ONTAP® 9

SAN Administration Guide

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NetApp®

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Deciding whether to use the SAN Administration Guide

This guide describes basic SAN host provisioning. It shows you how to configure and manage LUNs, igroups, and targets in iSCSI networks, FC and FC-NVMe fabrics.

You should use this guide under the following circumstances:

- You want to understand the range of ONTAP SAN host provisioning capabilities.
- You want to perform less common configuration and maintenance tasks, not basic SAN configuration.
- You want to use the command-line interface (CLI), not ONTAP System Manager or an automated scripting tool.

If you want to use ONTAP System Manager to provision SAN hosts, you should choose the following documentation:

- *Cluster management using System Manager*

If you want to create a basic SAN configuration using best practices, you should choose among the following documentation:

- FC configuration for Windows
  FC express configuration for Windows
- FC configuration for ESX
  FC express configuration for ESXi using VSC
- FC configuration for Red Hat Enterprise Linux
  FC express configuration for Red Hat Enterprise Linux
- iSCSI configuration for Windows
  iSCSI express configuration for Windows
- iSCSI configuration for ESX
  iSCSI express configuration for ESXi using VSC
- iSCSI configuration for Red Hat Enterprise Linux
  iSCSI express configuration for Red Hat Enterprise Linux

If you require additional configuration or conceptual information, you should choose among the following documentation:

- Conceptual background for SAN host provisioning
  ONTAP concepts
- Supported FC, iSCSI, and FCoE topologies for connecting host computers to nodes
  SAN configuration
- FlexVol volumes, FlexClone technology, and storage efficiency features
  Logical storage management
- Command reference
  ONTAP 9 commands
- Automation of management tasks
  NetApp Documentation: OnCommand Workflow Automation (current releases)

- SAN host and controller configuration limits
  NetApp Hardware Universe

Understanding SAN host provisioning

In iSCSI networks and FC fabrics, storage systems are targets that have storage target devices. For iSCSI and FC, the storage target devices are referred to as LUNs (logical units). For Non-Volatile Memory Express (NVMe) over Fibre Channel, the storage target devices are referred to as namespaces. You configure storage by creating LUNs for iSCSI and FC or by creating namespaces for NVMe. The LUNs or namespaces are then accessed by hosts.

How hosts connect to storage systems

Hosts can connect to SAN storage systems using Internet Small Computer Systems Interface (iSCSI) or Fibre Channel (FC) protocol networks.

To connect to iSCSI networks, hosts can use standard Ethernet network adapters (NICs), TCP offload engine (TOE) cards with software initiators, converged network adapters (CNAs), or dedicated iSCSI host bus adapters (HBAs).

To connect to FC networks, hosts require FC HBAs or CNAs.

Supported FC protocols include:

- FC
- FCoE
- NVMe

Simplified host management with SnapDrive

You can use SnapDrive software to simplify some of the management and data protection tasks associated with iSCSI and FC storage. SnapDrive is an optional management package for Windows and UNIX hosts.

You can use SnapDrive for Windows to easily create virtual disks from pools of storage that can be distributed among several storage systems.

You can use SnapDrive for UNIX to automate storage provisioning tasks and simplify the process of creating Snapshot copies and clones from Snapshot copies consistent with host data.

See NetApp product documentation for more information on SnapDrive.

Related information

NetApp Support: File Upload Utility

How ONTAP implements an iSCSI network

You should be aware of important concepts that are required to understand how ONTAP implements an iSCSI network.

How iSCSI target nodes connect to the network

You can implement iSCSI on the storage system using several different software solutions.

Target nodes can connect to the network in the following ways:

- Over Ethernet interfaces using software that is integrated into ONTAP.

- Over multiple system interfaces, with an interface used for iSCSI that can also transmit traffic for other protocols, such as CIFS and NFS.
- Using a unified target adapter (UTA) or a converged network adapter (CNA).

How iSCSI nodes are identified

Every iSCSI node must have a node name.

The two formats, or type designators, for iSCSI node names are *iqn* and *eui*. The SVM iSCSI target always uses the iqn-type designator. The initiator can use either the iqn-type or eui-type designator.

Storage system node name

Each SVM running iSCSI has a default node name based on a reverse domain name and a unique encoding number.

The node name is displayed in the following format:

iqn.1992-08.com.netapp:sn.`unique-encoding-number`

The following example shows the default node name for a storage system with a unique encoding number:

iqn.1992-08.com.netapp:sn.812921059e6c11e097b3123478563412:vs.6

TCP port for iSCSI

The iSCSI protocol is configured in ONTAP to use TCP port number 3260.

ONTAP does not support changing the port number for iSCSI. Port number 3260 is registered as part of the iSCSI specification and cannot be used by any other application or service.

How ONTAP implements an FC SAN

You should be aware of the important concepts that are required to understand how ONTAP implements an FC SAN.

How FC target nodes connect to the network

Storage systems and hosts have adapters so that they can be connected to FC switches with cables.

When a node is connected to the FC SAN, each SVM registers the World Wide Port Name (WWPN) of its LIF with the switch Fabric Name Service. The WWNN of the SVM and the WWPN of each LIF is automatically assigned by ONTAP..

Note: Direct-connection to nodes from hosts with FC is not supported, NPIV is required and this requires a switch to be used.

With iSCSI sessions, communication works with connections that are either network routed or direct-connect. However, both of these methods are supported with ONTAP.

How FC nodes are identified

Each SVM configured with FC is identified by a worldwide node name (WWNN).

How WWPNs are used

WWPNs identify each LIF in an SVM configured to support FC. These LIFs utilize the physical FC ports in each node in the cluster, which can be FC target cards, UTA or UTA2 configured as FC or FCoE in the nodes.

- Creating an initiator group
  The WWPNs of the host's HBAs are used to create an initiator group (igroup). An igroup is used to control host access to specific LUNs. You can create an igroup by specifying a collection of WWPNs of initiators in an FC network. When you map a LUN on a storage system to an igroup, you can grant all the initiators in that group access to that LUN. If a host's WWPN is not in an igroup that is mapped to a LUN, that host does not have access to the LUN. This means that the LUNs do not appear as disks on that host.
  You can also create port sets to make a LUN visible only on specific target ports. A port set consists of a group of FC target ports. You can bind an igroup to a port set. Any host in the igroup can access the LUNs only by connecting to the target ports in the port set.
- Uniquely identifying FC LIFs
  WWPNs uniquely identify each FC logical interface. The host operating system uses the combination of the WWNN and WWPN to identify SVMs and FC LIFs. Some operating systems require persistent binding to ensure that the LUN appears at the same target ID on the host.

NVMe provisioning

Beginning with ONTAP 9.4, FC-NVMe is supported in SAN environment. FC-NVMe enables storage administrators to provision namespaces and subsystems and then map the namespaces to subsystems, similar to the way LUNs are provisioned and mapped to igroups for FC and iSCSI.

An NVMe namespace is a quantity of non-volatile memory that can be formatted into logical blocks. Namespaces are the equivalent of LUNs for FC and iSCSI protocols, and an NVMe subsystem is analogous to an igroup. An NVMe subsystem can be associated with initiators so that namespaces within the subsystem can be accessed by the associated initiators.

Note: Although analogous in function, NVMe namespaces do not support all features supported by LUNs.

Beginning with ONTAP 9.5 a license is required to support host-facing data access with NVMe. If NVMe is enabled in ONTAP 9.4, a 90 day grace period is given to acquire the license after upgrading to ONTAP 9.5. You can enable the license using the following command:

```
system license add -license-code NVMe_license_key
```

Related information

NetApp Technical Report 4684: Implementing and Configuring Modern SANs with NVMe/FC

Provisioning volumes

ONTAP provides three basic volume provisioning options: thick provisioning, thin provisioning, and semi-thick provisioning. Each option uses different ways to manage the volume space and the space requirements for ONTAP block sharing technologies. Understanding how the options work enables you to choose the best option for your environment.

Note: Putting SAN LUNs and NAS shares in the same FlexVol volume is not recommended.

You should provision separate FlexVol volumes specifically for your SAN LUNs and you should provision separate FlexVol volumes specifically to your NAS shares. This simplifies management and replication deployments and parallels the way FlexVol volumes are supported in Active IQ Unified Manager (formerly OnCommand Unified Manager).

Thin provisioning for volumes

When a thinly provisioned volume is created, ONTAP does not reserve any extra space when the volume is created. As data is written to the volume, the volume requests the storage it needs from the aggregate to accommodate the write operation. Using thin-provisioned volumes enables you to overcommit your aggregate, which introduces the possibility of the volume not being able to secure the space it needs when the aggregate runs out of free space.

You create a thin-provisioned FlexVol volume by setting its `-space-guarantee` option to **none**.

Thick provisioning for volumes

When a thick-provisioned volume is created, ONTAP sets aside enough storage from the aggregate to ensure that any block in the volume can be written to at any time. When you configure a volume to use thick provisioning, you can employ any of the ONTAP storage efficiency capabilities, such as compression and deduplication, to offset the larger upfront storage requirements.

You create a thick-provisioned FlexVol volume by setting its `-space-slo` (service level objective) option to **`thick`**.

Semi-thick provisioning for volumes

When a volume using semi-thick provisioning is created, ONTAP sets aside storage space from the aggregate to account for the volume size. If the volume is running out of free space because blocks are in use by block-sharing technologies, ONTAP makes an effort to delete protection data objects (Snapshot copies and FlexClone files and LUNs) to free up the space they are holding. As long as ONTAP can delete the protection data objects fast enough to keep pace with the space required for overwrites, the write operations continue to succeed. This is called a “best effort” write guarantee.

Note: You cannot employ storage efficiency technologies such as deduplication, compression, and compaction on a volume that is using semi-thick provisioning.

You create a semi-thick-provisioned FlexVol volume by setting its `-space-slo` (service level objective) option to **`semi-thick`**.

Use with space-reserved files and LUNs

A space-reserved file or LUN is one for which storage is allocated when it is created. Historically, NetApp has used the term “thin-provisioned LUN” to mean a LUN for which space reservation is disabled (a non-space-reserved LUN).

Note: Non-space-reserved files are not generally referred to as “thin-provisioned files.”

The following table summarizes the major differences in how the three volume provisioning options can be used with space-reserved files and LUNs:

Volume provisioning	LUN/file space reservation	Overwrites	Protection data[2]	Storage efficiency[3]
Thick	Supported	Guaranteed[1]	Guaranteed	Supported
Thin	No effect	None	Guaranteed	Supported
Semi-thick	Supported	Best effort[1]	Best effort	Not supported

Notes

1. The ability to guarantee overwrites or provide a best-effort overwrite assurance requires that space reservation is enabled on the LUN or file.
2. Protection data includes Snapshot copies, and FlexClone files and LUNs marked for automatic deletion (backup clones).
3. Storage efficiency includes deduplication, compression, any FlexClone files and LUNs not marked for automatic deletion (active clones), and FlexClone subfiles (used for Copy Offload).

Support for SCSI thin-provisioned LUNs

ONTAP supports T10 SCSI thin-provisioned LUNs as well as NetApp thin-provisioned LUNs. T10 SCSI thin provisioning enables host applications to support SCSI features including LUN space reclamation and LUN space monitoring capabilities for blocks environments. T10 SCSI thin provisioning must be supported by your SCSI host software.

You use the ONTAP `space-allocation` setting to enable/disable support for the T10 thin provisioning on a LUN. You use the ONTAP `space-allocation enable` setting to enable T10 SCSI thin provisioning on a LUN.

The `[-space-allocation {enabled|disabled}]` command in the ONTAP Command Reference Manual has more information to enable/disable support for the T10 thin provisioning and to enable T10 SCSI thin provisioning on a LUN.

ONTAP 9 commands

Related concepts

Appendix: Recommended volume and file or LUN configuration combinations on page 95

Configuring volume provisioning options

You can configure a volume for thin provisioning, thick provisioning, or semi-thick provisioning.

About this task

Setting the `-space-slo` option to **`thick`** ensures the following:

- The entire volume is preallocated in the aggregate. You cannot use the `volume create` or `volume modify` command to configure the volume's `-space-guarantee` option.
- 100% of the space required for overwrites is reserved. You cannot use the `volume modify` command to configure the volume's `-fractional-reserve` option

Setting the `-space-slo` option to **`semi-thick`** ensures the following:

- The entire volume is preallocated in the aggregate. You cannot use the `volume create` or `volume modify` command to configure the volume's `-space-guarantee` option.
- No space is reserved for overwrites. You can use the `volume modify` command to configure the volume's `-fractional-reserve` option.
- Automatic deletion of Snapshot copies is enabled.

Step

1. Configure volume provisioning options:

`volume create -vserver` ***`vserver_name`*** **`-volume`** ***`volume_name`*** **`-aggregate`** ***`aggregate_name`*** **`-space-slo none|thick|semi-thick -space-guarantee none|volume`**

The `-space-guarantee` option defaults to **none** for AFF systems. Otherwise, it defaults to **`volume`**. For existing FlexVol volumes, use the `volume modify` command to configure provisioning options.

Example

The following command configures vol1 on SVM vs1 for thin provisioning:

```
cluster1::> volume create –vserver vs1 -volume vol1 -space-guarantee none
```

Example

The following command configures vol1 on SVM vs1 for thick provisioning:

```
cluster1::> volume create –vserver vs1 -volume vol1 -space-slo thick
```

Example

The following command configures vol1 on SVM vs1 for semi-thick provisioning:

```
cluster1::> volume create –vserver vs1 -volume vol1 -space-slo semi-thick
```

SAN volume configuration options

You must set various options on the volume containing your LUN. The way you set the volume options determines the amount of space available to LUNs in the volume.

Autogrow

You can enable or disable Autogrow. If you enable it, autogrow allows ONTAP to automatically increase the size of the volume up to a maximum size that you predetermine. There must be space available in the containing aggregate to support the automatic growth of the volume. Therefore, if you enable autogrow, you must monitor the free space in the containing aggregate and add more when needed.

Autogrow cannot be triggered to support Snapshot creation. If you attempt to create a Snapshot copy and there is insufficient space on the volume, the Snapshot creation fails, even with autogrow enabled.

If autogrow is disabled, the size of your volume will remain the same.

Autoshrink

You can enable or disable Autoshrink. If you enable it, autoshrink allows ONTAP to automatically decrease the overall size of a volume when the amount of space consumed in the volume decreases a predetermined threshold. This increases storage efficiency by triggering volumes to automatically release unused free space.

Snapshot autodelete

Snapshot autodelete automatically deletes Snapshot copies when one of the following occurs:

- The volume is nearly full.
- The Snapshot reserve space is nearly full.
- The overwrite reserve space is full.

You can configure Snapshot autodelete to delete Snapshot copies from oldest to newest or from newest to oldest. Snapshot autodelete does not delete Snapshot copies that are linked to Snapshot copies in cloned volumes or LUNs.

If your volume needs additional space and you have enabled both autogrow and Snapshot autodelete, by default, ONTAP attempts to acquire the needed space by triggering autogrow first. If enough space is not acquired through autogrow, then Snapshot autodelete is triggered.

Snapshot reserve

Snapshot reserve defines the amount of space in the volume reserved for Snapshot copies. Space allocated to Snapshot reserve cannot be used for any other purpose. If all of the space allocated for Snapshot reserve is used, then Snapshot copies begin to consume additional space on the volume.

Requirement for moving volumes in SAN environments

Before you move a volume that contains LUNs or namespaces, you must meet certain requirements.

- For volumes containing one or more LUNs, you should have a minimum of two paths per LUN (LIFs) connecting to each node in the cluster.
  This eliminates single points of failure and enables the system to survive component failures.
- For volumes containing namespaces, the cluster must be running ONTAP 9.6 or later.
  Volume move is not supported for NVMe configurations running ONTAP 9.5.

Considerations for setting fractional reserve

Fractional reserve, also called *LUN overwrite reserve*, enables you to turn off overwrite reserve for space-reserved LUNs and files in a FlexVol volume. This can help you maximize your storage utilization, but if your environment is negatively affected by write operations failing due to lack of space, you must understand the requirements that this configuration imposes.

The fractional reserve setting is expressed as a percentage; the only valid values are **`0`** and **`100`** percent. The fractional reserve setting is an attribute of the volume.

Setting fractional reserve to **`0`** increases your storage utilization. However, an application accessing data residing in the volume could experience a data outage if the volume is out of free space, even with the volume guarantee set to **`volume`**. With proper volume configuration and use, however, you can minimize the chance of writes failing. ONTAP provides a “best effort” write guarantee for volumes with fractional reserve set to **`0`** when *all* of the following requirements are met:

- Deduplication is not in use
- Compression is not in use
- FlexClone sub-files are not in use
- All FlexClone files and FlexClone LUNs are enabled for automatic deletion
  This is not the default setting. You must explicitly enable automatic deletion, either at creation time or by modifying the FlexClone file or FlexClone LUN after it is created.
- ODX and FlexClone copy offload are not in use
- Volume guarantee is set to **`volume`**
- File or LUN space reservation is **`enabled`**
- Volume Snapshot reserve is set to **`0`**
- Volume Snapshot copy automatic deletion is **`enabled`** with a commitment level of **`destroy`**, a destroy list of **`lun_clone,vol_clone,cifs_share,file_clone,sfsr`**, and a trigger of **`volume`**
  This setting also ensures that FlexClone files and FlexClone LUNs are deleted when necessary.

Note that if your rate of change is high, in rare cases the Snapshot copy automatic deletion could fall behind, resulting in the volume running out of space, even with all of the above required configuration settings in use.

In addition, you can optionally use the volume autogrow capability to decrease the likelihood of volume Snapshot copies needing to be deleted automatically. If you enable the autogrow capability, you must monitor the free space in the associated aggregate. If the aggregate becomes full enough that the volume is prevented from growing, more Snapshot copies will probably be deleted as the free space in the volume is depleted.

If you cannot meet all of the above configuration requirements and you need to ensure that the volume does not run out of space, you must set the volume's fractional reserve setting to **`100`**. This requires more free space up front, but guarantees that data modification operations will succeed even when the technologies listed above are in use.

