conditions, an object may consist of more than one component. This sharded data is simply an implementation detail of vSAN and not a manageable entity.

The **vSAN OSA has a maximum of 9,000 components per vSAN host.** A small 4-host vSAN cluster would have a limit of 36,000 components per cluster whereas a larger 32-host vSAN cluster would have a limit of 288,000 components per cluster. The Skyline Health Service for vSAN in vCenter Server includes a health check called "Component" that monitors component count at a cluster level and per-host level and alerts if the hosts are nearing their threshold. A yellow health alert warning will be triggered at 80% of the host component limit, while a red health alert error will be triggered at 90% of the host component limit.

Note that the **vSAN ESA has a maximum component limit of 27,000 per host.** This 3x increase is to help ensure that the additional components used in the ESA do not hit the previous limit of 9,000. At this time, the maximum supported number of VMs per host for vSAN ESA is 500, and for OSA, it remains at 200.

A component limit per host exists primarily to keep host resource consumption to reasonable levels. A distributed scale-out storage system like vSAN must create and manage data about the data. This metadata is what allows for the seamless scalability and adaptability of a vSAN cluster. As data is sharded into more components, additional resources may be consumed to manage the data. The component limit helps keep memory and CPU requirements of vSAN to reasonable levels while still maintaining resources for guest VM consumption. In most cases, in OSA, the hard limit of 9,000 components per host should be sufficient for the soft limit of 200 VMs per vSAN host.

The component and VM limits add another dimension to capacity management considerations that will impact both the design of a vSAN cluster, as well as the operation of a vSAN cluster. See the section topic "Estimating Approximate 'Free/Usable Space in vSAN Cluster" for more details.

Recommendations to Mitigate

There can be some circumstances where component counts in a vSAN cluster are approaching their limit. In those relatively rare cases, the following recommendations can help mitigate these issues.

- **Add another host to the vSAN cluster.** Adding another host can quickly relieve the pressure of clusters approaching a per-host maximum. Let's use a 7-host vSAN cluster with a theoretical component limit of 63,000 as an example. A component count of 57,000 would trigger a red health alert error, as it exceeds 90% utilization. Adding a host to the cluster would increase the theoretical component limit to 72,000. The component count of 57,000 would not even trigger a health alert warning, as it falls below the 80% threshold. Once the host was added, the Automatic Rebalancing in a vSAN cluster would take steps to evenly distribute the data across the hosts.
- **Minimize use of storage policies using the stripe width rule.** The stripe width rule aims to improve the performance of vSAN under very specific conditions. In many scenarios, it will unnecessarily increase the component count while having little to no effect on performance. For ESA, do not use the stripe width storage policy rule for any circumstances. For more information, see the post: "Stripe Width Storage Policy Rule in the vSAN ESA."
- **In OSA, choose your data placement scheme (RAID-1, RAID-5 or RAID-6) wisely.** For smaller VMs, RAID-1 data placement schemes will typically produce the fewest number of components. While VMs consuming more capacity may use fewer components per object in a RAID-5 or RAID-6 erasure code. This is because a component has a

maximum size of 255 GB. If a VMDK is 700GB in size, under a FTT=1, RAID-1 data placement scheme, it would create a total of 7 components across three hosts: 3 components for each object replica, and 1 component for the witness. This same 700GB object using a RAID-5 erasure code would create just 4 components across four hosts. This guidance is not as relevant for ESA, so it can be ignored.

- **Upgrade to the latest version of vSAN.** Recent updates to vSAN reduce the number of components created for objects using RAID-5/6 erasure coding, especially for objects larger than 2TB. See the post: Stripe Width Improvements in vSAN 7 U1 for more details.
- **Ensure sufficient free capacity in the cluster.** Capacity constrained clusters may split components up into smaller chunks to fit the component on an available host which can increase component count.
- **Maintain good snapshot hygiene.** Snapshots create additional objects (applicable to OSA only), which adds to the overall component count, often times doubling the component count of the VM with each and every snapshot. Make sure that snapshots are used only for temporary purposes, such as with your VADP-based backup solution or API driven solution such as VMware Horizon using clones. Ensure that if you are using snapshots as a part of an existing workflow, that they are temporary, and are not retaining multiple snapshots for a given object.

Viewing vSAN Cluster Partitions in the Health Service UI

vSAN inherently employs a highly resilient and distributed architecture. The network plays an important role in accommodating this distributed architecture.

Each host in the vSAN cluster is configured with a VMkernel port tagged with vSAN traffic and should be able to communicate with other hosts in the cluster. If one or more hosts are isolated, or not reachable over the network, the objects in the cluster may become inaccessible. To restore, resolve the underlying network issue.

There are multiple network-related validations embedded as part of the health service to detect and notify when there is an anomaly. These alerts ought to be treated with the highest priority, specifically the vSAN cluster partition. Health service UI can provide key diagnostic information to help ascertain the cause.

Recommendation: Focus on discovering the root cause of the cluster partition issue. A triggered cluster partition health check is often a symptomatic triggered alert as a result of some other issue that was the cause. If the cause is from an issue captured by another Skyline health check, this will show up in the new health check correlation feature as the "Primary issue." of the cluster partition.