The default value and allowed values for the fractional reserve setting depend on the guarantee of the volume:

Volume guarantee	Default fractional reserve	Allowed values
Volume	100	0, 100
None	0	0, 100

Setting up your LUN

After configuring your volume and LUN to the appropriate OS type, you must complete the steps that are necessary to set up your LUN. You should consider LUN setup guidelines and functions when setting up your LUNs.

Related concepts

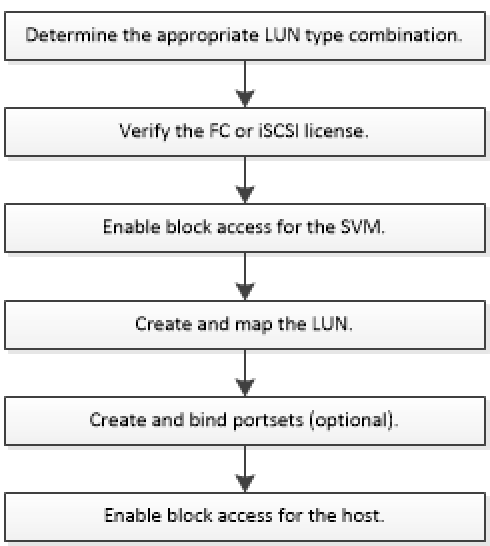
Selective LUN Map on page 27

Related tasks

Creating LUNs and mapping to igroups on page 21
Enabling block access for SVMs with iSCSI on page 20
Enabling block access for SVMs with FC on page 21
Verifying the license for FC or iSCSI on page 19
Enabling block access for a specific host on page 23
Creating port sets and binding igroups to port sets on page 27

LUN setup workflow

To set up your LUN, you must determine the best LUN type for your needs. Then you can follow a series of tasks to verify your protocol license, enable block access, create and map your LUN, and enable block access on your host. You can also optionally create and bind portsets as part of the LUN setup workflow.



Related tasks

Verifying the license for FC or iSCSI on page 19
Enabling block access for SVMs with iSCSI on page 20
Enabling block access for SVMs with FC on page 21
Creating LUNs and mapping to igroups on page 21
Enabling block access for a specific host on page 23

Creating port sets and binding igroups to port sets on page 27

LUN guidelines for SAN environments

Before you begin setting up your LUN, you need to review LUN guidelines, considerations, and supported configurations.

Guidelines for assigning LUN IDs

You can assign a number for the LUN ID, or you can accept the default LUN ID. However, your Host Utilities documentation might have additional guidelines about how to assign LUN IDs.

Typically, the default LUN ID begins with 0 and is assigned in increments of 1 for each additional mapped LUN. The host associates the LUN ID with the location and path name of the LUN. The range of valid LUN ID numbers depends on the host. For detailed information, see the documentation provided with your Host Utilities.

Related information

NetApp Documentation: Host Utilities (current releases)

Guidelines for mapping LUNs to igroups

There are several important guidelines that you must follow when mapping LUNs to an igroup.

- You can map a LUN only once to an igroup.
- You can map a LUN only once to a specific initiator through the igroup.
- You can add a single initiator to multiple igroups, but the initiator can be mapped to a LUN only once.
- You cannot use the same LUN ID for two LUNs mapped to the same igroup.
- You should use the same protocol type for igroups and port sets.

Setting up LUNs

You must complete several required tasks before you can access your LUNs including verifying your protocol license, enabling block access, creating your LUNs, and mapping your LUNs to igroups.

Configuring switches for FCoE

You must configure your switches for FCoE before your FC service can run over the existing Ethernet infrastructure.

Before you begin

- Your SAN configuration must be supported.
  For more information about supported configurations, see the Interoperability Matrix.
- A Unified Target Adapter (UTA) must be installed on your storage system.
  If you are using a UTA2, it must be set to `cna` mode.
- A converged network adapter (CNA) must be installed on your host.

Steps

1. Use your switch documentation to configure your switches for FCoE.

2. Use the `dcb show` command to verify that the DCB settings for each node in the cluster have been correctly configured.

   Example

   `run -node node1 -command dcb show`

   DCB settings are configured on the switch. Consult your switch documentation if the settings are incorrect.

3. Use the `fcp adapter show` command to verify that the FCoE login is working when the FC target port online status is **`true`**.

   Example

   ```
   cluster1::> fcp adapter show -fields
   node,adapter,status,state,speed,fabric-established,physical-protocol
   ```

   If the FC target port online status is **`false`**, consult your switch documentation.

Related information

NetApp Interoperability Matrix Tool
NetApp Technical Report 3800: Fibre Channel over Ethernet (FCoE) End-to-End Deployment Guide
Cisco MDS 9000 NX-OS and SAN-OS Software Configuration Guides
Brocade products

Prerequisites for setting up LUNs

Setting up LUNs involves creating a LUN, creating an igroup, and mapping the LUN to the igroup. Your system must meet certain prerequisites before you can set up your LUNs.

- The Interoperability Matrix must list your SAN configuration as supported.
- Your SAN environment must meet the SAN host and controller configuration limits specified in the *Hardware Universe* for your version of the ONTAP software.
- A supported version of Host Utilities must be installed.
  The Host Utilities documentation provides more information.
- You must have SAN LIFs on the LUN owning node and the owning node's HA partner.

Related information

NetApp Interoperability Matrix Tool
SAN configuration
NetApp Documentation: Host Utilities (current releases)
NetApp Technical Report 4017: Fibre Channel SAN Best Practices
NetApp Hardware Universe

Verifying the license for FC or iSCSI

Before you can enable block access for a storage virtual machine (SVM) with FC or iSCSI, you must have a license.

Steps

1. Use the `system license show` command to verify that you have a license for FC or iSCSI.

Example

`system license show`

```
Package           Type    Description           Expiration
 ----------------- ------- --------------------- --------------------
 Base              site    Cluster Base License  -
 NFS               site    NFS License           -
 CIFS              site    CIFS License          -
 iSCSI             site    iSCSI License         -
 FCP               site    FCP License           -
```

2. If you do not have a license for FC or iSCSI, use the `license add` command.

   Example

   `license add -license-code` ***`your_license_code`***

Enabling block access for SVMs with iSCSI

To enable block access, you must assign an iSCSI protocol to your storage virtual machine (SVM) and create LIFs for that SVM.

About this task

You need a minimum of one iSCSI LIF per node for each SVM serving data with the iSCSI protocol. For redundancy, you should create at least two LIFs per node.

Steps

1. Enable the SVMs to listen for iSCSI traffic:

   `vserver iscsi create -vserver` ***`vserver_name`*** **`-target-alias`** ***`vserver_name`***

2. Create a LIF for the SVMs on each node to use for iSCSI:

   `network interface create -vserver` ***`vserver_name`*** **`-lif`** ***`lif_name`*** **`-role data -data-protocol iscsi -home-node`** ***`node_name`*** **`-home-port`** ***`port_name`*** **`-address`** ***`ip_address`*** **`-netmask`** ***`netmask`***

3. Verify that you set up your LIFs correctly:

   `network interface show -vserver` ***`vserver_name`***

4. Verify that iSCSI is up and running and the target IQN for that SVM:

   `vserver iscsi show` ***`–vserver`*** **`<`*****`vserver name`*****`>`**

5. From your host, create iSCSI sessions to your LIFs.

Related concepts

Considerations for LIFs in cluster SAN environments on page 89
What CHAP authentication is on page 70

Related tasks

Defining a security policy method for an initiator on page 67

Enabling block access for SVMs with FC

To enable block access, you must create LIFs for a storage virtual machine (SVM) and assign the FC protocol to those LIFs.

Before you begin

You must have an FC license and it must be enabled. If the FC license is not enabled, the LIFs and SVMs appear to be online but the operational status is `down`. The FC service must be enabled for your LIFs and SVMs to be operational. You must use single initiator zoning for all of the FC LIFs in the SVM to host the initiators.

About this task

NetApp supports a minimum of one FC LIF per node for each SVM serving data with the FC protocol. You must use two LIFs per node and two fabrics, with one LIF per node attached. This provides for redundancy at the node layer and the fabric.

Steps

1. Enable FC service on the SVM:

   `vserver fcp create -vserver` ***`vserver_name`*** **`-status-admin up`**

2. Create two LIFs for the SVMs on each node serving FC:

   `network interface create -vserver` ***`vserver_name`*** **`-lif`** ***`lif_name`*** **`-role data -data-protocol fcp -home-node`** ***`node_name`*** **`-home-port`** ***`port`***

   The `-role` parameter should be **`data`** and the `data-protocol` parameter should be **`fcp`**.

3. Verify that your LIFs have been created and that their operational status is **`online`**:

   `network interface show -vserver` ***`vserver_name lif_name`***

Related concepts

Considerations for LIFs in cluster SAN environments on page 89

Related information

NetApp Support
NetApp Interoperability Matrix Tool

Creating LUNs and mapping to igroups

As part of configuring your SAN environment, you must create LUNs, create your initiator groups (igroups), and map your LUNs to your igroups.

Before you begin

- You must have created your aggregates, volumes, and storage virtual machines (SVMs).
- You must have enabled block access with FC or iSCSI.
- You must have created SAN LIFs on all of the nodes in the cluster.

About this task

When you create a LUN, you must specify the LUN OS type. The actual size of the LUN might vary slightly based on the OS type of the LUN. The LUN OS type cannot be modified after the LUN is created.

The metadata for each LUN requires approximately 64 KB of space in the containing aggregate. When you create a LUN, you must ensure that the containing aggregate has enough space for the LUN's metadata. If the aggregate does not contain enough space for the LUN's metadata, some hosts might not be able to access the LUN.

If necessary, you can grow your LUN up to 10 times its original size. For example, if you create a 100 GB LUN, you can grow that LUN to 1,000 GB. You cannot exceed 16 TB, which is the maximum LUN size.

Asymmetric logical unit access (ALUA) is always enabled during LUN creation. You cannot change the ALUA setting.

Steps

1. Create your LUNs:

   `lun create -vserver` ***`vserver_name`*** **`-volume`** ***`volume_name`*** **`-lun`** ***`lun_name`*** **`-size`** ***`lun_size`*** **`-ostype`** ***`lun_ostype`*** **`-space-reserve enabled|disabled`**

   If your host operating system is Windows 2008 or later, use the `windows` ostype. The `space-reserve` option is enabled by default. If you want a non-space-reserved LUN, you must set the `space-reserve` option to **`disabled`**.

   Note: The NVFAIL option is automatically enabled when a LUN is created in a volume.

2. Create your igroups:

   `igroup create -vserver` ***`vserver_name`*** **`-igroup`** ***`igroup_name`*** **`-protocol fcp|iscsi|mixed -ostype`** ***`lun_ostype`*** **`-initiator`** ***`initiator_name`***

   If your host operating system is Windows 2008 or later, use the `windows` ostype.

3. Map your LUNs to igroups:

   `lun mapping create -vserver` ***`vserver_name`*** **`-volume`** ***`volume_name`*** **`-lun`** ***`lun_name`*** **`-igroup`** ***`igroup_name`***

4. Verify that your LUNs are configured correctly:

   `lun show -vserver` ***`vserver_name`***

Related concepts

Guidelines for mapping LUNs to igroups on page 18
Selective LUN Map on page 27

Related tasks

Enabling block access for SVMs with iSCSI on page 20
Enabling block access for SVMs with FC on page 21

Related information

Disk and aggregate management
Logical storage management
Network and LIF management

Enabling block access for a specific host

You must enable block access on your specific host so that your initiators can access your targets.

Before you begin

- You must have network connectivity between the host and the LIFs on the SVM.
- Your FC or iSCSI service must be on and operational.
- You must have LUNs that are mapped to initiator groups (igroups).

Steps

1. Follow steps in your host documentation for enabling block access on your specific hosts.
2. Use the Host Utilities to complete the FC or iSCSI mapping and to discover your LUNs on the host.

Related information

NetApp Documentation: Host Utilities (current releases)

Setting up NVMe

To set up the NVMe protocol in your SAN environment, you must configure an SVM for NVMe, create namespaces and subsystems, configure an FC-NVMe LIF, and then map the namespaces to the subsytems.

NVMe namespaces considerations

There are certain considerations you should be aware of when working with NVMe namespaces.

- You cannot restore a namespace over a LUN, or vice versa.
- The space guarantee for namespaces is the same as the space guarantee of the containing volume.
- Beginning with ONTAP 9.6, namespaces support 512 byte blocks and 4096 byte blocks.
  4096 is the default value. 512 should only be used if the host operating system does not support 4096 byte blocks.
- Namespaces do not support the following:
  - Renaming
    You cannot rename a namespace.
  - Resizing
    You cannot increase or decrease the size of a namespace.
  - Inter-volume move
  - Inter-volume copy

Configuring an SVM for NVMe

If you want to use the NVMe protocol on a node, you must configure your SVM specifically for NVMe.

Before you begin

Your FC adapters must support NVMe. Supported adapters are listed in the *Hardware Universe*.

NetApp Hardware Universe

Steps

1. Verify that you have NVMe capable adapters installed in your cluster:

   `network fcp adapter show -data-protocols-supported fc-nvme`

2. Create an SVM:

   `vserver create -vserver` ***`SVM_name`***

3. Verify that the SVM is created:

   `vserver show`

4. Remove all protocols from the SVM:

   `vserver remove-protocols -vserver` ***`SVM_name`*** **`-protocols iscsi,fcp,nfs,cifs,ndmp`**

5. Add the NVMe protocol to the SVM:

   vserver add-protocols -vserver *SVM_name* -protocols nvme

6. Verify that NVMe is the only protocol allowed on the SVM:

   vserver show -vserver *SVM_name* -fields allowed-protocols

   NVMe should be the only protocol displayed under the `allowed protocols` column.

7. Create the NVMe service:

   vserver nvme create -vserver *SVM_name*

8. Verify that the NVMe service was created:

   vserver nvme show -vserver *SVM_name*

   The `Administrative Status` of the SVM should be listed as `up`.

9. Create an FC-NVMe LIF:

   network interface create -vserver *SVM_name* -lif *lif_name* -role data -data-protocol fc-nvme -home-node *home_node* -home-port *home_port*

10. Create an FC-NVMe LIF on the HA partner node:

    network interface create -vserver *SVM_name* -lif *lif_name* -role data -data-protocol fc-nvme -home-node *home_node* -home-port *home_port*

11. Verify the FC-NVMe LIFs were created:

    net interface show -veserver *SVM_name*

12. Create volume on the same node as the LIF:

    vol create -vserver *SVM-name* -volume *vol_name* -aggregate *aggregate_name* -size *volume_size*

    If a warning message is displayed about the auto efficiency policy, it can be safely ignored.

After you finish

Creating an NVMe namespace and subsystem

For systems using the NVMe protocol, you must create one or more NVMe namespaces and subsystems. Each namespace can then be mapped to an NVMe subsystem to allow data access from your host system.

Before you begin

The SVM must already be configured for NVMe.

Steps

1. Verify that the SVM is configured for NVMe:

   vserver show -vserver *SVM_name* -fields allowed-protocols

   `NVMe` should be displayed under the `allowed-protocols` column.

2. Create the NVMe namespace:

   vserver nvme namespace create -vserver *SVM_name* -path *path* -size *size_of_namespace* -ostype *OS_type*

3. Create the NVMe subsystem:

```
vserver name subsystem create -vserver SVM_name -subsystem
name_of_subsystem -ostype OS_type
```

4. Verify that the subsystem was created:

   ```
   vserver nvme subsystem show -vserver SVM_name
   ```

   The `nvme` subsystem should be displayed under the `Subsystem` column.

Mapping an NVMe namespace to a subsystem

You must map a namespace to a subsystem when using NVMe.

Before you begin

- You must have configured an SVM for NVMe.
- You must have created an NVMe namespace and subsystem.

About this task

A namespace can only be mapped to a single subsystem.

Steps

1. Obtain the NQN from the host.
2. Add the host NQN to the subsystem:

   ```
   vserver nvme subsystem host add -vserver SVM_name -subsystem
   Subsystem_name -host-nqn Host_NQN:subsystem.Subsystem_name
   ```

3. Map the namespace to the subsystem:

   ```
   vserver nvme subsystem map add -vserver SVM_name -subsystem
   subsystem_name -path path
   ```

4. Verify that the namespace is mapped to the subsystem:

   ```
   vserver nvme namespace show -vserver SVM_name -instance
   ```

   The subsystem should be listed as the `Attached subsystem`.

Managing LUNs

After you create your LUNs, you can manage them in a number of ways. For example, you can control LUN availability, unmap a LUN from an igroup, delete a LUN, and increase the LUN size.

Selective LUN Map

Selective LUN Map (SLM) reduces the number of paths from the host to the LUN. With SLM, when a new LUN map is created, the LUN is accessible only through paths on the node owning the LUN and its HA partner.

SLM enables management of a single igroup per host and also supports nondisruptive LUN move operations that do not require portset manipulation or LUN remapping.

Portsets can be used with SLM just as in previous versions of ONTAP to further restrict access of certain targets to certain initiators. When using SLM with portsets, LUNs will be accessible on the set of LIFs in the portset on the node that owns the LUN and on that node's HA partner.

SLM is enabled by default on all new LUN maps.

Related tasks

Modifying the SLM reporting-nodes list on page 28

How to determine whether SLM is enabled on a LUN map

If your environment has a combination of LUNs created in ONTAP and LUNs transitioned from previous versions, you might need to determine whether Selective LUN Map (SLM) is enabled on a specific LUN.

You can use the information displayed in the output of the `lun mapping show -fields reporting-nodes, node` command to determine whether SLM is enabled on your LUN map. If SLM is not enabled, “`-`” is displayed in the cells under the `reporting-nodes` column of the command output. If SLM is enabled, the list of nodes displayed under the `nodes` column is duplicated in the `reporting-nodes` column.

Creating port sets and binding igroups to port sets

In addition to using Selective LUN Map (SLM), you can create a port set and bind the port set to an igroup to further limit which LIFs can be used by an initiator to access a LUN. If you do not bind a port set to an igroup, then all of the initiators in the igroup can access mapped LUNs through all of the LIFs on the node owning the LUN and the owning node's HA partner.

Before you begin

You must have at least one LIF and one igroup.

Unless you are using interface groups, two LIFs are recommended for redundancy for both iSCSI and FC. Only one LIF is recommended for interface groups.

About this task

It is advantageous to use ports sets with SLM when you have more than two LIFs on a node and you want to restrict a certain initiator to a subset of LIFs. Without port sets, all targets on the node will be accessible by all of the initiators with access to the LUN through the node owning the LUN and the owning node's HA partner.

Steps

1. Create a port set containing the appropriate LIFs:

   `portset create -vserver` ***`vserver_name`*** **`-portset`** ***`portset_name`*** **`-protocol`** ***`protocol`*** **`-port-name`** ***`port_name`***

   If you are using FC, specify the `protocol` parameter as **`fcp`**. If you are using iSCSI, specify the `protocol` parameter as **`iscsi`**.

2. Bind the igroup to the port set:

   `lun igroup bind -vserver` ***`vserver_name`*** **`-igroup`** ***`igroup_name`*** **`-portset`** ***`portset_name`***

3. Verify that your port sets and LIFs are correct:

   `portset show -vserver` ***`vserver_name`***

   Example

   ```
   Vserver   Portset   Protocol Port Names    Igroups
   --------- --------- -------- ------------- --------
   vs3       portset0  iscsi    lif0,lif1     igroup1
   ```

Related concepts

Selective LUN Map on page 27

Modifying the SLM reporting-nodes list

If you are moving a LUN or a volume containing LUNs to another high availability (HA) pair within the same cluster, you should modify the Selective LUN Map (SLM) reporting-nodes list before initiating the move. This ensures that active, optimized LUN paths are maintained.

Steps

1. Add the destination node and its partner node to the reporting-nodes list of the aggregate or volume:

   `lun mapping add-reporting-nodes -vserver` ***`vserver_name`*** **`-path`** ***`lun_path`*** **`-igroup`** ***`igroup_name`*** **`[-destination-aggregate`** ***`aggregate_name`*** **`|-destination-volume`** ***`volume_name`*** **`]`**

   If you have a consistent naming convention, you can modify multiple LUN mappings at the same time by using `*-igroup` instead of `igroup`.

2. Rescan the host to discover the newly added paths.

3. If your OS requires it, add the new paths to your multipath network I/O (MPIO) configuration.

4. Run the command for the needed move operation and wait for the operation to finish.

5. Verify that I/O is being serviced through the Active/Optimized path:

   `lun mapping show -fields reporting-nodes`

6. Remove the previous LUN owner and its partner node from the reporting-nodes list:

   `lun mapping remove-reporting-nodes -vserver` ***`vserver_name`*** **`-path`** ***`lun_path`*** **`-igroup`** ***`igroup_name`*** **`-remote-nodes`**

7. Verify that the LUN has been removed from the existing LUN map:

   `lun mapping show -fields reporting-nodes`

8. Remove any stale device entries for the host OS.
9. Change any multipathing configuration files if required.
10. Rescan the host to verify removal of old paths.

    See your host documentation for specific steps to rescan your hosts.

Related concepts

Selective LUN Map on page 27

Related information

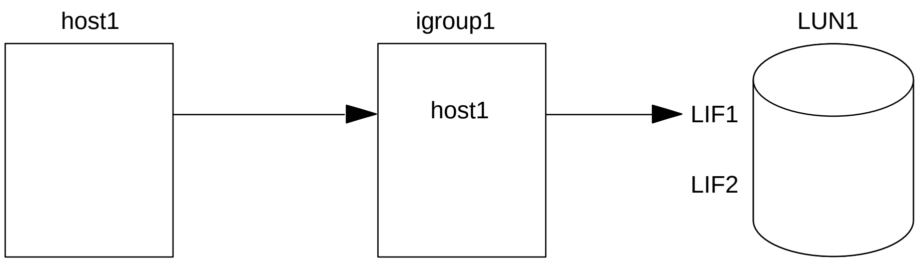
NetApp Documentation: Host Utilities (current releases)

Ways to limit LUN access with port sets and igroups

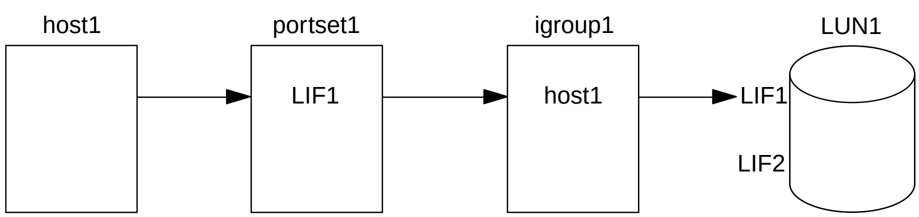
In addition to using Selective LUN Map (SLM), you can limit access to your LUNs through igroups and port sets.

Port sets can be used with SLM to further restrict access of certain targets to certain initiators. When using SLM with port sets, LUNs will be accessible on the set of LIFs in the port set on the node that owns the LUN and on that node's HA partner.

In the following example, initiator1 does not have a port set. Without a port set, initiator1 can access LUN1 through both LIF1 and LIF2.



You can limit access to LUN1 by using a port set. In the following example, initiator1 can access LUN1 only through LIF1. However, initiator1 cannot access LUN1 through LIF2 because LIF2 is not in port set1.



Related concepts

Selective LUN Map on page 27

Related tasks

Creating port sets and binding igroups to port sets on page 27

Considerations for transitioning SAN configurations

In a SAN environment, a disruption in service is required during the transition of a 7-Mode volume to ONTAP. You need to shut down your hosts to complete the transition. After transition, you must update your host configurations before you can begin serving data in ONTAP

You need to schedule a maintenance window during which you can shut down your hosts and complete the transition.

Related information

Copy-based transition

Capabilities and restrictions of transitioned LUNs

LUNs that have been transitioned from Data ONTAP operating in 7-Mode to ONTAP have certain capabilities and restrictions that affect the way the LUNs can be managed.

You can do the following with transitioned LUNs:

- View the LUN using the `lun show` command
- View the inventory of LUNs transitioned from the 7-Mode volume using the `transition 7-mode show` command
- Restore a volume from a 7-Mode Snapshot copy
  Restoring the volume transitions all of the LUNs captured in the Snapshot copy
- Restore a single LUN from a 7-Mode Snapshot copy using the `snapshot restore-file` command
- Create a clone of a LUN in a 7-Mode Snapshot copy
- Restore a range of blocks from a LUN captured in a 7-Mode Snapshot copy
- Create a FlexClone of the volume using a 7-Mode Snapshot copy

You cannot do the following with transitioned LUNs:

- Access Snapshot copy-backed LUN clones captured in the volume

Considerations for copying LUNs

There are considerations you should be aware of when copying a LUN.

Cluster administrators can copy a LUN across storage virtual machines (SVMs) within the cluster by using the `lun copy` command. Cluster administrators must establish the storage virtual machine (SVM) peering relationship using the `vserver peer create` command before an inter-SVM LUN copy operation is performed. There must be enough space in the source volume for a SIS clone.

LUNs in Snapshot copies can be used as source LUNs for the `lun copy` command. When you copy a LUN using the `lun copy` command, the LUN copy is immediately available for read and write access. The source LUN is unchanged by creation of a LUN copy. Both the source LUN and the LUN copy exist as unique LUNs with different LUN serial numbers. Changes made to the source LUN are not reflected in the LUN copy, and changes made to the LUN copy are not reflected in the source LUN. The LUN mapping of the source LUN is not copied to the new LUN; the LUN copy must be mapped.

Data protection through Snapshot copies occurs at the volume level. Therefore, if you copy a LUN to a volume different from the volume of the source LUN, the destination LUN falls under the data protection scheme of the destination volume. If you do not have Snapshot copies established for the destination volume, Snapshot copies are not created of the LUN copy.

Copying LUNs is a nondisruptive operation.

You cannot copy the following types of LUNs:

- A LUN that has been created from a file
- A LUN that is in NVFAIL state
- A LUN that is in a load-sharing relationship
- A protocol-endpoint class LUN

Increasing the size of a LUN

Beginning in ONTAP 9.5, you can grow your LUN up to 16 TB regardless of its original size. In ONTAP 9.4 and earlier, you can only grow your LUN to approximately 10 times its original size, but not greater than 16 TB.

About this task

For example, in ONTAP 9.5 or later, if you create a 100 GB LUN, you can grow that LUN to the maximum LUN size of 16 TB. However, if you create a 100 GB LUN, in ONTAP 9.4 or earlier, you can only grow that LUN to approximately 1,000 GB. The actual LUN size might vary slightly based on the OS type of the LUN. No LUN can exceed the 16 TB maximum size limit regardless of the version of ONTAP in which it was created.

You do not need to take the LUN offline to increase the size. However, after you have increased the size, you must rescan the LUN on the host for the host to recognize the change in size.

See the Command Reference page for the `lun resize` command for more information about resizing a LUN.

Steps

1. Increase the size of the LUN:

   `lun resize -vserver` ***`vserver_name`*** **`-volume`** ***`volume_name`*** **`-lun`** ***`lun_name`*** **`-size`** ***`lun_size`***

2. Verify the increased LUN size:

   `lun show -vserver` ***`vserver_name`***

3. Rescan the LUN on the host.

4. Follow your host documentation to make the newly created LUN size visible to the host file system.

Decreasing the size of a LUN

Before you decrease the size of a LUN, the host needs to migrate the blocks containing the LUN data into the boundary of the smaller LUN size. You should use a tool such as SnapDrive for Windows to ensure that the LUN is properly decreased without truncating blocks containing LUN data. Manually decreasing the size of your LUN is not recommended.

About this task

After you decrease the size of your LUN, ONTAP automatically notifies the initiator that the LUN size has decreased. However, additional steps might be required on your host for the host to recognize the new LUN size. Check your host documentation for specific information about decreasing the size of the host file structure.

Moving LUNs

You can move a LUN across volumes within a storage virtual machine (SVM), but you cannot move a LUN across SVMs. LUNs moved across volumes within an SVM are moved immediately and without loss of connectivity.

Before you begin

If your LUN is using Selective LUN Map (SLM), the SLM reporting nodes must have been modified to include the destination node and its HA partner.

About this task

Storage efficiency features, such as deduplication, compression, and compaction are not preserved during a LUN move. They must be reapplied after the LUN move is completed.

Data protection through Snapshot copies occurs at the volume level. Therefore, when you move a LUN, it falls under the data protection scheme of the destination volume. If you do not have Snapshot copies established for the destination volume, Snapshot copies of the LUN are not created. Also, all of the Snapshot copies of the LUN stay in the original volume until those Snapshot copies are deleted.

You cannot move a LUN to the following volumes:

- A SnapMirror destination volume
- The SVM root volume

You cannot move the following types of LUNs:

- A LUN that has been created from a file
- A LUN that is in NVFail state
- A LUN that is in a load-sharing relationship
- A protocol-endpoint class LUN

Note: For Solaris os_type LUNs that are 1 TB or larger, the host might experience a timeout during the LUN move. For this LUN type, you should unmount the LUN before initiating the move.

Steps

1. Move the LUN by using the `lun move start` command.

   During a very brief period, the LUN is visible on both the origin and destination volume. This is expected and is resolved upon completion of the move.

2. Track the status of the move and verify successful completion by using the `lun move show` command.

Related concepts

Selective LUN Map on page 27

Related tasks

Modifying the SLM reporting-nodes list on page 28

Deleting LUNs

You can delete a LUN from a storage virtual machine (SVM) if you no longer need the LUN.

Before you begin

The LUN must be unmapped from its igroup before you can delete it.

Steps

1. Verify that the application or host is not using the LUN.
2. Unmap the LUN from the igroup:

   `lun mapping delete`

   Example

   `lun mapping delete -vserver vs5 -volume vo5 -lun lun5 -igroup igr5`
3. Delete the LUN:

   `lun delete`

   Example

   `lun delete -vserver vs5 -volume vol5 -lun lun5`
4. Verify that you deleted the LUN:

   `lun show`

   Example

   `lun show -vserver vs5`

   ```
   Vserver   Path               State    Mapped  Type     Size
   --------- ------------------ -------- ------- -------- ------
   vs5       /vol/vol16/lun8    online   mapped  windows  10.00GB
   ```

Examining configured and used space of a LUN

Knowing the configured space and actual space used for your LUNs can help you determine the amount of space that can be reclaimed when doing space reclamation, the amount of reserved space that contains data, and the total configured size versus the actual size used for a LUN.

Step

1. View the configured space versus the actual space used for a LUN:

   `lun show`

Example

The following example show the configured space versus the actual space used by the LUNs in the vs3 storage virtual machine (SVM):

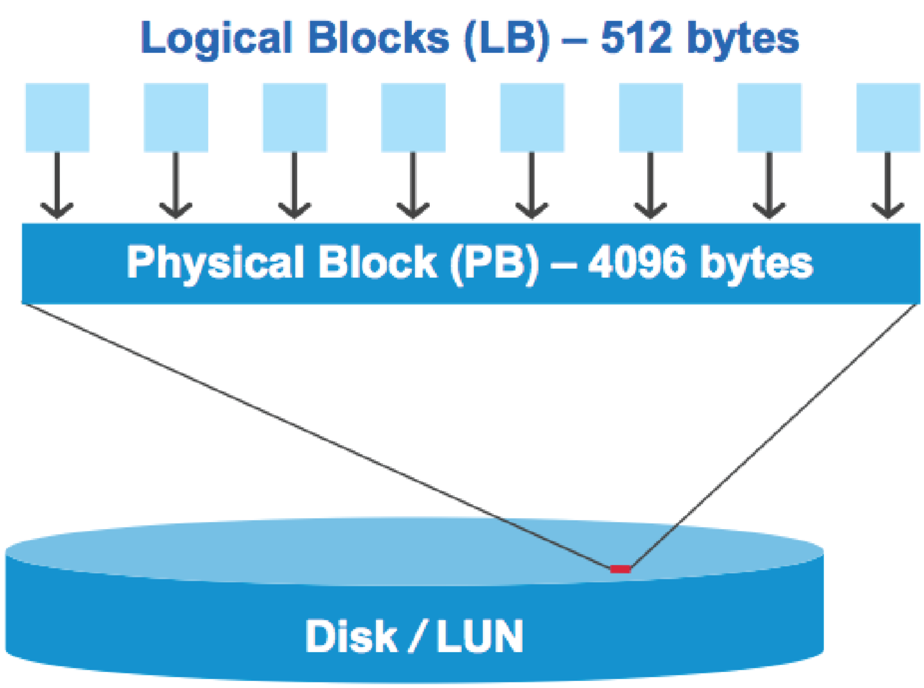
lun show -vserver vs3 -fields path, size, size-used, space-reserve

```
vserver path              size    space-reserve size-used
------- ----------------- ------- ------------- ---------
vs3     /vol/vol0/lun1    50.01GB disabled      25.00GB
vs3     /vol/vol0/lun1_backup
                          50.01GB disabled      32.15GB
vs3     /vol/vol0/lun2    75.00GB disabled
0B
vs3     /vol/volspace/lun0
                          5.00GB  enabled       4.50GB
4 entries were displayed.
```

I/O misalignments might occur on properly aligned LUNs

ONTAP might report I/O misalignments on properly aligned LUNs. In general, these misalignment warnings can be disregarded as long as you are confident that your LUN is properly provisioned and your partitioning table is correct.

LUNs and hard disks both provide storage as blocks. Because the block size for disks on the host is 512 bytes, LUNs present blocks of that size to the host while actually using larger, 4-KB blocks to store data. The 512-byte data block used by the host is referred to as a logical block. The 4-KB data block used by the LUN to store data is referred to as a physical block. This means that there are eight 512-byte logical blocks in each 4-KB physical block.



The host operating system can begin a read or write I/O operation at any logical block. I/O operations are only considered aligned when they begin at the first logical block in the physical block. If an I/O operation begins at a logical block that is not also the start of a physical block, the I/O is considered misaligned. ONTAP automatically detects the misalignment and reports it on the LUN. However, the presence of misaligned I/O does not necessarily mean that the LUN is also misaligned. It is possible for misaligned I/O to be reported on properly aligned LUNs.

If further investigation is required, technical support can run diagnostic commands that show detailed I/O alignment data to confirm the presence or absence of true LUN misalignment.

For more information about tools for correcting alignment problems, see the following documentation:

- *Data ONTAP DSM for Windows MPIO Installation and Administration Guide*
- *Windows Host Utilities Installation and Setup Guide*
- *Virtual Storage Console for VMware vSphere Installation and Administration Guide*

Related concepts

ESX boot LUNs report as misaligned on page 36

Related information

NetApp Technical Report 3747: Best Practices for File System Alignment in Virtual Environments
NetApp Documentation: Host Utilities (current releases)

How to achieve I/O alignment using LUN OS types

To achieve I/O alignment with your OS partitioning scheme, you should use the recommended ONTAP LUN `ostype` value that most closely matches your operating system.

The partition scheme employed by the host operating system is a major contributing factor to I/O misalignments. Some ONTAP LUN `ostype` values use a special offset known as a "prefix" to enable the default partitioning scheme used by the host operating system to be aligned.

Note: In some circumstances, a custom partitioning table might be required to achieve I/O alignment. However, for `ostype` values with a "prefix" value greater than **`0`**, a custom partition might create misaligned I/O.

The LUN `ostype` values in the following table should be used based on your operating system.

LUN `ostype`	Prefix (bytes)	Prefix (sectors)	Operating system
`windows`	32,256	63	Windows 2000, 2003 (MBR format)
`windows_gpt`	17,408	34	Windows 2003 (GPT format)
`windows_2008`	0	0	Windows 2008 and later
`hyper_v`	0	0	Windows 2008 Hyper-V and later
`linux`	0	0	All Linux distributions
`xen`	0	0	Citrix XenServer
`vmware`	0	0	VMware ESX
`solaris`	1MB	2,048	Solaris
`solaris_efi`	17,408	34	Solaris
`hpux`	0	0	HP-UX

LUN `ostype`	Prefix (bytes)	Prefix (sectors)	Operating system
`aix`	0	0	AIX

Special I/O alignment considerations for Linux

Linux distributions offer a wide variety of ways to use a LUN including as raw devices for databases, various volume managers, and file systems. It is not necessary to create partitions on a LUN when used as a raw device or as physical volume in a logical volume.