Accessing the health service UI

The vSAN Skyline Health service UI provides a snapshot of the health of the vSAN cluster and highlights areas needing attention. Each health check validates whether a certain condition is met. It also provides guidance on remediation when there is a deviation from expected behavior. The UI can be accessed by clicking on the vSAN cluster and viewing the Monitor tab. The specific “vSAN cluster partition” health check is a good starting point to determine the cluster state. A partition ID represents the cluster as a single unit. In an ideal state, all hosts reflect the same partition ID. Multiple subgroups within the cluster indicate a network partition requiring further investigation. At a micro level, this plausibly translates to an object not having access to all of its components.

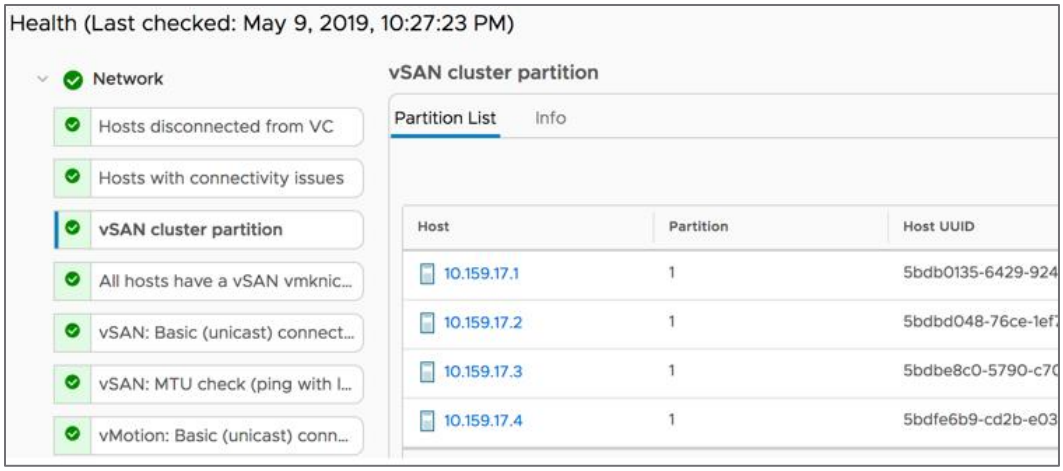


Figure. Identifying unhealthy network partitions in a vSAN cluster

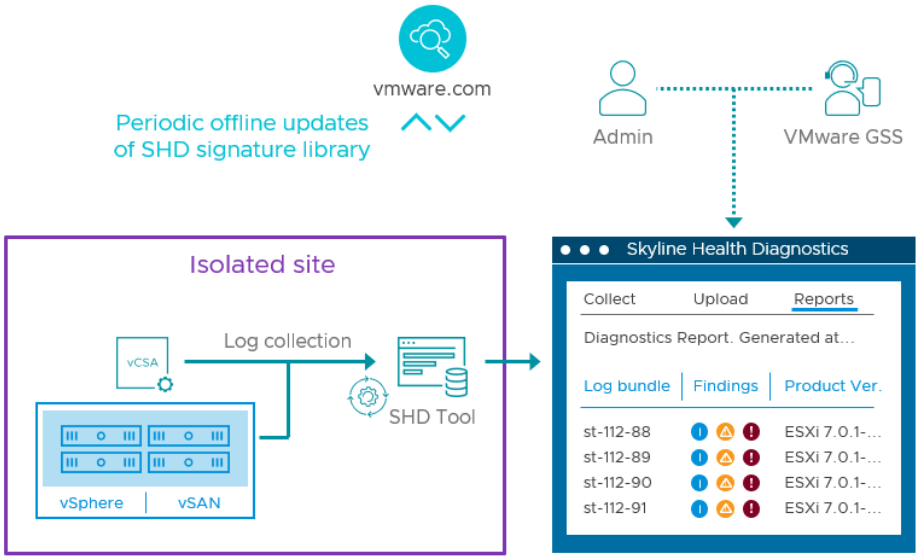
The network section in the health service UI has a plethora of network tests that cover some basic yet critical diagnostics, such as ping, MTU Check, Unicast connectivity, and host connectivity with vCenter. Each health check can systematically confirm or eliminate a layer in the network as the cause.

Recommendation: As with any network troubleshooting, a layered methodology is strongly recommended (top-down or bottom-up).

Monitoring and Management of Isolated vSAN Environments

Some environments require full isolation from any management access of a vSAN cluster to the Internet. While this is quite easy to do, it can pose additional operational challenges in asynchronous health check updates, troubleshooting and incident support with VMware Global Support.

vSAN 7 U2 introduced support for the VMware Skyline Health Diagnostics Tool (SHD). The Skyline Health Diagnostics tool is a self-service tool that brings some of the benefits of Skyline health directly to an isolated environment. The tool is run by an administrator at a frequency they desire. It will scan critical log bundles to detect issues, and give notifications and recommendations to important issues and their related KB articles. The goal for our customers is a faster time to resolution for issues, and for isolated environments, this is the tool to help with that.



Recommendation: For isolated environments, use the SHD Tool and the VMware vSAN VCG Notification Service together to help improve the management of your isolated vSAN clusters. The VCG notification service can provide hardware-based compatibility updates without any connectivity of the infrastructure to the internet. Administrators or others can view and subscribe to change notifications of compatibility in hardware against the VCG, as it relates to firmware, hypervisor versions, and drivers.