For RHEL 5 and earlier and SLES 10 and earlier, if the LUN will be used without a volume manager, you should partition the LUN to have one partition that begins at an aligned offset, which is a sector that is an even multiple of eight logical blocks.

Special I/O alignment considerations for Solaris LUNs

You need to consider various factors when determining whether you should use the `solaris` `ostype` or the `solaris_efi` `ostype`.

See the *Solaris Host Utilities Installation and Administration Guide* for detailed information.

Related information

NetApp Documentation: Host Utilities (current releases)

ESX boot LUNs report as misaligned

LUNs used as ESX boot LUNs are typically reported by ONTAP as misaligned. ESX creates multiple partitions on the boot LUN, making it very difficult to align. Misaligned ESX boot LUNs are not typically a performance problem because the total amount of misaligned I/O is small. Assuming that the LUN was correctly provisioned with the VMware `ostype`, no action is needed.

Related concepts

I/O misalignments might occur on properly aligned LUNs on page 34

Controlling and monitoring I/O performance to LUNs by using Storage QoS

You can control input/output (I/O) performance to LUNs by assigning LUNs to Storage QoS policy groups. You might control I/O performance to ensure that workloads achieve specific performance objectives or to throttle a workload that negatively impacts other workloads.

About this task

Policy groups enforce a maximum throughput limit (for example, 100 MB/s). You can create a policy group without specifying a maximum throughput, which enables you to monitor performance before you control the workload.

You can also assign storage virtual machines (SVMs) with FlexVol volumes and LUNs to policy groups.

Note the following requirements about assigning a LUN to a policy group:

- The LUN must be contained by the SVM to which the policy group belongs.
  You specify the SVM when you create the policy group.
- If you assign a LUN to a policy group, then you cannot assign the LUN's containing volume or SVM to a policy group.

For more information about how to use Storage QoS, see the *System Administration Reference*.

Steps

1. Use the `qos policy-group create` command to create a policy group.
2. Use the `lun create` command or the `lun modify` command with the `-qos-policy-group` parameter to assign a LUN to a policy group.
3. Use the `qos statistics` commands to view performance data.
4. If necessary, use the `qos policy-group modify` command to adjust the policy group's maximum throughput limit.

Related information

System administration

Tools available to effectively monitor your LUNs

Tools are available to help you effectively monitor your LUNs and avoid running out of space.

- Active IQ Unified Manager is a free tool that enables you to manage all storage across all clusters in your environment.
- System Manager is a graphical user interface built into ONTAP that enables you to manually manage storage needs at the cluster level.
- OnCommand Insight presents a single view of your storage infrastructure and enables you to set up automatic monitoring, alerts, and reporting when your LUNs, volumes, and aggregates are running out of storage space.

Ways to address issues when LUNs go offline

When no space is available for writes, LUNs go offline to preserve data integrity. LUNs can run out of space and go offline for various reasons, and there are several ways you can address the issue.

If the...	You can...
Aggregate is full	• Add more disks. • Use the `volume modify` command to shrink a volume that has available space. • If you have space-guarantee volumes that have available space, change the volume space guarantee to **none** with the `volume modify` command.

If the...	You can...
Volume is full but there is space available in the containing aggregate	• For space guarantee volumes, use the `volume modify` command to increase the size of your volume. • For thinly provisioned volumes, use the `volume modify` command to increase the maximum size of your volume. If volume autogrow is not enabled, use `volume modify -autogrow-mode` to enable it. • Delete Snapshot copies manually with the `volume snapshot delete` command, or use the `volume snapshot autodelete modify` command to automatically delete Snapshot copies.

Related information

Disk and aggregate management
Logical storage management

What host-side space management is

In a thinly provisioned environment, host side space management completes the process of managing space from the storage system that has been freed in the host file system.

A host file system contains metadata to keep track of which blocks are available to store new data and which blocks contain valid data that must not be overwritten. This metadata is stored within the LUN. When a file is deleted in the host file system, the file system metadata is updated to mark that file's blocks as free space. Total file system free space is then recalculated to include the newly freed blocks. To the storage system, these metadata updates appear no different from any other writes being performed by the host. Therefore, the storage system is unaware that any deletions have occurred.

This creates a discrepancy between the amount of free space reported by the host and the amount of free space reported by the underlying storage system. For example, suppose you have a newly provisioned 200-GB LUN assigned to your host by your storage system. Both the host and the storage system report 200 GB of free space. Your host then writes 100 GB of data. At this point, both the host and storage system report 100 GB of used space and 100 GB of unused space.

Then you delete 50 GB of data from your host. At this point, your host will report 50 GB of used space and 150 GB of unused space. However, your storage system will report 100 GB of used space and 100 GB of unused space.

Host-side space management uses various methods to reconcile the space differential between the host and the storage system.

Automatic host-side space management with SCSI thinly provisioned LUNs

If your host supports SCSI thin provisioning, you can enable the `space-allocation` option in ONTAP to turn on automatic host-side space management.

Enabling SCSI thin provisioning enables you to do the following.

- Automatic host-side space management
  When data is deleted on a host that supports SCSI thin provisioning, host-side space management identifies the blocks of deleted data on the host file system and automatically issues one or more `SCSI UNMAP` commands to free corresponding blocks on the storage system.
- Notify the host when a LUN runs out of space while keeping the LUN online
  On hosts that do not support SCSI thin provisioning, when the volume containing LUN runs out of space and cannot automatically grow, ONTAP takes the LUN offline. However, on hosts that support SCSI thin provisioning, ONTAP does not take the LUN offline when it runs out of space. The LUN remains online in read-only mode and the host is notified that the LUN can no longer accept writes.

Related concepts

Tools available to effectively monitor your LUNs on page 37

Related tasks

Enabling space allocation for SCSI thinly provisioned LUNs on page 39

Related references

Host support for SCSI thin provisioning on page 40

Related information

NetApp Documentation: Host Utilities (current releases)

Enabling space allocation for SCSI thinly provisioned LUNs

If you set the `space-allocation` option to **`enabled`**, ONTAP notifies the host when the volume has run out of space and the LUN in the volume cannot accept writes. This option also enables ONTAP to reclaim space automatically when your host deletes data.

About this task

The `space-allocation` option is set to **`disabled`** by default, and you must take the LUN offline to enable space allocation. After you enable space allocation, you must perform discovery on the host before the host will recognize that space allocation has been enabled.

Steps

1. Take the LUN offline:

   `lun modify -vserver` ***`vserver_name`*** **`-volume`** ***`volume_name`*** **`-lun`** ***`lun_name`*** **`-state offline`**

2. Set the `-space-allocation` parameter to **`enabled`**:

   `lun modify -vserver` ***`vserver_name`*** **`-volume`** ***`volume_name`*** **`-lun`** ***`lun_name`*** **`-space-allocation enabled`**

3. Verify that space allocation is enabled:

   `lun show -vserver` ***`vserver_name`*** **`-volume`** ***`volume_name`*** **`-lun`** ***`lun_name`*** **`-fields space-allocation`**

4. Bring the LUN online:

   `lun modify -vserver` ***`vserver_name`*** **`-volume`** ***`volume_name`*** **`-lun`** ***`lun_name`*** **`-state online`**

5. On the host, rescan all disks to ensure that the change to the `-space-allocation` option is correctly discovered.

Related concepts

Automatic host-side space management with SCSI thinly provisioned LUNs on page 38
Tools available to effectively monitor your LUNs on page 37
Using FlexClone LUNs to protect your data on page 51
Effect of moving or copying a LUN on Snapshot copies on page 49

Related references

Host support for SCSI thin provisioning on page 40

Host support for SCSI thin provisioning

To leverage the benefits of SCSI thin provisioning, it must be supported by your host. SCSI thin provisioning uses the Logical Block Provisioning feature as defined in the SCSI SBC-3 standard. Only hosts that support this standard can use SCSI thin provisioning in ONTAP.

The following hosts currently support SCSI thin provisioning when you enable space allocation:

- VMware ESX 5.0 and later
- Red Hat Enterprise Linux 6.2 and later
- Citrix XenServer 6.5 and later
- Microsoft Windows 2012
- Microsoft Windows 2016

When you enable the space allocation functionality in ONTAP, you turn on the following SCSI thin provisioning features:

- Unmapping and reporting space usage for space reclamation
- Reporting resource exhaustion errors

Related concepts

Automatic host-side space management with SCSI thinly provisioned LUNs on page 38

Related tasks

Enabling space allocation for SCSI thinly provisioned LUNs on page 39

Managing igroups

You can manage your initiator groups (igroups) by performing a range of tasks, including creating, destroying, and renaming igroups.

What igroups are

Initiator groups (igroups) are tables of FC protocol host WWPNs or iSCSI host node names. You can define igroups and map them to LUNs to control which initiators have access to LUNs.

Typically, you want all of the host's initiator ports or software initiators to have access to a LUN. If you are using multipathing software or have clustered hosts, each initiator port or software initiator of each clustered host needs redundant paths to the same LUN.

You can create igroups that specify which initiators have access to the LUNs either before or after you create LUNs, but you must create igroups before you can map a LUN to an igroup.

Initiator groups can have multiple initiators, and multiple igroups can have the same initiator. However, you cannot map a LUN to multiple igroups that have the same initiator. An initiator cannot be a member of igroups of differing ostypes.

Related concepts

Managing igroups on page 41

Example of how igroups give LUN access

You can create multiple igroups to define which LUNs are available to your hosts. For example, if you have a host cluster, you can use igroups to ensure that specific LUNs are visible to only one host in the cluster or to all of the hosts in the cluster.

The following table illustrates how four igroups give access to the LUNs for four different hosts that are accessing the storage system. The clustered hosts (Host3 and Host4) are both members of the same igroup (group3) and can access the LUNs mapped to this igroup. The igroup named group4 contains the WWPNs of Host4 to store local information that is not intended to be seen by its partner.

Hosts with HBA WWPNs, IQNs, or EUIs	igroups	WWPNs, IQNs, EUIs added to igroups	LUNs mapped to igroups
Host1, single-path (iSCSI software initiator) iqn.1991-05.com.microsoft:host1	group1	iqn.1991-05.com.microsoft:host1	`/vol/vol2/lun1`
Host2, multipath (two HBAs) 10:00:00:00:c9:2b:6b:3c 10:00:00:00:c9:2b:02:3c	group2	10:00:00:00:c9:2b:6b:3c 10:00:00:00:c9:2b:02:3c	`/vol/vol2/lun2`

Hosts with HBA WWPNs, IQNs, or EUIs	igroups	WWPNs, IQNs, EUIs added to igroups	LUNs mapped to igroups
Host3, multipath, clustered with host 4 10:00:00:00:c9:2b:32:1b 10:00:00:00:c9:2b:41:02	group3	10:00:00:00:c9:2b:32:1b 10:00:00:00:c9:2b:41:02 10:00:00:00:c9:2b:51:2c 10:00:00:00:c9:2b:47:a2	`/vol/vol2/qtree1/lun3`
Host4, multipath, clustered (not visible to Host3) 10:00:00:00:c9:2b:51:2c 10:00:00:00:c9:2b:47:a2	group4	10:00:00:00:c9:2b:51:2c 10:00:00:00:c9:2b:47:a2	`/vol/vol2/qtree2/lun4` `/vol/vol2/qtree1/lun5`

How to specify initiator WWPNs and iSCSI node names for an igroup

You can specify the iSCSI node names and WWPNs of the initiators when you create an igroup or you can add them later. If you choose to specify the initiator iSCSI node names and WWPNs when you create the LUN, they can be removed later, if needed.

Follow the instructions in your Host Utilities documentation to obtain WWPNs and to find the iSCSI node names associated with a specific host. For hosts running ESX software, use Virtual Storage Console.

Related information

NetApp Documentation: Host Utilities (current releases)

Managing LIFs

LIFs can be removed from port sets, moved to different nodes within a storage virtual machine (SVM), and deleted.

Related concepts

Considerations for LIFs in cluster SAN environments on page 89

Related information

Network and LIF management

Configuring an NVMe LIF

Certain requirements must be met when configuring NVMe LIFs.

Before you begin

NVMe must be supported by the FC adapter on which you create the LIF. Supported adapters are listed in the *Hardware Universe*.

NetApp Hardware Universe

About this task

The following rules apply when creating an NVMe LIF:

- NVMe can be the only data protocol on data LIFs.
- You should configure one management LIF for every SVM that supports SAN.
- For ONTAP 9.5 and later:
  - You can only configure two NVMe LIFs per node on a maximum of four nodes.
  - You must configure an NVMe LIF on the node containing the namespace and on node's HA partner.
- For ONTAP 9.4 only:
  - NVMe LIFs and namespaces must be hosted on the same node.
  - Only one NVMe data LIF can be configured per SVM.

Steps

1. Create the LIF:

   ```
   network interface create -vserver SVM_name -lif LIF_name -role LIF_role
   -data-protocol fc-nvme -home-node home_node -home-port
   home_port
   ```

2. Verify that the LIF was created:

   ```
   network interface show -vserver SVM_name
   ```

Considerations for SAN LIF movement

You only need to perform a LIF movement if you are changing the contents of your cluster, for example, adding nodes to the cluster or deleting nodes from the cluster. If you perform a LIF movement, you do not have to re-zone your FC fabric or create new iSCSI sessions between the attached hosts of your cluster and the new target interface.

You cannot move a SAN LIF using the `network interface move` command. SAN LIF movement must be performed by taking the LIF offline, moving the LIF to a different home node or port, and then bringing it back online in its new location. Asymmetric Logical Unit Access (ALUA) provides redundant paths and automatic path selection as part of any ONTAP SAN solution. Therefore, there is no I/O interruption when the LIF is taken offline for the movement. The host simply retries and then moves I/O to another LIF.

Using LIF movement, you can nondisruptively do the following:

- Replace one HA pair of a cluster with an upgraded HA pair in a way that is transparent to hosts accessing LUN data
- Upgrade a target interface card
- Shift the resources of a storage virtual machine (SVM) from one set of nodes in a cluster to another set of nodes in the cluster

Removing a SAN LIF from a port set

If the LIF you want to delete or move is in a port set, you must remove the LIF from the port set before you can delete or move the LIF.

About this task

You need to do Step 1 in the following procedure only if one LIF is in the port set. You cannot remove the last LIF in a port set if the port set is bound to an initiator group. Otherwise, you can start with Step 2 if multiple LIFs are in the port set.

Steps

1. If only one LIF is in the port set, use the `lun igroup unbind` command to unbind the port set from the initiator group.

   Note: When you unbind an initiator group from a port set, all of the initiators in the initiator group have access to all target LUNs mapped to the initiator group on all network interfaces.

   Example

   ```
   cluster1::>lun igroup unbind -vserver vs1 -igroup ig1
   ```

2. Use the `lun portset remove` command to remove the LIF from the port set.

   ```
   cluster1::> port set remove -vserver vs1 -portset ps1 -port-name lif1
   ```

Moving SAN LIFs

If a node needs to be taken offline, you can move a SAN LIF to preserve its configuration information, such as its WWPN, and avoid rezoning the switch fabric. Because a SAN LIF must be taken offline before it is moved, host traffic must rely on host multipathing software to provide nondisruptive access to the LUN. You can move SAN LIFs to any node in a cluster, but you cannot move the SAN LIFs between storage virtual machines (SVMs).

Before you begin

If the LIF is a member of a port set, the LIF must have been removed from the port set before the LIF can be moved to a different node.

About this task

The destination node and physical port for a LIF that you want to move must be on the same FC fabric or Ethernet network. If you move a LIF to a different fabric that has not been properly zoned, or if you move a LIF to an Ethernet network that does not have connectivity between iSCSI initiator and target, the LUN will be inaccessible when you bring it back online.

Steps

1. View the administrative and operational status of the LIF:

   `network interface show -vserver` ***`vserver_name`***

2. Change the status of the LIF to **`down`** (offline):

   `network interface modify -vserver` ***`vserver_name`*** **`-lif`** ***`LIF_name`*****`-status-admin down`**

3. Assign the LIF a new node and port:

   `network interface modify -vserver` ***`vserver_name`*** **`-lif`** ***`LIF_name`*** **`-home-node`** ***`node_name`*** **`-home-port`** ***`port_name`***

4. Change the status of the LIF to **`up`** (online):

   `network interface modify -vserver` ***`vserver_name`*** **`-lif`** ***`LIF_name`*** **`-status-admin up`**

5. Verify your changes:

   `network interface show -vserver` ***`vserver_name`***

Related tasks

Removing a SAN LIF from a port set on page 44

Deleting a LIF in a SAN environment

Before you delete a LIF, you should ensure that the host connected to the LIF can access the LUNs through another path.

Before you begin

If the LIF you want to delete is a member of a port set, you must first remove the LIF from the port set before you can delete the LIF.

Steps

1. Verify the name of the LIF and current port to be deleted:

   `network interface show –vserver` ***`vserver_name`***

2. Delete the LIF:

   `network interface delete`

Example

`network interface delete -vserver vs1 -lif lif1`

3. Verify that you deleted the LIF:

   `network interface show`

Example

`network interface show -vserver vs1`

```
Logical Status     Network                          Current   Current Is
Vserver Interface  Admin/Oper Address/Mask          Node      Port    Home
------- ---------- ---------- ---------------- --------- ------- ----
vs1
        lif2       up/up      192.168.2.72/24  node-01   e0b     true
        lif3       up/up      192.168.2.73/24  node-01   e0b     true
```

Related tasks

Removing a SAN LIF from a port set on page 44

Considerations for adding nodes to a cluster

You need to be aware of certain considerations when adding nodes to a cluster.

- You must create LIFs on the new nodes as appropriate before you create LUNs on those new nodes.
- You must discover those LIFs from the hosts as dictated by the host stack and protocol.
- You must create LIFs on the new nodes so that the LUN and volume movements are possible without using the cluster interconnect network.

Configuring iSCSI LIFs to return FQDN to host iSCSI SendTargets Discovery Operation

Beginning in ONTAP 9, iSCSI LIFs can be configured to return a Fully Qualified Domain Name (FQDN) when a host OS sends an iSCSI SendTargets Discovery Operation. Returning a FQDN is useful when there is a Network Address Translation (NAT) device between the host OS and the storage service.