Section 15: Monitoring vSAN Performance

Navigating Across the Different Levels of Performance Metrics

The vSAN performance service provides storage-centric visibility to a vSAN cluster. It is responsible for collecting vSAN performance metrics and presents them in vCenter. A user can set the selectable time window from 1 to 24 hours, and the data presented uses a 5-minute sampling rate. The data may be retained for up to 90 days, although the actual time retained may be shorter based on environmental conditions.

vSAN 8 U1 introduced **high resolution performance metrics**. This allows the ability for the administrator to monitor critical performance metrics using 30 second intervals, which will be much more representative of the actual workload than the longer, 5 minute intervals. For more information, see the post: "High Resolution Performance Monitoring in vSAN 8 U1." This capability is available in the ESA and the OSA.

Levels of navigation

The vSAN performance service presents metrics at multiple locations in the stack. vSAN-related data can be viewed at the VM level, the host level, the disk and disk group level, and the cluster level. Some metrics such as IOPS, throughput, and latency are common at all locations in the stack, while more specific metrics may only exist at a specific location, such as a host. The performance metrics can be viewed at each location simply by highlighting the entity (VM, host, or cluster) and clicking on

Monitor → vSAN → Performance.

Figure. Collects and renders performance data at multiple levels

The metrics are typically broken up into a series of categories, or tabs at each level. Below is a summary of the tabs that can be found at each level.

- VM Level
  - **VM:** This tab presents metrics for the frontend VM traffic (I/Os to and from the VM) for all VMs on the selected host.
  - **Virtual disk:** This presents metrics for the VM, broken down by the individual VMDK and especially helpful for VMs with multiple VMDKs.
- Host Level

- **VM:** This tab presents metrics for the frontend VM traffic (I/Os to and from the VM) for all VMs on the selected host.
- **Backend:** This tab presents metrics for all backend traffic, as a result of replica traffic and resynchronization data.
- **Disks:** This tab presents performance metrics for the selected disk group, or the individual devices that compose the disk group(s) on a host.
- **Physical adapters:** This tab presents metrics for the physical uplink for the selected host.
- **Host network:** This tab presents metrics for the specific or aggregate VMkernel ports used on a host.
- **iSCSI:** This tab presents metrics for objects containing data served up by the vSAN iSCSI service.

- Cluster Level
  - **VM:** This tab presents metrics for the frontend VM traffic (I/Os to and from the VM) for all VMs living on the selected host.
  - **Backend:** This tab presents metrics for all backend traffic as a result of replica traffic and resynchronization data.
  - **iSCSI:** This tab presents metrics for objects containing data served up by the vSAN iSCSI service.

vSAN also includes a VM consolidated performance view. This solves some of the difficulties when attempting to compare performance metrics of more than one VM, side by side, and can be extremely helpful in doing comparisons and correlations. vSAN also has a Top Contributors view at the cluster level. This will help administrators quickly see VMs and disk groups that contribute to the most demand on resources provided by the vSAN cluster, and pairs nicely with the VM Consolidated performance view.

Typically, the cluster level is an aggregate of a limited set of metrics, and the VM level is a subset of metrics that pertain to only the selected VM. The host level is the location at which there will be the most metrics, especially as it pertains to the troubleshooting process. A visual mapping of each category can be found in the image below.

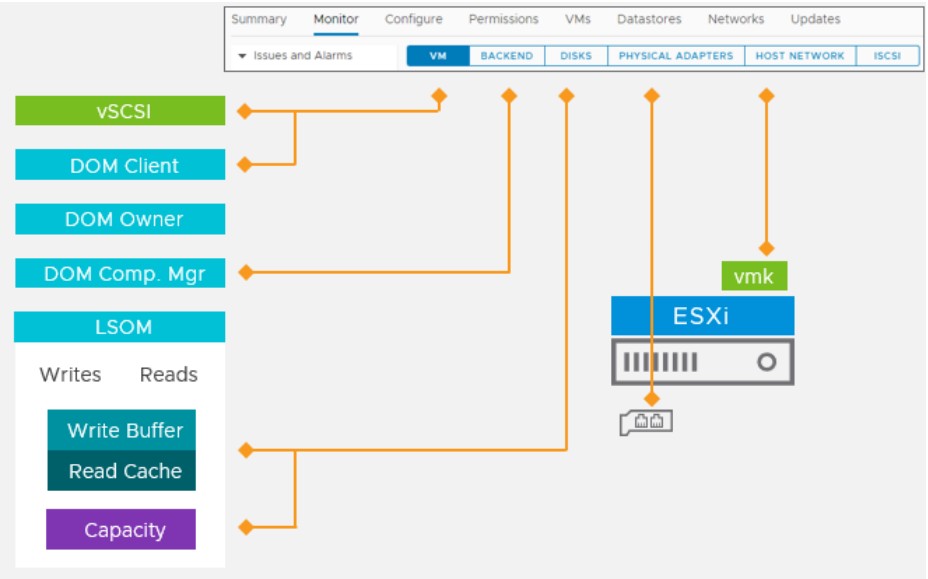


Figure. Provides vSAN-specific metrics and other vSphere-/ESXi-related metrics

Note that the performance service can only aggregate performance data up to the cluster level. It will not be able to provide aggregate statistics from multiple vSAN clusters. Aria Operations can achieve that result. Which are most important? They all relate to each other in some form or another. The conditions of the environment and the root cause of a performance issue will dictate which metrics are more significant than another. For more general information on troubleshooting vSAN, see the topic “Troubleshooting vSAN Performance” in this document. For a more detailed understanding of troubleshooting

performance as well as definitions to specific metrics found in the vSAN performance service, see "Troubleshooting vSAN Performance" on core.vmware.com.

Recommendation: If you need longer periods of storage performance retention, use Aria Operations. The performance data collected by the performance service does not persist after the service has been turned off then back on. Aria Operations fetches the performance data directly from the vSAN performance service, so the data will be consistent yet remain intact if the performance service needs to be disabled and enabled.

The information provided by the vSAN performance service (rendered in the vCenter Server UI) is the preferred starting point for most performance data collection and analysis scenarios. Depending on the circumstances, there may be a need for additional tooling that exposes different types of data, such as the vSAN's IOInsight or vSAN's VM I/O Trip Analizer. This aims to help administrators identify the primary points of contention (bottlenecks) more easily. A list of common tools used for performance diagnostics are listed in Appendix B of the Troubleshooting vSAN Performance document.

Troubleshooting vSAN Performance

Troubleshooting performance issues is a common challenge for many administrators, regardless of the underlying infrastructure and topology. A distributed storage platform like vSAN also introduces other elements that can influence performance, and the practices for troubleshooting should accommodate those. Use the metrics in the vSAN performance service to isolate the sources of the performance issue.

While originally developed prior to the debut of the ESA, the framework described is generally applicable to ESA clusters as well.

The performance troubleshooting workflow

The basic framework for troubleshooting performance in a vSAN environment is outlined in the image below. Each of the five steps is critical to identifying the root cause properly and mitigating it systematically.

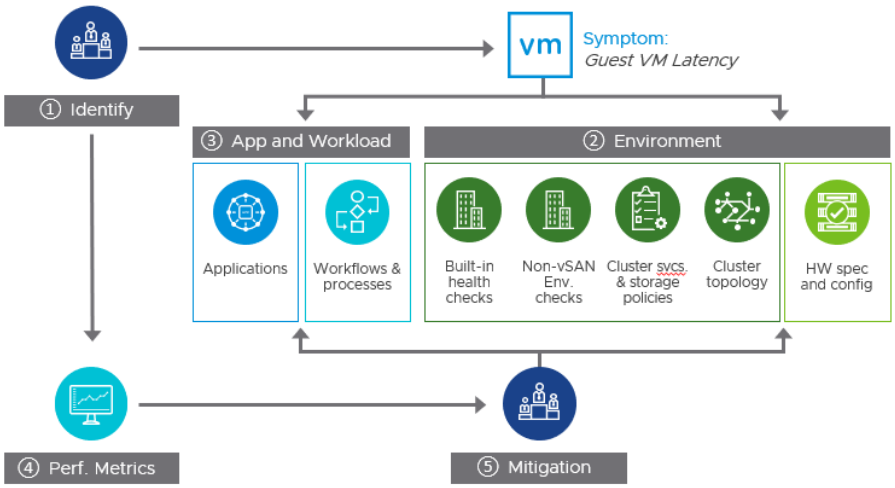


Figure. The troubleshooting framework

"Troubleshooting vSAN Performance" contains a more complete understanding of the performance troubleshooting process.

The order of review for metrics

Once steps 1–3 have been completed, begin using the performance metrics. The order in which the metrics are viewed can help decipher what level of contention may be occurring. The figure below shows the order in which to better understand and isolate the issue; it is the same order used in "Appendix C: Troubleshooting Example" in "Troubleshooting vSAN Performance."

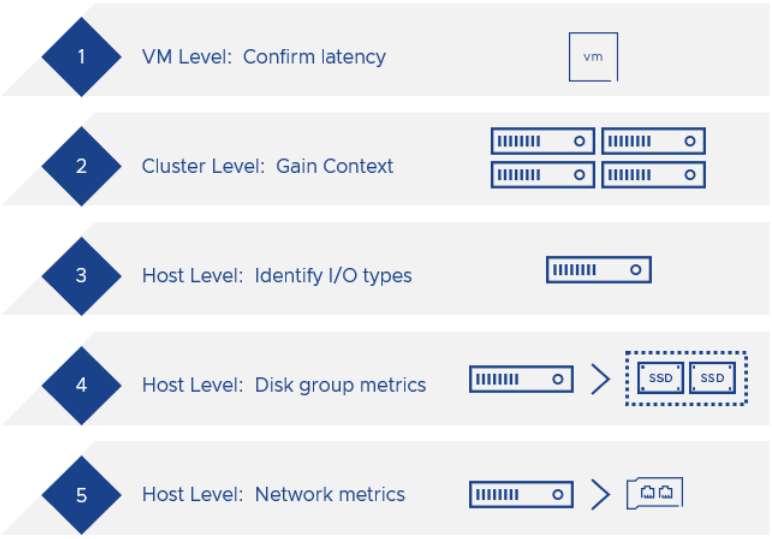


Figure. Viewing order of performance metrics

Here is a bit more context to each step:

- View metrics at the VM level to confirm unusually high storage related latency. This must be verified that there is in fact storage latency as seen by the guest VM.
- View metrics at the cluster level to provide context and look for other anomalies. This helps identify potential "noise" coming from somewhere else in the cluster.
- View metrics on the host to isolate the type of storage I/O associated with the latency.
- View metrics on the host, looking at the disk group level to determine type and source of latency.
- View metrics on the host, looking at the host network and VMkernel metrics to determine if the issue is network related.