About this task

IP addresses on one side of the NAT device are meaningless on the other side, but FQDNs can have meaning on both sides.

Note: The FQDN value interoperability limit is 128 characters on all host OS.

Steps

1. Change the privilege setting to advanced:

   `set -privilege advanced`

2. Configure iSCSI LIFs to return FQDN:

vserver iscsi interface modify -vserver *SVM_name* -lif *iscsi_LIF_name* -sendtargets_fqdn *FQDN*

Example

In the following example, the iSCSI LIFs are configured to return storagehost-005.example.com as the FQDN.

vserver iscsi interface modify -vserver vs1 -lif vs1_iscsi1 -sendtargets-fqdn storagehost-005.example.com

3. Verify that sendtargets is the FQDN:

   vserver iscsi interface show -vserver *SVM_name* -fields sendtargets-fqdn

Example

In this example, storagehost-005.example.com is displayed in the sendtargets-fqdn output field.

```
cluster::vserver*> vserver iscsi interface show -vserver vs1 -fields
sendtargets-fqdn
vserver lif        sendtargets-fqdn
------- ---------- ---------------------------
vs1     vs1_iscsi1 storagehost-005.example.com
vs1     vs1_iscsi2 storagehost-006.example.com
```

Related information

ONTAP 9 commands

Data protection methods in SAN environments

You can protect your data by making copies of it so that it is available for restoration in the event of accidental deletion, application crashes, data corruption, or disaster. Depending on your data protection and backup needs, ONTAP offers a variety of methods that enable you to protect your data.

Snapshot copy

Enables you to manually or automatically create, schedule, and maintain multiple backups of your LUNs. Snapshot copies use only a minimal amount of additional volume space and do not have a performance cost. If your LUN data is accidentally modified or deleted, that data can easily and quickly be restored from one of the latest Snapshot copies.

FlexClone LUNs (FlexClone license required)

Provides point-in-time, writable copies of another LUN in an active volume or in a Snapshot copy. A clone and its parent can be modified independently without affecting each other.

SnapRestore (license required)

Enables you to perform fast, space-efficient, on-request data recovery from Snapshot copies on an entire volume. You can use SnapRestore to restore a LUN to an earlier preserved state without rebooting the storage system.

Data protection mirror copies (SnapMirror license required)

Provides asynchronous disaster recovery by enabling you to periodically create Snapshot copies of data on your volume; copy those Snapshot copies over a local or wide area network to a partner volume, usually on another cluster; and retain those Snapshot copies. The mirror copy on the partner volume provides quick availability and restoration of data from the time of the last Snapshot copy, if the data on the source volume is corrupted or lost.

SnapVault backups (SnapMirror license required)

Provides storage efficient and long-term retention of backups. SnapVault relationships enable you to back up selected Snapshot copies of volumes to a destination volume and retain the backups.

If you conduct tape backups and archival operations, you can perform them on the data that is already backed up on the SnapVault secondary volume.

SnapDrive for Windows or UNIX (SnapDrive license required)

Configures access to LUNs, manages LUNs, and manages storage system Snapshot copies directly from a Windows or UNIX hosts.

Native tape backup and recovery

Support for most existing tape drives are included in ONTAP, as well as a method for tape vendors to dynamically add support for new devices. ONTAP also supports the Remote Magnetic Tape (RMT) protocol, enabling backup and recovery to any capable system.

Related information

NetApp Documentation: SnapDrive for UNIX
NetApp Documentation: SnapDrive for Windows (current releases)

Data protection using tape backup

Effect of moving or copying a LUN on Snapshot copies

Snapshot copies are created of the volume. Therefore, if you copy or move a LUN to a different volume, the moved LUN or LUN copy will fall under the data protection scheme of the destination volume. If you do not have Snapshot copies established for the destination volume, Snapshot copies will not be created of the LUN or LUN copy on that volume.

Restoring a single LUN from a Snapshot copy

You can restore a single LUN from a Snapshot copy without restoring the entire volume that contains the single LUN. You can restore the LUN in place or to a new path in the volume. The operation restores only the single LUN without impacting other files or LUNs in the volume. You can also restore files with streams.

Before you begin

- You must have enough space on your volume to complete the restore operation:
    - If you are restoring a space-reserved LUN where the fractional reserve is 0%, you require one times the size of the restored LUN.
    - If you are restoring a space-reserved LUN where the fractional reserve is 100%, you require two times the size of the restored LUN.
    - If you are restoring a non-space-reserved LUN, you only require the actual space used for the restored LUN.
- A Snapshot copy of the destination LUN must have been created.
  If the restore operation fails, the destination LUN might be truncated. In such cases, you can use the Snapshot copy to prevent data loss.
- A Snapshot copy of the source LUN must have been created.
  In rare cases, the LUN restore can fail, leaving the source LUN unusable. If this occurs, you can use the Snapshot copy to return the LUN to the state just before the restore attempt.
- The destination LUN and source LUN must have the same OS type.
  If your destination LUN has a different OS type from your source LUN, your host can lose data access to the destination LUN after the restore operation.

Steps

1. From the host, stop all host access to the LUN.
2. Unmount the LUN on its host so that the host cannot access the LUN.
3. Unmap the LUN:

   lun mapping delete -vserver *vserver_name* -volume *volume_name* -lun *lun_name* -igroup *igroup_name*
4. Determine the Snapshot copy you want to restore your LUN to:

   volume snapshot show -vserver *vserver_name* -volume *volume_name*
5. Create a Snapshot copy of the LUN prior to restoring the LUN:

   volume snapshot create -vserver *vserver_name* -volume *volume_name*-snapshot *snapshot_name*

6. Restore the specified LUN in a volume:

   volume snapshot restore-file -vserver *vserver_name* -volume *volume_name* -snapshot *snapshot_name* -path *lun_path*

7. Follow the steps on the screen.
8. If necessary, bring the LUN online:

   lun modify -vserver *vserver_name* -path *lun_path* -state online

9. If necessary, remap the LUN:

   lun mapping create -vserver *vserver_name* -volume *volume_name* -lun *lun_name* -igroup *igroup_name*

10. From the host, remount the LUN.
11. From the host, restart access to the LUN.

Restoring all LUNs in a volume from a Snapshot copy

You can use `volume snapshot restore` command to restore all the LUNs in a specified volume from a Snapshot copy.

Steps

1. From the host, stop all host access to the LUNs.

   Using SnapRestore without stopping all host access to LUNs in the volume can cause data corruption and system errors.

2. Unmount the LUNs on that host so that the host cannot access the LUNs.
3. Unmap your LUNs:

   lun mapping delete -vserver *vserver_name* -volume *volume_name* -lun *lun_name* -igroup *igroup_name*

4. Determine the Snapshot copy to which you want to restore your volume:

   volume snapshot show -vserver *vserver_name* -volume *volume_name*

5. Change your privilege setting to advanced:

   set -privilege advanced

6. Restore your data:

   volume snapshot restore -vserver *vserver_name* -volume *volume_name* -snapshot *snapshot_name*

7. Follow the instructions on the screen.
8. Remap your LUNs:

   lun mapping create -vserver *vserver_name* -volume *volume_name* -lun *lun_name* -igroup *igroup_name*

9. Verify that your LUNs are online:

   lun show -vserver *vserver_name* -path *lun_path* -fields state

10. If your LUNs are not online, bring them online:

    lun modify -vserver *vserver_name* -path *lun_path* -state online

11. Change your privilege setting to admin:

    set -privilege admin

12. From the host, remount your LUNs.
13. From the host, restart access to your LUNs.

Deleting one or more existing Snapshot copies from a volume

You can manually delete one or more existing Snapshot copies from the volume. You might want to do this if you need more space on your volume.

Steps

1. Use the `volume snapshot show` command to verify which Snapshot copies you want to delete.

   Example

```
cluster::> volume snapshot show -vserver vs3 -volume vol3

                                                        ---Blocks---
Vserver  Volume  Snapshot                Size   Total% Used%
-------- ------- ---------------------- -----   ------ -----
vs3      vol3
                 snap1.2013-05-01_0015   100KB   0%    38%
                 snap1.2013-05-08_0015   76KB   0%    32%
                 snap2.2013-05-09_0010   76KB   0%    32%
                 snap2.2013-05-10_0010   76KB   0%    32%
                 snap3.2013-05-10_1005   72KB   0%    31%
                 snap3.2013-05-10_1105   72KB   0%    31%
                 snap3.2013-05-10_1205   72KB   0%    31%
                 snap3.2013-05-10_1305   72KB   0%    31%
                 snap3.2013-05-10_1405   72KB   0%    31%
                 snap3.2013-05-10_1505   72KB   0%    31%
10 entries were displayed.
```

2. Use the `volume snapshot delete` command to delete all of the Snapshot copies.

   Example

```
cluster::> volume snapshot delete -vserver vs3 -volume vol3 *

10 entries were acted on.
```

Using FlexClone LUNs to protect your data

A FlexClone LUN is a point-in-time, writeable copy of another LUN in an active volume or in a Snapshot copy. The clone and its parent can be modified independently without affecting each other.

A FlexClone LUN shares space initially with its parent LUN. By default, the FlexClone LUN inherits the space-reserved attribute of the parent LUN. For example, if the parent LUN is non-space-reserved, the FlexClone LUN is also non-space-reserved by default. However, you can create a non-space-reserved FlexClone LUN from a parent that is a space-reserved LUN.

When you clone a LUN, block sharing occurs in the background and you cannot create a volume Snapshot copy until the block sharing is finished.

You must configure the volume to enable the FlexClone LUN automatic deletion function with the `volume snapshot autodelete modify` command. Otherwise, if you want FlexClone LUNs to be deleted automatically but the volume is not configured for FlexClone auto delete, none of the FlexClone LUNs are deleted.

When you create a FlexClone LUN, the FlexClone LUN automatic deletion function is disabled by default. You must manually enable it on every FlexClone LUN before that FlexClone LUN can be automatically deleted. If you are using semi-thick volume provisioning and you want the “best effort” write guarantee provided by this option, you must make *all* FlexClone LUNs available for automatic deletion.

> **Note:** When you create a FlexClone LUN from a Snapshot copy, the LUN is automatically split from the Snapshot copy by using a space-efficient background process so that the LUN does not continue to depend on the Snapshot copy or consume any additional space. If this background split has not been completed and this Snapshot copy is automatically deleted, that FlexClone LUN is deleted even if you have disabled the FlexClone auto delete function for that FlexClone LUN. After the background split is complete, the FlexClone LUN is not deleted even if that Snapshot copy is deleted.

Related information

Logical storage management

Reasons for using FlexClone LUNs

You can use FlexClone LUNs to create multiple read/write copies of a LUN.

You might want to do this for the following reasons:

- You need to create a temporary copy of a LUN for testing purposes.
- You need to make a copy of your data available to additional users without giving them access to the production data.
- You want to create a clone of a database for manipulation and projection operations, while preserving the original data in an unaltered form.
- You want to access a specific subset of a LUN's data (a specific logical volume or file system in a volume group, or a specific file or set of files in a file system) and copy it to the original LUN, without restoring the rest of the data in the original LUN. This works on operating systems that support mounting a LUN and a clone of the LUN at the same time. SnapDrive for UNIX supports this with the `snap connect` command.
- You need multiple SAN boot hosts with the same operating system.

How a FlexVol volume can reclaim free space with autodelete setting

You can enable the autodelete setting of a FlexVol volume to automatically delete FlexClone files and FlexClone LUNs. By enabling autodelete, you can reclaim a target amount of free space in the volume when a volume is nearly full.

You can configure a volume to automatically start deleting FlexClone files and FlexClone LUNs when the free space in the volume decreases below a particular threshold value, and automatically stop deleting clones when a target amount of free space in the volume is reclaimed. Although, you cannot specify the threshold value that starts the automatic deletion of clones, you can specify whether a clone is eligible for deletion, and you can specify the target amount of free space for a volume.

A volume automatically deletes FlexClone files and FlexClone LUNs when the free space in the volume decreases below a particular threshold and when *both* of the following requirements are met:

- The autodelete capability is enabled for the volume that contains the FlexClone files and FlexClone LUNs.
  You can enable the autodelete capability for a FlexVol volume by using the `volume snapshot autodelete modify` command. You must set the `-trigger` parameter to **`volume`** or **`snap_reserve`** for a volume to automatically delete FlexClone files and FlexClone LUNs.
- The autodelete capability is enabled for the FlexClone files and FlexClone LUNs.

You can enable autodelete for a FlexClone file or FlexClone LUN by using the `file clone create` command with the `-autodelete` parameter. As a result, you can preserve certain FlexClone files and FlexClone LUNs by disabling autodelete for the clones and ensuring that other volume settings do not override the clone setting.

Configuring a FlexVol volume to automatically delete FlexClone files and FlexClone LUNs

You can enable a FlexVol volume to automatically delete FlexClone files and FlexClone LUNs with autodelete enabled when the free space in the volume decreases below a particular threshold.

Before you begin

- The FlexVol volume must contain FlexClone files and FlexClone LUNs and be online.
- The FlexVol volume must not be a read-only volume.

Steps

1. Enable automatic deletion of FlexClone files and FlexClone LUNs in the FlexVol volume by using the `volume snapshot autodelete modify` command.
    - For the `-trigger` parameter, you can specify **`volume`** or **`snap_reserve`**.
    - For the `-destroy-list` parameter, you must always specify **`lun_clone,file_clone`** regardless of whether you want to delete only one type of clone.

    #### Example

    The following example shows how you can enable volume vol1 to trigger the automatic deletion of FlexClone files and FlexClone LUNs for space reclamation until 25% of the volume consists of free space:

    ```
    cluster1::> volume snapshot autodelete modify -vserver vs1 -volume
    vol1 -enabled true -commitment disrupt -trigger volume -target-free-
    space 25 -destroy-list lun_clone,file_clone

    Volume modify successful on volume:vol1
    ```

    Note: While enabling FlexVol volumes for automatic deletion, if you set the value of the `-commitment` parameter to **`destroy`**, all the FlexClone files and FlexClone LUNs with the `-autodelete` parameter set to **`true`** might be deleted when the free space in the volume decreases below the specified threshold value. However, FlexClone files and FlexClone LUNs with the `-autodelete` parameter set to **`false`** will not be deleted.

2. Verify that automatic deletion of FlexClone files and FlexClone LUNs is enabled in the FlexVol volume by using the `volume snapshot autodelete show` command.

    #### Example

    The following example shows that volume vol1 is enabled for automatic deletion of FlexClone files and FlexClone LUNs:

    ```
    cluster1::> volume snapshot autodelete show -vserver vs1 -volume vol1

             Vserver Name: vs1
              Volume Name: vol1
              Enabled: true
               Commitment: disrupt
             Defer Delete: user_created
    ```

```
         Delete Order: oldest_first
  Defer Delete Prefix: (not specified)
    Target Free Space: 25%
              Trigger: volume
     Destroy List: lun_clone,file_clone
Is Constituent Volume: false
```

3. Ensure that autodelete is enabled for the FlexClone files and FlexClone LUNs in the volume that you want to delete by performing the following steps:

   a. Enable automatic deletion of a particular FlexClone file or FlexClone LUN by using the `volume file clone autodelete` command.

      You can force a specific FlexClone file or FlexClone LUN to be automatically deleted by using the `volume file clone autodelete` command with the `-force` parameter.

      Example

      The following example shows that automatic deletion of the FlexClone LUN lun1_clone contained in volume vol1 is enabled:

      ```
      cluster1::> volume file clone autodelete -vserver vs1 -clone-
      path /vol/vol1/lun1_clone -enabled true
      ```

      You can enable autodelete when you create FlexClone files and FlexClone LUNs.

   b. Verify that the FlexClone file or FlexClone LUN is enabled for automatic deletion by using the `volume file clone show-autodelete` command.

      Example

      The following example shows that the FlexClone LUN lun1_clone is enabled for automatic deletion:

      ```
      cluster1::> volume file clone show-autodelete -vserver vs1 -clone-
      path vol/vol1/lun1_clone

      Vserver Name: vs1
                                                              Clone
      Path: vol/vol1/lun1_clone

      Autodelete Enabled: true
      ```

   For more information about using the commands, see the respective man pages.

Cloning LUNs from an active volume

You can create copies of your LUNs by cloning the LUNs in the active volume. These FlexClone LUNs are readable and writeable copies of the original LUNs in the active volume.

Before you begin

A FlexClone license must be installed.

About this task

Note: A space-reserved FlexClone LUN requires as much space as the space-reserved parent LUN. If the FlexClone LUN is not space-reserved, you must ensure that the volume has enough space to accommodate changes to the FlexClone LUN.

Steps

1. You must have verified that the LUNs are not mapped to an igroup or are written to before making the clone.

2. Use the `lun show` command to verify that the LUN exists.

   Example

   `lun show -vserver vs1`

```
Vserver  Path               State     Mapped    Type     Size
-------- ------------------ --------- --------- -------- -------
vs1      /vol/vol1/lun1     online   unmapped  windows  47.07MB
```

3. Use the `volume file clone create` command to create the FlexClone LUN.

   Example

   `volume file clone create -vserver vs1 -volume vol1 -source-path lun1 -destination-path/lun1_clone`

   If you need the FlexClone LUN to be available for automatic deletion, you include `-autodelete true`. If you are creating this FlexClone LUN in a volume using semi-thick provisioning, you must enable automatic deletion for all FlexClone LUNs.

4. Use the `lun show` command to verify that you created a LUN.

   Example

   `lun show -vserver vs1`

```

Vserver  Path                     State    Mapped   Type     Size
-------- ------------------------ -------- -------- -------- ------
vs1      /vol/volX/lun1           online   unmapped windows  47.07MB
vs1      /vol/volX/lun1_clone     online   unmapped windows  47.07MB
```

Related concepts

Reasons for using FlexClone LUNs on page 52
Using FlexClone LUNs to protect your data on page 51

Creating FlexClone LUNs from a Snapshot copy in a volume

You can use a Snapshot copy in your volume to create FlexClone copies of your LUNs. FlexClone copies of LUNs are both readable and writeable.

Before you begin

A FlexClone license must be installed.

About this task

The FlexClone LUN inherits the space reservations attribute of the parent LUN. A space-reserved FlexClone LUN requires as much space as the space-reserved parent LUN. If the FlexClone LUN is not space-reserved, the volume must have enough space to accommodate changes to the clone.

Steps

1. Verify that the LUN is not mapped or being written to.

2. Create a Snapshot copy of the volume that contains the LUNs:

   volume snapshot create -vserver *vserver_name* -volume *volume_name* -snapshot *snapshot_name*

   You must create a Snapshot copy (the backing Snapshot copy) of the LUN you want to clone.

3. Create the FlexClone LUN from the Snapshot copy:

   file clone create -vserver *vserver_name* -volume *volume_name* -source-path *source_path* -snapshot-name *snapshot_name* -destination-path *destination_path*

   If you need the FlexClone LUN to be available for automatic deletion, you include `-autodelete true`. If you are creating this FlexClone LUN in a volume using semi-thick provisioning, you must enable automatic deletion for all FlexClone LUNs.

4. Verify that the FlexClone LUN is correct:

   lun show -vserver *vserver_name*

   Example

```
Vserver Path                       State    Mapped    Type     Size
------- ----------------------     -------- --------- -------- -------
vs1     /vol/vol1/lun1_clone       online   unmapped windows   47.07MB
vs1     /vol/vol1/lun1_snap_clone online   unmapped windows   47.07MB
```

Related concepts

Reasons for using FlexClone LUNs on page 52
Using FlexClone LUNs to protect your data on page 51

Preventing a specific FlexClone file or FlexClone LUN from being automatically deleted

If you configure a FlexVol volume to automatically delete FlexClone files and FlexClone LUNs, any clone that fits the criteria you specify might be deleted. If you have specific FlexClone files or FlexClone LUNs that you want to preserve, you can exclude them from the automatic FlexClone deletion process.

Before you begin

A FlexClone license must be installed.

About this task

When you create a FlexClone file or FlexClone LUN, by default the autodelete setting for the clone is disabled. FlexClone files and FlexClone LUNs with autodelete disabled are preserved when you configure a FlexVol volume to automatically delete clones to reclaim space on the volume.

Attention: If you set the `commitment` level on the volume to **`try`** or **`disrupt`**, you can individually preserve specific FlexClone files or FlexClone LUNs by disabling autodelete for those clones. However, if you set the `commitment` level on the volume to **`destroy`** and the destroy lists include **`lun_clone,file_clone`**, the volume setting overrides the clone setting, and all FlexClone files and FlexClone LUNs can be deleted regardless of the autodelete setting for the clones.

Steps

1. Prevent a specific FlexClone file or FlexClone LUN from being automatically deleted by using the `volume file clone autodelete` command.

   Example

   The following example shows how you can disable autodelete for FlexClone LUN lun1_clone contained in vol1:

   ```
   cluster1::> volume file clone autodelete -vserver vs1 -volume vol1 -
   clone-path lun1_clone -enable false
   ```

   A FlexClone file or FlexClone LUN with autodelete disabled cannot be deleted automatically to reclaim space on the volume.

2. Verify that autodelete is disabled for the FlexClone file or FlexClone LUN by using the `volume file clone show-autodelete` command.

   Example

   The following example shows that autodelete is false for the FlexClone LUN lun1_clone:

   ```
   cluster1::> volume file clone show-autodelete -vserver vs1 -clone-
   path vol/vol1/lun1_clone
                                                               Vserver
   Name: vs1
                                                               Clone
   Path: vol/vol1/lun1_clone

   Autodelete Enabled: false
   ```

Configuring and using SnapVault backups in a SAN environment

SnapVault configuration and use in a SAN environment is very similar to configuration and use in a NAS environment, but restoring LUNs in a SAN environment requires some special procedures.

SnapVault backups contain a set of read-only copies of a source volume. In a SAN environment you always back up entire volumes to the SnapVault secondary volume, not individual LUNs.

The procedure for creating and initializing the SnapVault relationship between a primary volume containing LUNs and a secondary volume acting as a SnapVault backup is identical to the procedure used with FlexVol volumes used for file protocols. This procedure is described in detail in the *Data Protection Power Guide.*

Data protection

It is important to ensure that LUNs being backed up are in a consistent state before the Snapshot copies are created and copied to the SnapVault secondary volume. Automating the Snapshot copy creation with a product like SnapManager for Microsoft SQL Server ensures that backed up LUNs are complete and usable by the original application.

There are three basic choices for restoring LUNs from a SnapVault secondary volume:

- You can map a LUN directly from the SnapVault secondary volume and connect a host to the LUN to access the contents of the LUN.
  The LUN is read-only and you can map only from the most recent Snapshot copy in the SnapVault backup. Persistent reservations and other LUN metadata are lost. If desired, you can

use a copy program on the host to copy the LUN contents back to the original LUN if it is still accessible.
The LUN has a different serial number from the source LUN.

- You can clone any Snapshot copy in the SnapVault secondary volume to a new read-write volume.
  You can then map any of the LUNs in the volume and connect a host to the LUN to access the contents of the LUN. If desired, you can use a copy program on the host to copy the LUN contents back to the original LUN if it is still accessible.
- You can restore the entire volume containing the LUN from any Snapshot copy in the SnapVault secondary volume.
  Restoring the entire volume replaces all of the LUNs, and any files, in the volume. Any new LUNs created since the Snapshot copy was created are lost.
  The LUNs retain their mapping, serial numbers, UUIDs, and persistent reservations.

Accessing a read-only LUN copy from a SnapVault backup

You can access a read-only copy of a LUN from the latest Snapshot copy in a SnapVault backup. The LUN ID, path, and serial number are different from the source LUN and must first be mapped. Persistent reservations, LUN mappings, and igroups are not replicated to the SnapVault secondary volume.

Before you begin

- The SnapVault relationship must be initialized and the latest Snapshot copy in the SnapVault secondary volume must contain the desired LUN.
- The storage virtual machine (SVM) containing the SnapVault backup must have one or more LIFs with the desired SAN protocol accessible from the host used to access the LUN copy.
- If you plan to access LUN copies directly from the SnapVault secondary volume, you must create your igroups on the SnapVault SVM in advance.
  You can access a LUN directly from the SnapVault secondary volume without having to first restore or clone the volume containing the LUN.

About this task

If a new Snapshot copy is added to the SnapVault secondary volume while you have a LUN mapped from a previous Snapshot copy, the contents of the mapped LUN changes. The LUN is still mapped with the same identifiers, but the data is taken from the new Snapshot copy. If the LUN size changes, some hosts automatically detect the size change; Windows hosts require a disk rescan to pick up any size change.

Steps

1. Run the `lun show` command to list the available LUNs in the SnapVault secondary volume.

   #### Example

   In this example, you can see both the original LUNs in the primary volume srcvolA and the copies in the SnapVault secondary volume dstvolB:

```
cluster::> lun show

Vserver   Path                State   Mapped   Type          Size
--------  ------------------  ------  -------  --------      -------
vserverA  /vol/srcvolA/lun_A  online  mapped   windows_2008  300.0GB
vserverA  /vol/srcvolA/lun_B  online  mapped   windows_2008  300.0GB
vserverA  /vol/srcvolA/lun_C  online  mapped   windows_2008  300.0GB
vserverB  /vol/dstvolB/lun_A  online  unmapped windows_2008  300.0GB
```

```
vserverB  /vol/dstvolB/lun_B  online  unmapped windows_2008  300.0GB
vserverB  /vol/dstvolB/lun_C  online  unmapped windows_2008  300.0GB

6 entries were displayed.
```

2. If the igroup for the desired host does not already exist on the SVM containing the SnapVault secondary volume, run the `igroup create` command to create an igroup.

   Example

   This command creates an igroup for a Windows host that uses the iSCSI protocol:

   ```
   cluster::> igroup create -vserver vserverB -igroup temp_igroup
     -protocol iscsi -ostype windows
     -initiator iqn.1991-05.com.microsoft:hostA
   ```

3. Run the `lun mapping create` command to map the desired LUN copy to the igroup.

   Example

   ```
   cluster::> lun mapping create -vserver vserverB -path /vol/dstvolB/
   lun_A
     -igroup temp_igroup
   ```

4. Connect the host to the LUN and access the contents of the LUN as desired.

Restoring a single LUN from a SnapVault backup

You can restore a single LUN to a new location or to the original location. You can restore from any Snapshot copy in the SnapVault secondary volume. To restore the LUN to the original location, you first restore it to a new location and then copy it.

Before you begin

- The SnapVault relationship must be initialized and the SnapVault secondary volume must contain an appropriate Snapshot copy to restore.
- The storage virtual machine (SVM) containing the SnapVault secondary volume must have one or more LIFs with the desired SAN protocol that are accessible from the host used to access the LUN copy.
- The igroups must already exist on the SnapVault SVM.

About this task

The process includes creating a read-write volume clone from a Snapshot copy in the SnapVault secondary volume. You can use the LUN directly from the clone, or you can optionally copy the LUN contents back to the original LUN location.

The LUN in the clone has a different path and serial number from the original LUN. Persistent reservations are not retained.

Steps

1. Run the `snapmirror show` command to verify the secondary volume that contains the SnapVault backup.

Example

```
cluster::> snapmirror show

Source          Dest     Mirror  Relation  Total             Last
Path     Type  Path     State   Status    Progress  Healthy Updated
-------- ---- --------- ------- --------- --------- ------- -------
vserverA:srcvolA
         XDP  vserverB:dstvolB
                        Snapmirrored
                                Idle       -         true    -
```

2. Run the `volume snapshot show` command to identify the Snapshot copy that you want to restore the LUN from.

Example

```
cluster::> volume snapshot show

Vserver  Volume  Snapshot               State Size   Total% Used%
-------- ------- ---------------------- ----- ------ ------ -----
vserverB
         dstvolB
                 snap2.2013-02-10_0010  valid  124KB     0%    0%
                 snap1.2013-02-10_0015 valid  112KB     0%    0%
                 snap2.2013-02-11_0010  valid  164KB     0%    0%
```

3. Run the `volume clone create` command to create a read-write clone from the desired Snapshot copy.

   The volume clone is created in the same aggregate as the SnapVault backup. There must be enough space in the aggregate to store the clone.

Example

```
cluster::> volume clone create -vserver vserverB
  -flexclone dstvolB_clone -type RW -parent-volume dstvolB
  -parent-snapshot daily.2013-02-10_0010
[Job 108] Job succeeded: Successful
```

4. Run the `lun show` command to list the LUNs in the volume clone.

Example

```
cluster::> lun show -vserver vserverB -volume dstvolB_clone

Vserver   Path                     State   Mapped   Type
--------- ------------------------ ------- -------- --------
vserverB  /vol/dstvolB_clone/lun_A online  unmapped windows_2008
vserverB  /vol/dstvolB_clone/lun_B online  unmapped windows_2008
vserverB  /vol/dstvolB_clone/lun_C online  unmapped windows_2008

3 entries were displayed.
```

5. If the igroup for the desired host does not already exist on the SVM containing the SnapVault backup, run the `igroup create` command to create an igroup.

Example

This example creates an igroup for a Windows host that uses the iSCSI protocol:

```
cluster::> igroup create -vserver vserverB -igroup temp_igroup
  -protocol iscsi -ostype windows
  -initiator iqn.1991-05.com.microsoft:hostA
```

6. Run the `lun mapping create` command to map the desired LUN copy to the igroup.

   Example

   ```
   cluster::> lun mapping create -vserver vserverB
     -path /vol/dstvolB_clone/lun_C -igroup temp_igroup
   ```

7. Connect the host to the LUN and access the contents of the LUN, as desired.

   The LUN is read-write and can be used in place of the original LUN. Because the LUN serial number is different, the host interprets it as a different LUN from the original.

8. Use a copy program on the host to copy the LUN contents back to the original LUN.

Restoring all LUNs in a volume from a SnapVault backup

If one or more LUNs in a volume need to be restored from a SnapVault backup, you can restore the entire volume. Restoring the volume affects all LUNs in the volume.

Before you begin

The SnapVault relationship must be initialized and the SnapVault secondary volume must contain an appropriate Snapshot copy to restore.

About this task

Restoring an entire volume returns the volume to the state it was in when the Snapshot copy was made. If a LUN was added to the volume after the Snapshot copy, that LUN is removed during the restore process.

After restoring the volume, the LUNs remain mapped to the igroups they were mapped to just before the restore. The LUN mapping might be different from the mapping at the time of the Snapshot copy. Persistent reservations on the LUNs from host clusters are retained.

Steps

1. Stop I/O to all LUNs in the volume.

2. Run the `snapmirror show` command to verify the secondary volume that contains the SnapVault secondary volume.

   Example

   ```
   cluster::> snapmirror show

   Source          Dest      Mirror  Relation  Total             Last
   Path     Type  Path      State   Status    Progress  Healthy Updated
   -------- ---- --------- ------- --------- --------- ------- -------
   vserverA:srcvolA
            XDP  vserverB:dstvolB
                            Snapmirrored
                                    Idle       -         true    -
   ```

3. Run the `volume snapshot show` command to identify the Snapshot copy that you want to restore from.

Example

```
cluster::> volume snapshot show

Vserver  Volume  Snapshot              State Size   Total% Used%
-------- ------- --------------------- ----- ------ ------ -----
vserverB
         dstvolB
                 snap2.2013-02-10_0010  valid  124KB     0%    0%
                 snap1.2013-02-10_0015 valid  112KB     0%    0%
                 snap2.2013-02-11_0010  valid  164KB     0%    0%
```

4. Run the `snapmirror restore` command and specify the `-source-snapshot` option to specify the Snapshot copy to use.

   The destination you specify for the restore is the original volume you are restoring to.

Example

```
cluster::> snapmirror restore -destination-path vserverA:srcvolA
  -source-path vserverB:dstvolB -source-snapshot daily.2013-02-10_0010

Warning: All data newer than Snapshot copy hourly.2013-02-11_1205 on
volume vserverA:src_volA will be deleted.
Do you want to continue? {y|n}: y
[Job 98] Job is queued: snapmirror restore from source
"vserverB:dstvolB" for the snapshot daily.2013-02-10_0010.
```

5. If you are sharing LUNs across a host cluster, restore the persistent reservations on the LUNs from the affected hosts.

Restoring a volume from a SnapVault backup

In the following example, the LUN named lun_D was added to the volume after the Snapshot copy was created. After restoring the entire volume from the Snapshot copy, lun_D no longer appears.

In the `lun show` command output, you can see the LUNs in the primary volume srcvolA and the read-only copies of those LUNs in the SnapVault secondary volume dstvolB. There is no copy of lun_D in the SnapVault backup.

```
cluster::> lun show
Vserver   Path                State   Mapped   Type          Size
--------- ------------------  ------- -------- --------      -------
vserverA  /vol/srcvolA/lun_A  online  mapped   windows_2008  300.0GB
vserverA  /vol/srcvolA/lun_B  online  mapped   windows_2008  300.0GB
vserverA  /vol/srcvolA/lun_C  online  mapped   windows_2008  300.0GB
vserverA  /vol/srcvolA/lun_D  online  mapped   windows_2008  250.0GB
vserverB  /vol/dstvolB/lun_A  online  unmapped windows_2008  300.0GB
vserverB  /vol/dstvolB/lun_B  online  unmapped windows_2008  300.0GB
vserverB  /vol/dstvolB/lun_C  online  unmapped windows_2008  300.0GB

7 entries were displayed.

cluster::>snapmirror restore -destination-path vserverA:srcvolA
  -source-path vserverB:dstvolB
  -source-snapshot daily.2013-02-10_0010

Warning: All data newer than Snapshot copy hourly.2013-02-11_1205
on volume vserverA:src_volA will be deleted.
Do you want to continue? {y|n}: y
[Job 98] Job is queued: snapmirror restore from source
"vserverB:dstvolB" for the snapshot daily.2013-02-10_0010.

cluster::> lun show
Vserver   Path                State   Mapped   Type          Size
```

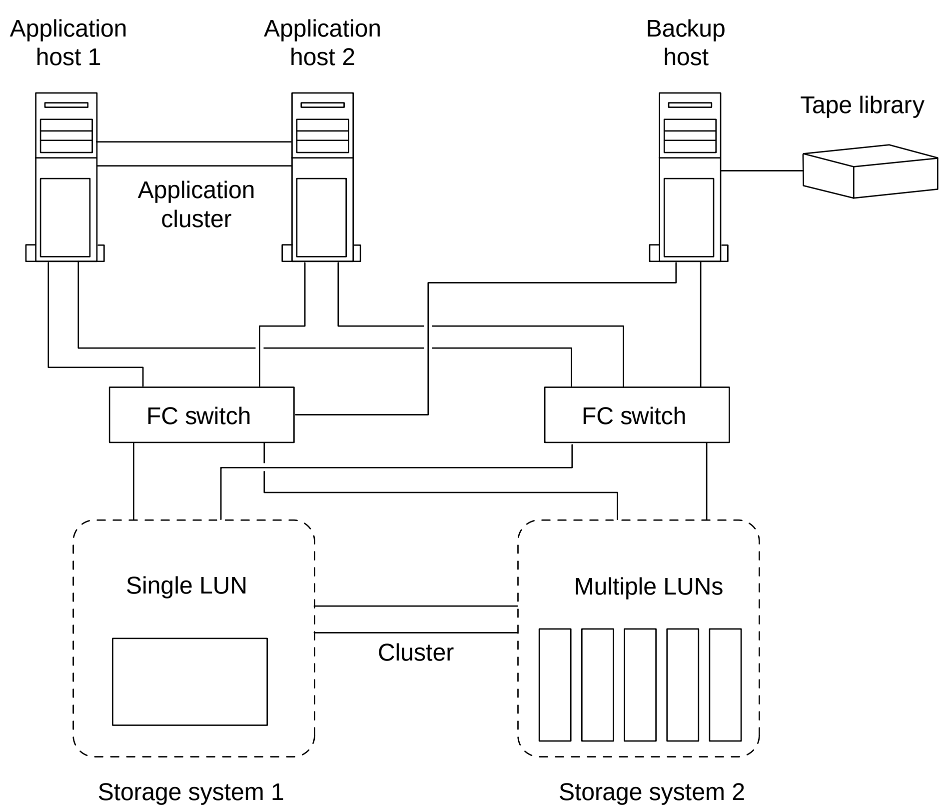
```
--------- -----------------  ------- -------- --------      -------
vserverA  /vol/srcvolA/lun_A  online  mapped   windows_2008  300.0GB
vserverA  /vol/srcvolA/lun_B  online  mapped   windows_2008  300.0GB
vserverA  /vol/srcvolA/lun_C  online  mapped   windows_2008  300.0GB
vserverB  /vol/dstvolB/lun_A  online  unmapped windows_2008  300.0GB
vserverB  /vol/dstvolB/lun_B  online  unmapped windows_2008  300.0GB
vserverB  /vol/dstvolB/lun_C  online  unmapped windows_2008  300.0GB

6 entries were displayed.
```

After the volume is restored from the SnapVault secondary volume, the source volume no longer contains lun_D. You do not need to remap the LUNs in the source volume after the restore because they are still mapped.