Steps 3–5 assume that one has identified the hosts where the VM's objects reside. Host-level metrics should look at only the hosts where the objects reside for the particular VM in question. For further information on the different levels of performance metrics in vSAN, see the topic "Navigating Across the Different Levels of Performance Metrics."

Viewing metrics at the disk group level (OSA) can provide some of the most significant insight of all metrics. However, they shouldn't be viewed in complete isolation, as there will be influencing factors that affect these metrics.

Recommendation: Be diligent and deliberate when changing your environment to improve performance. Changing multiple settings at once, overlooking a simple configuration issue, or not measuring the changes in performance can often make the situation worse, and more complex to resolve.

Monitoring Resynchronization Activity

Resynchronizations are a common activity that occur in a vSAN environment. They are simply the process of replicating the data across the vSAN cluster so it adheres to the conditions of the assigned storage policy that determines levels of resilience, space efficiency, and performance. Resynchronizations occur automatically and are the result of policy changes to an object, host or disk group evacuations, rebalancing of data across a cluster, and object repairs should vSAN detect a failure condition.

Methods of visibility

Resynchronization visibility occurs in multiple ways: through vCenter, Aria Operations, and PowerCLI. The best method depends on what you attempt to view, and familiarity with the tools available.

Viewing resynchronizations in vCenter

Resynchronization activity can be found in vCenter in two different ways:

- At the cluster level as an enumerated list of objects currently being resynchronized
- At the host level as time-based resynchronization metrics for IOPS, throughput, and latency

Find the list of objects resynchronizing in the cluster by highlighting the cluster and clicking on Monitor → vSAN → Resyncing Objects.

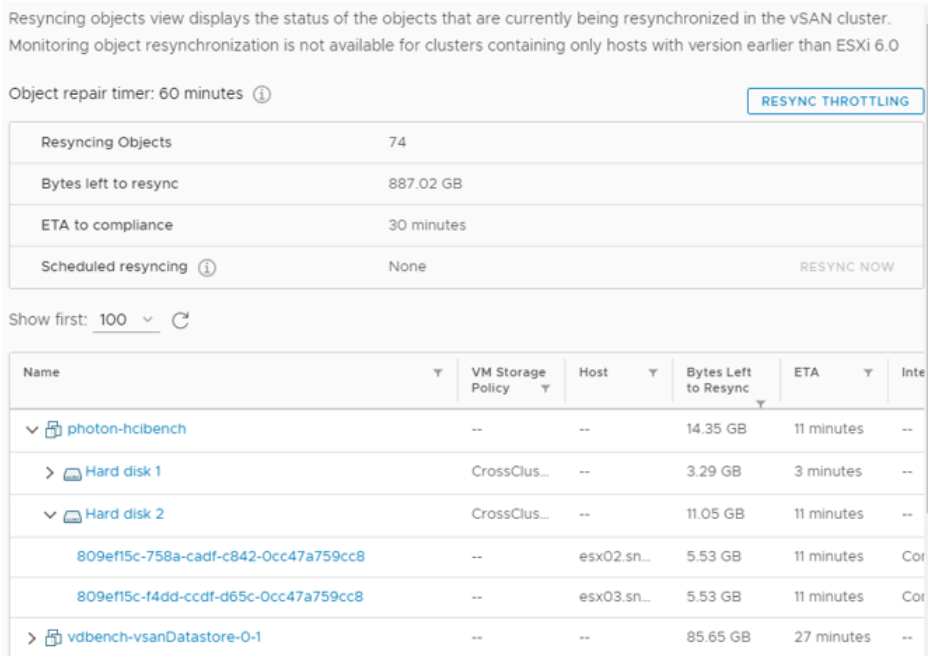


Figure. Viewing the status of resynchronization activity at the cluster level

Find time-based resynchronization metrics by highlighting the desired host and clicking on Monitor → vSAN → Performance → Backend.