How you can connect a host backup system to the primary storage system

You can back up SAN systems to tape through a separate backup host to avoid performance degradation on the application host.

It is imperative that you keep SAN and NAS data separated for backup purposes. The figure below shows the recommended physical configuration for a host backup system to the primary storage system. You must configure volumes as SAN-only. LUNs can be confined to a single volume or the LUNs can be spread across multiple volumes or storage systems.



Volumes on a host can consist of a single LUN mapped from the storage system or multiple LUNs using a volume manager, such as VxVM on HP-UX systems.

Related tasks

Backing up a LUN through a host backup system on page 64

Backing up a LUN through a host backup system

You can use a cloned LUN from a Snapshot copy as source data for the host backup system.

Before you begin

A production LUN must exist and be mapped to an igroup that includes the WWPN or initiator node name of the application server. The LUN must also be formatted and accessible to the host

Steps

1. Save the contents of the host file system buffers to disk.

   You can use the command provided by your host operating system, or you can use SnapDrive for Windows or SnapDrive for UNIX. You can also opt to make this step part of your SAN backup pre-processing script.

2. Use the `volume snapshot create` command to create a Snapshot copy of the production LUN.

   Example

   ```
   volume snapshot create -vserver vs0 -volume vol3 -snapshot vol3_snapshot
   -comment "Single snapshot" -foreground false
   ```

3. Use the `volume file clone create` command to create a clone of the production LUN.

   Example

   ```
   volume file clone create -vserver vs3 -volume vol3 -source-path lun1 -
   snapshot-name snap_vol3 -destination-path lun1_backup
   ```

4. Use the `lun igroup create` command to create an igroup that includes the WWPN of the backup server.

   Example

   ```
   lun igroup create -vserver vs3 -igroup igroup3 -protocol fc -ostype
   windows -initiator 10:00:00:00:c9:73:5b:91
   ```

5. Use the `lun mapping create` command to map the LUN clone you created in Step 3 to the backup host.

   Example

   ```
   lun mapping create -vserver vs3 -volume vol3 -lun lun1_backup -igroup
   igroup3
   ```

   You can opt to make this step part of your SAN backup application's post-processing script.

6. From the host, discover the new LUN and make the file system available to the host.

   You can opt to make this step part of your SAN backup application's post-processing script.

7. Back up the data in the LUN clone from the backup host to tape by using your SAN backup application.

8. Use the `lun modify` command to take the LUN clone offline.

Example

`lun modify -vserver vs3 -path /vol/vol3/lun1_backup -state offline`

9. Use the `lun delete` to remove the LUN clone.

   Example

   `lun delete -vserver vs3 -volume vol3 -lun lun1_backup`

10. Use the `volume snapshot delete` command to remove the Snapshot copy.

    Example

    `volume snapshot delete -vserver vs3 -volume vol3 -snapshot vol3_snapshot`

Related concepts

How you can connect a host backup system to the primary storage system on page 63

Ways to implement SVM disaster recovery in SAN environments

The storage virtual machine (SVM) disaster recovery provides support for data recovery at the SVM level if an SVM becomes inaccessible.

The *primary* SVM is the SVM requiring disaster recovery support. The *secondary* SVM is an SVM in another cluster that is peered with the primary SVM to provide disaster recovery support. The cluster containing the secondary SVM does not have to have the same number of nodes or the same number of FC and Ethernet ports as the primary SVM.

If the `-vserver-dr-protection` option of the volume is set to **`unprotected`**, the SVM disaster recovery does not replicate this volume at the destination SVM. Existing volumes and newly created volumes on the source SVM are protected by default.

Volume, configuration, and metadata is replicated to the secondary SVM at regular scheduled intervals. If the primary SVM becomes inaccessible, the secondary SVM can be brought online. Persistent reservations are not copied to the secondary SVM. This means that certain hosts must either be rebooted or have persistent reservations reset after the secondary SVM becomes active. The following hosts require a reboot or a persistent reservation reset:

- AIX
- Solaris
- Veritas

SVM disaster recovery can be implemented in two ways.

Identity preserve SVM disaster recovery

With identity preserve SVM disaster recovery, volumes, LIFs, and LUNs in the secondary SVM are not visible to hosts until the entire disaster recovery operation has been successfully completed.

The volumes, LIFs, and LUNs in the secondary SVM have the same identity as the corresponding volumes, LIFs, and LUNs in the primary SVM. Therefore, the primary SVM and secondary SVM cannot be visible to the host simultaneously.

Identity preserve SVM disaster recovery does not require FC port zoning.

Identity discard SVM disaster recovery

With identity discard SVM disaster recovery, the volumes, LIFs, and LUNs in the primary SVM remain visible to the host in read-only mode for the duration of the disaster recovery event.

The volumes, LIFs, and LUNs in the secondary SVM do not have the same identity as the corresponding volumes, LIFs, and LUNs in the primary SVM. Therefore, the primary SVM and secondary SVM can be visible to the host simultaneously.

To use identity discard SVM disaster recovery, the primary SVM FC LIFs must use WWPN zoning.

Related information

Data protection

Managing your iSCSI service

You can perform various task for managing your iSCSI service, such as deleting iSCSI service from a particular SVM, enabling error recovery levels, and defining authentication methods.

Configuring your network for best performance

Ethernet networks vary greatly in performance. You can maximize the performance of the network used for iSCSI by selecting specific configuration values.

Steps

1. Connect the host and storage ports to the same network.

   It is best to connect to the same switches. Routing should never be used.

2. Select the highest speed ports available, and dedicate them to iSCSI.

   10 GbE ports are best. 1 GbE ports are the minimum.

3. Disable Ethernet flow control for all ports.

   You should see the *ONTAP 9 Network Management Guide* for using the CLI to configure Ethernet port flow control.

   Network and LIF management

4. Enable jumbo frames (typically MTU of 9000).

   All devices in the data path, including initiators, targets, and switches, must support jumbo frames. Otherwise, enabling jumbo frames actually reduces network performance substantially.

Defining a security policy method for an initiator

You can define a list of initiators and their authentication methods. You can also modify the default authentication method that applies to initiators that do not have a user-defined authentication method.

About this task

You can generate unique passwords using security policy algorithms in the product or you can manually specify the passwords that you want to use.

Note: Not all initiators support hexadecimal CHAP secret passwords.

Steps

1. Use the `vserver iscsi security create` command to create a security policy method for an initiator.

   Example

   ```
   vserver iscsi security create -vserver vs2 -initiator iqn.
   1991-05.com.microsoft:host1 -auth-type CHAP -user-name bob1 -outbound-
   user-name bob2
   ```

2. Follow the screen commands to add the passwords.

Creates a security policy method for initiator iqn.1991-05.com.microsoft:host1 with inbound and outbound CHAP user names and passwords.

Related concepts

How iSCSI authentication works on page 69
Guidelines for using CHAP authentication on page 70
What CHAP authentication is on page 70

Deleting an iSCSI service for an SVM

You can delete an iSCSI service for a storage virtual machine (SVM) if it is no longer required.

Before you begin

The administration status of the iSCSI service must be in the "down" state before you can delete an iSCSI service. You can move the administration status to down with the `vserver iscsi modify` command.

Steps

1. Use the `vserver iscsi modify` command to stop the I/O to the LUN.

   Example

   `vserver iscsi modify -vserver vs1 -status-admin down`

2. Use the `vserver iscsi delete` command to remove the iscsi service from the SVM.

   Example

   `vserver iscsi delete -vserver vs_1`

3. Use the `vserver iscsi show command` to verify that you deleted the iSCSI service from the SVM.

   `vserver iscsi show -vserver vs1`

Getting more details in iSCSI session error recoveries

Increasing the iSCSI session error recovery level enables you to receive more detailed information about iSCSI error recoveries. Using a higher error recovery level might cause a minor degrade in iSCSI session performance.

About this task

By default, ONTAP is configured to use error recovery level 0 for iSCSI sessions. If you are using an initiator that has been qualified for error recovery level 1 or 2, you can choose to increase the error recovery level. The modified session error recovery level affects only the newly created sessions and does not affect existing sessions.

In ONTAP 9.4, the **`max-error-recovery-level`** option is not supported in the `iscsi show` and `iscsi modify` commands.

Steps

1. Enter advanced mode:

   `set -privilege advanced`

2. Verify the current setting by using the `iscsi show` command.

Example

`iscsi show -vserver vs3 -fields max-error-recovery-level`

```
vserver max-error-recovery-level
------- ------------------------
vs3     0
```

3. Change the error recovery level by using the `iscsi modify` command.

Example

`iscsi modify -vserver vs3 -max-error-recovery-level 2`

iSCSI service management

You can manage the availability of the iSCSI service on the iSCSI logical interfaces of the storage virtual machine (SVM) by using the `vserver iscsi interface enable` or `vserver iscsi interface disable` commands.

By default, the iSCSI service is enabled on all iSCSI logical interfaces.

How iSCSI is implemented on the host

iSCSI can be implemented on the host using hardware or software.

You can implement iSCSI in one of the following ways:

- Using Initiator software that uses the host's standard Ethernet interfaces.
- Through an iSCSI host bus adapter (HBA): An iSCSI HBA appears to the host operating system as a SCSI disk adapter with local disks.
- Using a TCP Offload Engine (TOE) adapter that offloads TCP/IP processing.
  The iSCSI protocol processing is still performed by host software.

How iSCSI authentication works

During the initial stage of an iSCSI session, the initiator sends a login request to the storage system to begin an iSCSI session. The storage system then either permits or denies the login request, or determine that a login is not required.

iSCSI authentication methods are:

- Challenge Handshake Authentication Protocol (CHAP)—The initiator logs in using a CHAP user name and password.
  You can specify a CHAP password or generate a hexadecimal secret password. There are two types of CHAP user names and passwords:
  - Inbound—The storage system authenticates the initiator.
    Inbound settings are required if you are using CHAP authentication.
  - Outbound—This is an optional setting to enable the initiator to authenticate the storage system.
    You can use outbound settings only if you define an inbound user name and password on the storage system.
- deny—The initiator is denied access to the storage system.

- none—The storage system does not require authentication for the initiator.

You can define the list of initiators and their authentication methods. You can also define a default authentication method that applies to initiators that are not on this list.

Related information

Windows Multipathing Options with Data ONTAP: Fibre Channel and iSCSI

iSCSI initiator security management

ONTAP provides a number of features for managing security for iSCSI initiators. You can define a list of iSCSI initiators and the authentication method for each, display the initiators and their associated authentication methods in the authentication list, add and remove initiators from the authentication list, and define the default iSCSI initiator authentication method for initiators not in the list.

iSCSI endpoint isolation

Beginning in ONTAP 9.1 existing iSCSI security commands were enhanced to accept an IP address range, or multiple IP addresses.

All iSCSI initiators must provide origination IP addresses when establishing a session or connection with a target. This new functionality prevents an initiator from logging into the cluster if the origination IP address is unsupported or unknown, providing a unique identification scheme. Any initiator originating from an unsupported or unknown IP address will have their login rejected at the iSCSI session layer, preventing the initiator from accessing any LUN or volume within the cluster.

Implement this new functionality with two new commands to help manage pre-existing entries.

Add initiator address range

Improve iSCSI initiator security management by adding an IP address range, or multiple IP addresses with the `vserver iscsi security add-initiator-address-range` command.

`cluster1::> vserver iscsi security add-initiator-address-range`

Remove initiator address range

Remove an IP address range, or multiple IP addresses, with the `vserver iscsi security remove-initiator-address-range` command.

`cluster1::> vserver iscsi security remove-initiator-address-range`

What CHAP authentication is

The Challenge Handshake Authentication Protocol (CHAP) enables authenticated communication between iSCSI initiators and targets. When you use CHAP authentication, you define CHAP user names and passwords on both the initiator and the storage system.

During the initial stage of an iSCSI session, the initiator sends a login request to the storage system to begin the session. The login request includes the initiator's CHAP user name and CHAP algorithm. The storage system responds with a CHAP challenge. The initiator provides a CHAP response. The storage system verifies the response and authenticates the initiator. The CHAP password is used to compute the response.

Guidelines for using CHAP authentication

You should follow certain guidelines when using CHAP authentication.

- If you define an inbound user name and password on the storage system, you must use the same user name and password for outbound CHAP settings on the initiator. If you also define an outbound user name and password on the storage system to enable bidirectional authentication, you must use the same user name and password for inbound CHAP settings on the initiator.

- You cannot use the same user name and password for inbound and outbound settings on the storage system.
- CHAP user names can be 1 to 128 bytes.
  A null user name is not allowed.
- CHAP passwords (secrets) can be 1 to 512 bytes.
  Passwords can be hexadecimal values or strings. For hexadecimal values, you should enter the value with a prefix of “0x” or “0X”. A null password is not allowed.
- For additional restrictions, you should see the initiator’s documentation.
  For example, the Microsoft iSCSI software initiator requires both the initiator and target CHAP passwords to be at least 12 bytes if IPsec encryption is not being used. The maximum password length is 16 bytes regardless of whether IPsec is used.

Related concepts

What CHAP authentication is on page 70

How using iSCSI interface access lists to limit initiator interfaces can increase performance and security

ISCSI interface access lists can be used to limit the number of LIFs in an SVM that an initiator can access, thereby increasing performance and security.

When an initiator begins a discovery session using an iSCSI `SendTargets` command, it receives the IP addresses associated with the LIF (network interface) that is in the access list. By default, all initiators have access to all iSCSI LIFs in the SVM. You can use the access list to restrict the number of LIFs in an SVM that an initiator has access to.

iSNS server registration requirement

If you decide to use an iSNS service, you must ensure that your storage virtual machines (SVMs) are properly registered with an Internet Storage Name Service (iSNS) server.

What iSNS is

The Internet Storage Name Service (iSNS) is a protocol that enables automated discovery and management of iSCSI devices on a TCP/IP storage network. An iSNS server maintains information about active iSCSI devices on the network, including their IP addresses, iSCSI node names IQN's, and portal groups.

You can obtain an iSNS server from a third-party vendor. If you have an iSNS server on your network configured and enabled for use by the initiator and target, you can use the management LIF for a storage virtual machine (SVM) to register all the iSCSI LIFs for that SVM on the iSNS server. After the registration is complete, the iSCSI initiator can query the iSNS server to discover all the LIFs for that particular SVM.

If you do not have an iSNS server on your network, you must manually configure each target to be visible to the host.

What an iSNS server does

An iSNS server uses the Internet Storage Name Service (iSNS) protocol to maintain information about active iSCSI devices on the network, including their IP addresses, iSCSI node names (IQNs), and portal groups.

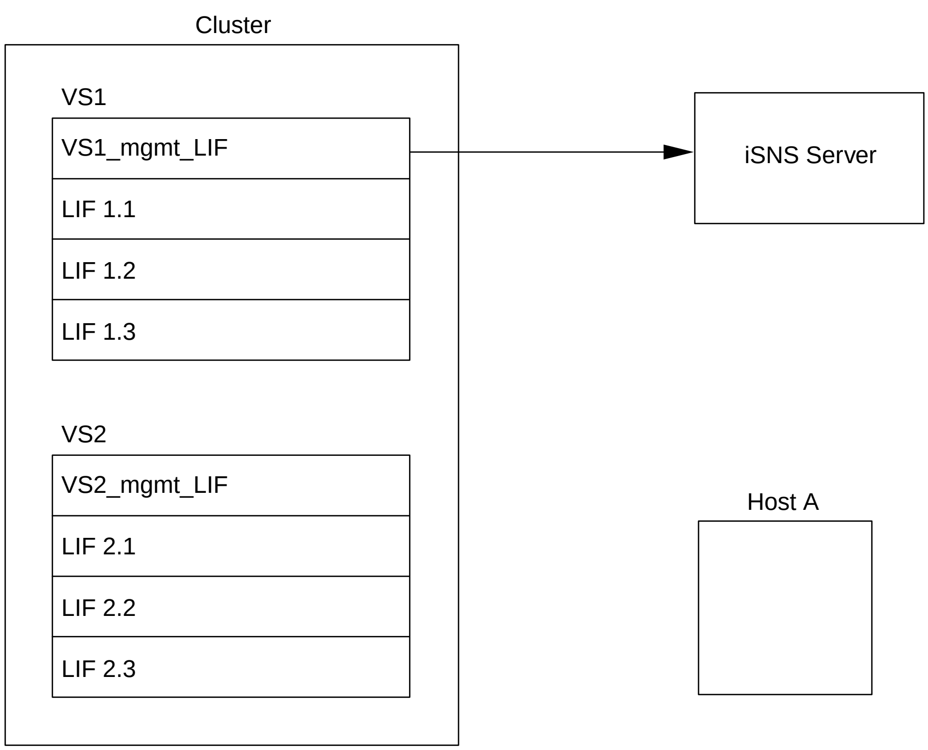
The iSNS protocol enables automated discovery and management of iSCSI devices on an IP storage network. An iSCSI initiator can query the iSNS server to discover iSCSI target devices.

NetApp does not supply or resell iSNS servers. You can obtain these servers from a vendor supported by NetApp. See the NetApp iSCSI Support Matrix to view the list of iSNS servers that are currently supported.