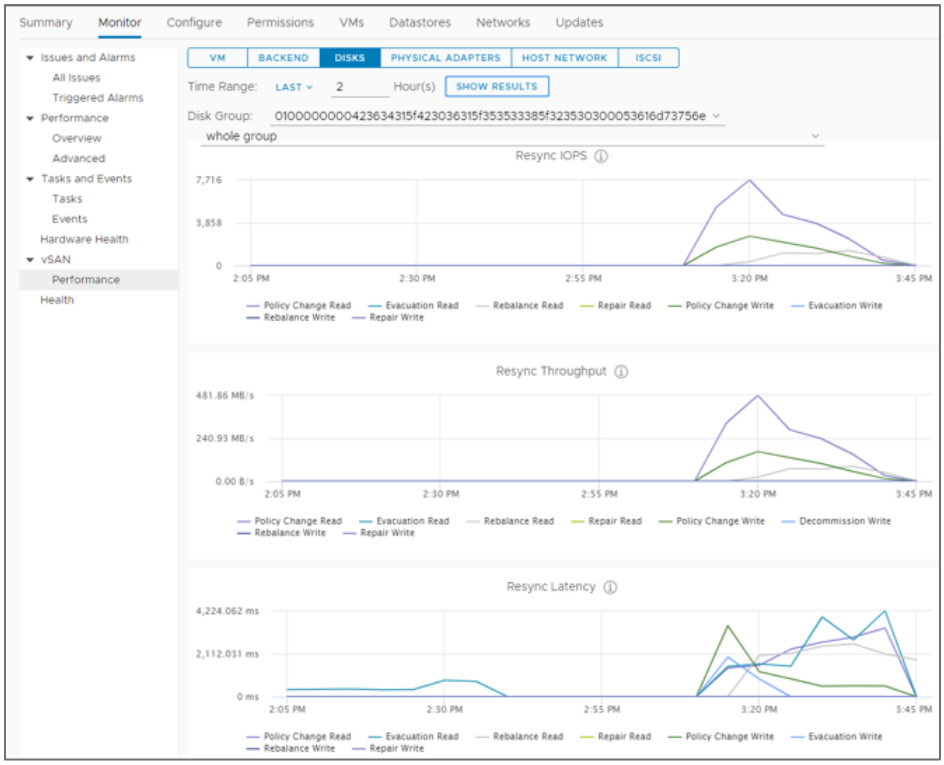


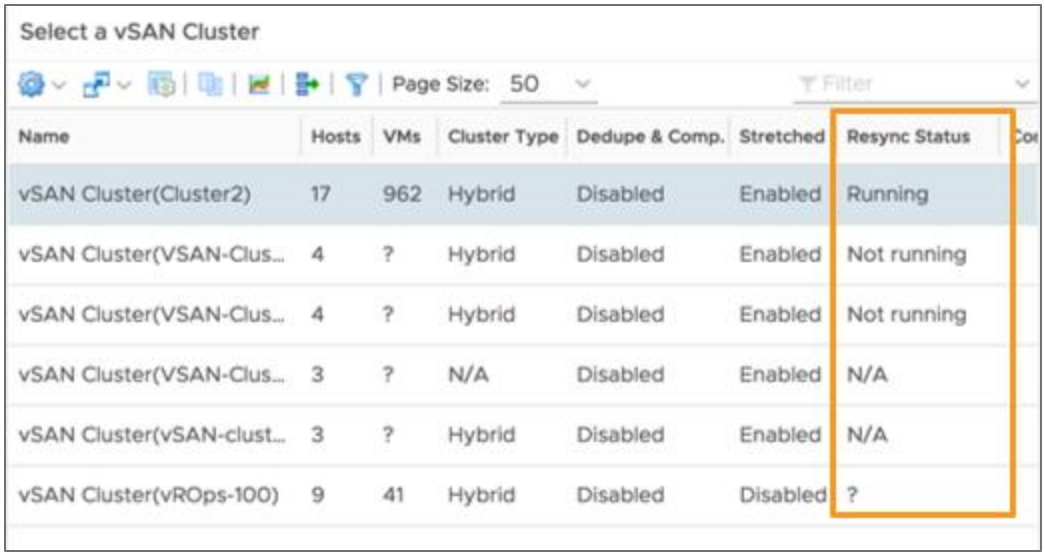
Figure. A breakdown of resynchronization types found in the host-level view of the vSAN performance metrics

Recommendation: Discrete I/O types can be "unticked" in these time-based graphs. This can provide additional clarity when deciphering the type of I/O activity occurring at a host level.

Viewing resynchronizations in VCF Operations

VCF Operations has visibility for resynchronizations in a vSAN cluster. It can be used to augment the information found in vCenter, as the resynchronization intelligence found in Aria Operations is not readily available within the vSAN performance metrics found in Center.

VCF Operations can provide an easy-to-read resynchronization status indicator for all vSAN clusters managed by the vCenter server.



Name	Hosts	VMs	Cluster Type	Dedupe & Comp.	Stretched	Resync Status
vSAN Cluster(Cluster2)	17	962	Hybrid	Disabled	Enabled	Running
vSAN Cluster(VSAN-Clus...	4	?	Hybrid	Disabled	Enabled	Not running
vSAN Cluster(VSAN-Clus...	4	?	Hybrid	Disabled	Enabled	Not running
vSAN Cluster(VSAN-Clus...	3	?	N/A	Disabled	Enabled	N/A
vSAN Cluster(vSAN-clust...	3	?	Hybrid	Disabled	Enabled	N/A
vSAN Cluster(vROps-100)	9	41	Hybrid	Disabled	Disabled	?

Figure. Resynchronization status of multiple vSAN clusters

VCF Operations provides burn down rates for resynchronization activity over time. Measuring a burn down rate helps provide the context in a way that can be difficult to understand using simple resynchronization throughput statistics. A burn down graph for resynchronization activity provides an understanding of the extent of data queued for resynchronization, how far along the process is, and a trajectory toward completion. Most importantly, it measures this at the cluster level, eliminating the need to gather this data per host to determine the activity across the entire cluster.

VCF Operations renders resynchronization activity in one of two ways:

- Total objects left to resynchronize
- Total bytes left to resynchronize

A good example of this is illustrated in a simple dashboard, where several VMs had their storage policy changed from using RAID-1 mirroring to RAID-5 erasure coding.

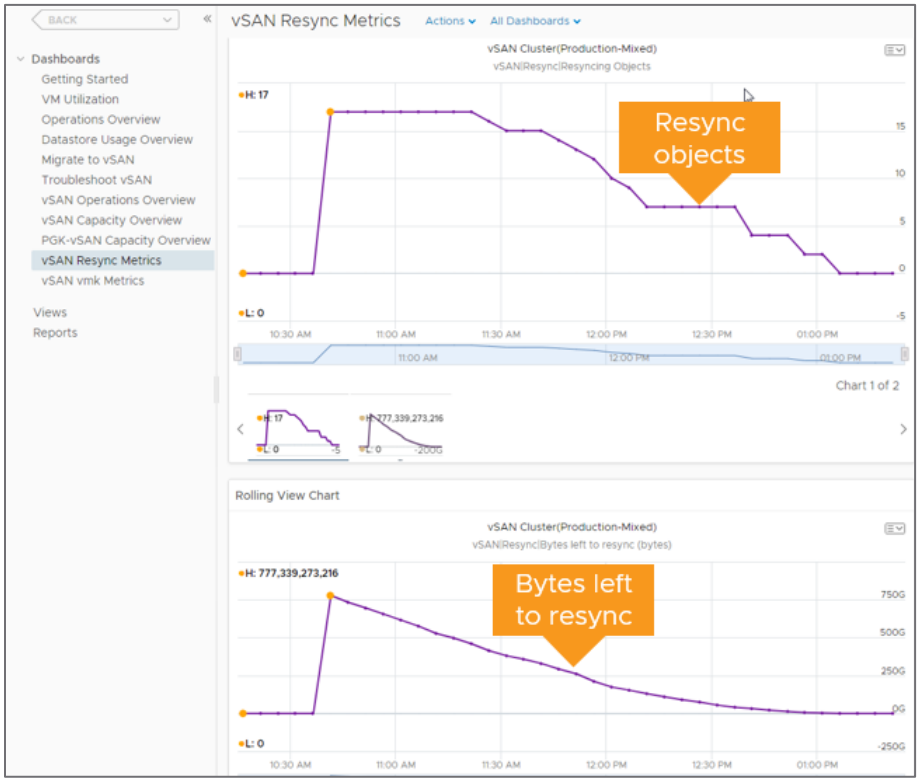


Figure. Resynchronization burn down rates for objects, and bytes remaining

When paired, the “objects remaining” and “bytes left” can help us understand the correlation between the number of objects to be resynchronized, and the rate at which the data is being synchronized. Observing rates of completion using these burn down graphs helps better understand how Adaptive Resync in vSAN dynamically manages resynchronization rates during periods of contention with VM traffic. These charts are easily combined with VM latency graphs to see how vSAN helps prioritize different types of traffic under these periods of contention.

Burn down graphs can provide insight when comparing resynchronization activities at other times, or in other clusters. For example, the figure below shows burn down activity over a larger time window. We can see that the amount of activity was very different during the periods that resynchronizations occurred.

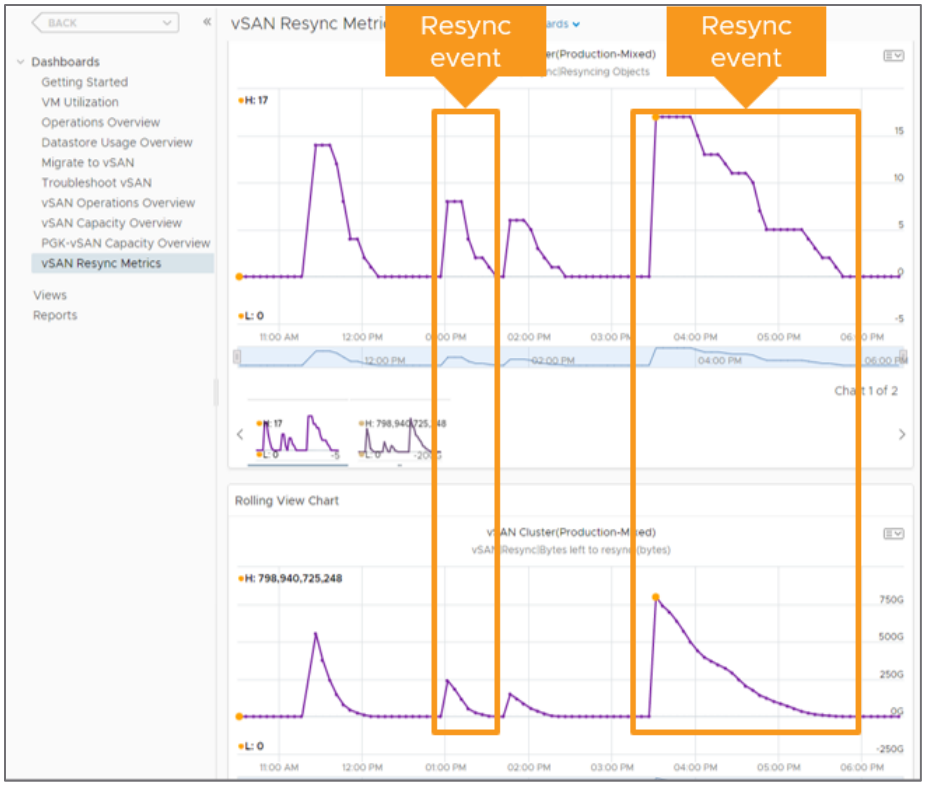


Figure. Comparing resynchronization activity—viewing burn down rates across a larger time window

The two events highlighted represent a different quantity of VMs that had their policies changed. This is the reason for the overall difference in the amount of data synchronized.

Viewing resynchronizations in PowerCLI

Resynchronization information can be gathered at the cluster level using the following PowerCLI command:

```
Get-VsanResyncingComponent -Cluster (Get-Cluster -Name "Clustername")
```

Additional information will be shown with the following:

```
Get-VsanResyncingComponent -Cluster (Get-Cluster -Name "Clustername") |fl
```

See the "PowerCLI Cookbook for vSAN" for more PowerCLI commands and how to expose resynchronization data.

Network Monitoring of vSAN Powered Cluster

Understanding the health and performance of a network is an important part of ensuring a hyper converged platform like vSAN is running at its very best. A distributed storage system like vSAN depends heavily on the network that connects the hosts, as it is the hosts in the cluster that make up the storage system. Network interruptions can generate packet loss in ways that even at relatively low levels, can degrade the effective throughput of communication required for transmission of storage.

vSAN has several network related metrics to monitor. In addition to the new and existing network metrics listed above, there are additional metrics found in the "Performance for Support" section of the vCenter Server UI. These are metrics typically intended for GSS cases, but still visible to the administrator.

Recommendation: Use some tools for visibility into the operation of the network switches. Network switch configurations and performance are outside of the management domain of vSphere, but should be monitored with equal levels of importance. Something as simple as an open source solution such as Cacti may be suitable.

Networking related health checks provide better visibility into the switch fabric that connects the vSAN hosts, and ensure higher levels of consistency across a cluster. Duplicate IP detection is now a part of the health checks, as well as LACP synchronization issues that can occur with these LAG configurations. vSAN 7 U3 even adds a configuration status check for the participating network interface cards and their configuration status of LRO/TSO. Ensuring consistency of LRO/TSO settings will help detect issues that may come as a result of the inconsistent configurations.

Mitigating Network Connectivity Issues in a vSAN cluster

As with any type of distributed storage system, VMware vSAN is highly dependent on the network to provide reliable and consistent communication between hosts in a cluster. When network communication suffers, impacts may not only be seen in the expected performance of the VMs in the cluster but also with vSAN's automated mechanisms that ensure data remains available and resilient in a timely manner.

In this type of topology, issues unrelated to vSAN can lead to the potential of a systemic issue across the cluster because of vSAN's dependence on the network. Examples include improper firmware or drivers for the network cards used on the hosts throughout the cluster, or perhaps configuration changes in the switchgear that are not ideal. Leading indicators of such issues include:

- **Much higher storage latency than previously experienced.** This would generally be viewed at the cluster level, by highlighting the cluster, clicking Monitor > vSAN > Performance and observing the latency.
- **Noticeably high levels of network packet loss.** Degradations in storage performance may be related to increased levels of packet loss occurring on the network used by vSAN. Recent editions of vSAN have enhanced levels of network monitoring and can be viewed by highlighting a host, clicking on vSAN > Performance > Physical Adapters, and looking at the relevant packet loss and drop rates.

Remediation of such issues may require care to minimize potential disruption and expedite the correction. When the above conditions are observed, **VMware recommends holding off on any corrective actions such as host restarts and reaching out to VMware Global Support Services (GS) for further assistance.**

Summary

With the proper guidance, operational tasks and other monitoring activities related to vSAN can be easily incorporated into existing data centers. This operational guidance, paired with Broadcom's official vSAN documentation is a great way to deploy and operate vSAN efficiently.

Additional Resources

The following are a collection of useful links that relate to bandwidth sizing for vSAN stretched clusters.

Performance Recommendations for vSAN ESA. This is a collection of recommendations to help achieve the highest levels of performance in a vSAN ESA cluster. Many of these same recommendations apply to vSAN storage clusters.

vSAN Proof of Concept (PoC) Performance Testing. This is a collection of recommendations that will guide users to test the performance of a vSAN cluster. While it is currently written for the OSA, many of the testing methods used are also applicable to the ESA.

Design and Sizing for vSAN ESA clusters. This post offers some nice guidance on using the vSAN Sizer for the ESA that summarizes some key points that can be found in the VMware vSAN Design Guide.

vSAN Network Design Guide. This network design guide applies to environments running vSAN 8 and later.

vSAN technical blogs. Stay up to date on the most recently published technical information about vSAN. These posts are created by the vSAN Technical Marketing team.

VMware Resource Center. The location for design guides, operations guides and other technical white papers on vSAN. These assets are created by the vSAN Technical Marketing and Product Enablement teams.

Official vSAN documentation. The location for all "how to" documentation on vSAN.

About the Author

Pete Koehler is a Product Marketing Engineer in the VCF division at Broadcom. With a primary focus on vSAN, Pete covers topics such as design and sizing, operations, performance, troubleshooting, and integration with other products and platforms.