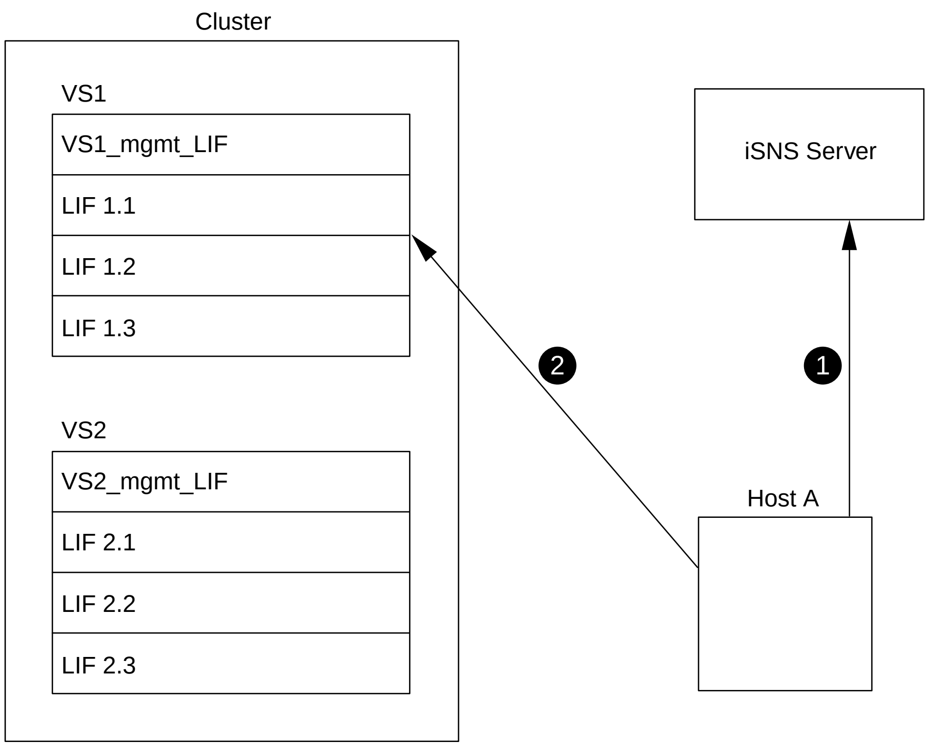
How SVMs interact with an iSNS server

The iSNS server communicates with each storage virtual machine (SVM) through the SVM management LIF. The management LIF registers all iSCSI target node name, alias, and portal information with the iSNS service for a specific SVM.

In the following example, SVM VS1 uses the SVM management LIF vs1_mgmt_lif to register with the iSNS server. During iSNS registration, an SVM sends all the iSCSI LIFs through the SVM management LIF to the iSNS Server. After the iSNS registration is complete, the iSNS server has a list of all the LIFs serving iSCSI in VS1. If a cluster contains multiple SVMs, each SVM must register individually with the iSNS server to use the iSNS service.



In the next example, after the iSNS server completes the registration with the target, Host A can discover all the LIFs for VS1 through the iSNS server as indicated in step 1. After Host A completes the discovery of the LIFs for VS1, Host A can establish a connection with any of the LIFs in VS1 as shown in step 2. Host A is not aware of any of the LIFs in VS2 until the management LIF VS2_mgmt_LIF for VS2 registers with the iSNS server.



However, if you define the interface access lists, the host can only use the defined LIFs in the interface access list to access the target.

After iSNS is initially configured, ONTAP automatically updates the iSNS server when the SVM configuration settings change.

A delay of a few minutes can occur between the time you make the configuration changes and when ONTAP sends the update to the iSNS server. Force an immediate update of the iSNS information on the iSNS server: `vserver iscsi isns update`

Related tasks

Registering the SVM with an iSNS server on page 73

Related references

Commands for managing iSNS on page 74

Registering the SVM with an iSNS server

You can use the `vserver iscsi isns` command to configure the storage virtual machine (SVM) to register with an iSNS server.

About this task

The `vserver iscsi isns create` command configures the SVM to register with the iSNS server. The SVM does not provide commands that enable you to configure or manage the iSNS server. To manage the iSNS server, you can use the server administration tools or the interface provided by the vendor for the iSNS server.

Steps

1. On your iSNS server, ensure that your iSNS service is up and available for service.

2. Create the SVM management LIF on a data port:

   network interface create -vserver *SVM_name* -lif *LIF_name* -role data -data-protocol none -home-node *home_node_name* -home-port *home_port* -address *IP_address* -netmask *nework_mask*

3. Create an iSCSI service on your SVM if one does not already exist:

   vserver iscsi create -vserver *SVM_name*

4. Verify that the iSCSI service was created successfully:

   iscsi show -vserver *SVM_name*

5. Verify that a default route exists for the SVM:

   network route show -vserver *SVM_name*

6. If a default route does not exist for the SVM, create a default route:

   network route create -vserver *SVM_name* -destination *destination* -gateway *gateway*

7. Configure the SVM to register with the iSNS service:

   vserver iscsi isns create -vserver *SVM_name* -address *IP_address*

   Both IPv4 and IPv6 address families are supported. The address family of the iSNS server must be the same as that of the SVM management LIF.

   For example, you cannot connect an SVM management LIF with an IPv4 address to an iSNS server with an IPv6 address.

8. Verify that the iSNS service is running:

   vserver iscsi isns show -vserver *SVM_name*

9. If the iSNS service is not running, start it:

   vserver iscsi isns start -vserver *SVM_name*

Related concepts

How SVMs interact with an iSNS server on page 72
What iSNS is on page 71

Related references

Commands for managing iSNS on page 74

Commands for managing iSNS

ONTAP provides commands to manage your iSNS service.

If you want to...	Use this command...
Configure an iSNS service	`vserver iscsi isns create`
Start an iSNS service	`vserver iscsi isns start`
Modify an iSNS service	`vserver iscsi isns modify`
Display iSNS service configuration	`vserver iscsi isns show`
Force an update of registered iSNS information	`vserver iscsi isns update`
Stop an iSNS service	`vserver iscsi isns stop`
Remove an iSNS service	`vserver iscsi isns delete`

If you want to...	Use this command...
View the man page for a command	`man` *`command name`*

See the man page for each command for more information.

Related concepts

How SVMs interact with an iSNS server on page 72
What iSNS is on page 71

Related tasks

Registering the SVM with an iSNS server on page 73

iSCSI troubleshooting tips

You can troubleshoot common problems that occur with iSCSI networks.

Troubleshooting iSCSI LUNs not visible on the host

The iSCSI LUNs appear as local disks to the host. If the storage system LUNs are not available as disks on the host, you should verify the configuration settings.

Configuration setting	What to do
Cabling	Verify that the cables between the host and storage system are properly connected.
Network connectivity	Verify that there is TCP/IP connectivity between the host and storage system. • From the storage system command line, ping the host interfaces that are being used for iSCSI: **`ping –node`** ***`node_name`*** **`-destination`** ***`host_ip_address_for_iSCSI`*** • From the host command line, ping the storage system interfaces that are being used for iSCSI: **`ping –node`** ***`node_name`*** **`-destination`** ***`host_ip_address_for_iSCSI`***
System requirements	Verify that the components of your configuration are qualified. Also, verify that you have the correct host operating system (OS) service pack level, initiator version, ONTAP version, and other system requirements. The Interoperability Matrix contains the most up-to-date system requirements.
Jumbo frames	If you are using jumbo frames in your configuration, verify that jumbo frames are enabled on all devices in the network path: the host Ethernet NIC, the storage system, and any switches.
iSCSI service status	Verify that the iSCSI service is licensed and started on the storage system.
Initiator login	Verify that the initiator is logged in to the storage system. If the `iscsi initiator show` command output shows no initiators are logged in, check the initiator configuration on the host. Also verify that the storage system is configured as a target of the initiator.

Configuration setting	What to do
iSCSI node names (IQNs)	Verify that you are using the correct initiator node names in the igroup configuration. On the host, you can use the initiator tools and commands to display the initiator node name. The initiator node names configured in the igroup and on the host must match.
LUN mappings	Verify that the LUNs are mapped to an igroup. On the storage system console, you can use one of the following commands: • `lun mapping show` displays all LUNs and the igroups to which they are mapped. • `lun mapping show -igroup` displays the LUNs mapped to a specific igroup.
iSCSI LIFs enable	Verify that the iSCSI logical interfaces are enabled.

Related information

NetApp Interoperability Matrix Tool

Resolving iSCSI error messages on the storage system

There are a number of common iSCSI-related error messages that you can view with the `event log show` command. You need to know what these messages mean and what you can do to resolve the issues they identify.

The following table contains the most common error messages, and instructions for resolving them:

Message	Explanation	What to do
`ISCSI: network interface` *`identifier`* `disabled for use; incoming connection discarded`	The iSCSI service is not enabled on the interface.	You can use the `iscsi interface enable` command to enable the iSCSI service on the interface. For example: **`iscsi interface enable -vserver vs1 -lif lif1`**
`ISCSI: Authentication failed for initiator` *`nodename`*	CHAP is not configured correctly for the specified initiator.	You should check the CHAP settings; you cannot use the same user name and password for inbound and outbound settings on the storage system: • Inbound credentials on the storage system must match outbound credentials on the initiator. • Outbound credentials on the storage system must match inbound credentials on the initiator.

Related concepts

Guidelines for using CHAP authentication on page 70

Managing your FC service

You can start, verify, stop, or delete an FC service. You can also add LIFs, create WWPN aliases, and display FC logical interface information.

Beginning in ONTAP 9.4, FC-NVMe is supported.

Beginning with ONTAP 9.5 a license is required to support NVMe. If NVMe is enabled in ONTAP 9.4, a 90 day grace period is given to acquire the license after upgrading to ONTAP 9.5. You can enable the license using the following command:

`system license add -license-code` ***`NVMe_license_key`***

Deleting an FC service for an SVM

You can delete an FC service for a storage virtual machine (SVM) if it is no longer required.

Before you begin

The administration status must be “down” before you can delete a FC service for an SVM. You can set the administration status to down with either the `vserver fcp modify` command or the `vserver fcp stop` command.

Steps

1. Use the `vserver fcp stop` command to stop the I/O to the LUN.

   Example

   `vserver fcp stop -vserver vs_1`

2. Use the `vserver fcp delete` command to remove the service from the SVM.

   Example

   `vserver fcp delete -vserver vs_1`

3. Use the `vserver fcp show` to verify that you deleted the FC service from your SVM:

   `vserver fcp show -vserver vs_1`

Starting the FC-NVMe service for an SVM

Beginning with ONTAP 9.4 the FC-NVMe protocol is supported. Before you can use the FC-NVMe protocol on your storage virtual machine (SVM), you must start the FC-NVMe service on the SVM.

Before you begin

FC-NVMe must be allowed as a protocol on your system.

Beginning with ONTAP 9.4, NVMe is allowed by default.

Steps

1. Change the privilege setting to advanced:

   `set -privilege advanced`

2. Verify that NVMe is allowed as a protocol:

   vserver nvme show

3. Create the NVMe protocol service:

   vserver nvme create

4. Start the NVMe protocol service on the SVM:

   vserver nvme modify -status -admin up

Deleting FC-NVMe service from an SVM

If needed, you can delete the FC-NVMe service from your storage virtual machine (SVM).

Steps

1. Change the privilege setting to advanced:

   set -privilege advanced

2. Stop the NVMe service on the SVM:

   vserver nvme modify -status -admin down

3. Delete the NVMe service:

   vserver nvme delete

How worldwide name assignments work

Worldwide names are created sequentially in ONTAP. However, because of the way ONTAP assigns them, they might appear to be assigned in a non-sequential order.

Each adapter has a pre-configured WWPN and WWNN, but ONTAP does not use these pre-configured values. Instead, ONTAP assigns its own WWPNs or WWNNs, based on the MAC addresses of the onboard Ethernet ports.

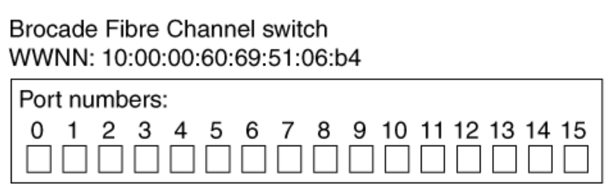
The worldwide names might appear to be non-sequential when assigned for the following reasons:

- Worldwide names are assigned across all the nodes and storage virtual machines (SVMs) in the cluster.
- Freed worldwide names are recycled and added back to the pool of available names.

How FC switches are identified

Fibre Channel switches have one worldwide node name (WWNN) for the device itself, and one worldwide port name (WWPN) for each of its ports.

For example, the following diagram shows how the WWPNs are assigned to each of the ports on a 16-port Brocade switch. For details about how the ports are numbered for a particular switch, see the vendor-supplied documentation for that switch.



Port **0**, WWPN 20:**00**:00:60:69:51:06:b4
Port **1**, WWPN 20:**01**:00:60:69:51:06:b4
Port **14**, WWPN 20:**0e**:00:60:69:51:06:b4
Port **15**, WWPN 20:**0f**:00:60:69:51:06:b4

Recommended MTU configurations for FCoE jumbo frames

For Fibre Channel over Ethernet (FCoE), jumbo frames for the Ethernet adapter portion of the CNA should be configured at 9000 MTU. Jumbo frames for the FCoE adapter portion of the CNA should be configured at greater than 1500 MTU. Only configure jumbo frames if the initiator, target, and all intervening switches support and are configured for jumbo frames.

Managing systems with FC adapters

Commands are available to manage onboard FC adapters and FC adapter cards. These commands can be used to configure the adapter mode, display adapter information, and change the speed.

Most storage systems have onboard FC adapters that can be configured as initiators or targets. You can also use FC adapter cards configured as initiators or targets. Initiators connect to back-end disk shelves, and possibly foreign storage arrays (FlexArray). Targets connect only to FC switches. Both the FC target HBA ports and the switch port speed should be set to the same value and should not be set to auto.

Related information

SAN configuration

Commands for managing FC adapters

You can use FC commands to manage FC target adapters, FC initiator adapters, and onboard FC adapters for your storage controller. The same commands are used to manage FC adapters for the FC protocol and the FC-NVMe protocol.

FC initiator adapter commands work only at the node level. You must use the `run -node` *`node_name`* command before you can use the FC initiator adapter commands.

Commands for managing FC target adapters

If you want to...	Use this command...
Display FC adapter information on a node	`network fcp adapter show`
Modify FC target adapter parameters	`network fcp adapter modify`
Display FC protocol traffic information	`run -node` *`node_name`* `sysstat -f`
Display how long the FC protocol has been running	`run -node` *`node_name`* `uptime`
Display adapter configuration and status	`run -node` *`node_name`* `sysconfig -v` *`adapter`*
Verify which expansion cards are installed and whether there are any configuration errors	`run -node` *`node_name`* `sysconfig -ac`
View a man page for a command	`man` *`command_name`*

Commands for managing FC initiator adapters

If you want to...	Use this command...
Display information for all initiators and their adapters in a node	`run -node` *`node_name`* `storage show adapter`
Display adapter configuration and status	`run -node` *`node_name`* `sysconfig -v` *`adapter`*
Verify which expansion cards are installed and whether there are any configuration errors	`run -node` *`node_name`* `sysconfig -ac`

Commands for managing onboard FC adapters

If you want to...	Use this command...
Display the status of the onboard FC ports	`run -node` *`node_name`* `system hardware unified-connect show`

Configuring FC adapters for initiator mode

You can configure individual FC ports of onboard adapters and certain FC adapter cards for initiator mode. Initiator mode is used to connect the ports to tape drives, tape libraries, or third-party storage with FlexArray Virtualization or Foreign LUN Import (FLI).

Before you begin

- LIFs on the adapter must be removed from any port sets of which they are members.
- All LIF's from every storage virtual machine (SVM) using the physical port to be modified must be migrated or destroyed before changing the personality of the physical port from target to initiator.

About this task

Each onboard FC port can be individually configured as an initiator or a target. Ports on certain FC adapters can also be individually configured as either a target port or an initiator port, just like the onboard FC ports. A list of adapters that can be configured for target mode is available in the *Hardware Universe*.

Note: FC-NVMe does support initiator mode.

Steps

1. Remove all LIFs from the adapter:

   `network interface delete -vserver` ***`SVM_name`*** **`-lif`** ***`LIF_name,LIF_name`***

2. Take your adapter offline:

   `network fcp adapter modify -node` ***`node_name`*** **`-adapter`** ***`adapter_port`*** **`-status-admin down`**

   If the adapter does not go offline, you can also remove the cable from the appropriate adapter port on the system.

3. Change the adapter from target to initiator:

   `system hardware unified-connect modify -t initiator` ***`adapter_port`***

4. Reboot the node hosting the adapter you changed.

5. Verify that the FC ports are configured in the correct state for your configuration:

   `system hardware unified-connect show`

6. Bring the adapter back online:

   `node run -node` ***`node_name`*** **`storage enable adapter`** ***`adapter_port`***

Related tasks

Deleting a LIF in a SAN environment on page 45

Related information

NetApp Hardware Universe

Configuring FC adapters for target mode

You can configure individual FC ports of onboard adapters and certain FC adapter cards for target mode. Target mode is used to connect the ports to FC initiators.

About this task

Each onboard FC port can be individually configured as an initiator or a target. Ports on certain FC adapters can also be individually configured as either a target port or an initiator port, just like the onboard FC ports. A list of adapters that can be configured for target mode is available in the *Hardware Universe*.

The same steps are used when configuring FC adapters for the FC protocol and the FC-NVMe protocol. However, only certain FC adapters support FC-NVMe. See *Hardware Universe* for a list of adapters that support the FC-NVMe protocol.

Steps

1. Take the adapter offline:

   `node run -node` ***`node_name`*** **`storage disable adapter -d`** ***`adapter_port`***

   If the adapter does not go offline, you can also remove the cable from the appropriate adapter port on the system.

2. Change the adapter from initiator to target:

   `system hardware unified-connect modify -t target` ***`adapter_port`***

3. Reboot the node hosting the adapter you changed.

4. Verify that the target port has the correct configuration:

   `network fcp adapter show -node` ***`node_name`***

5. Bring your adapter online:

   `network fcp adapter modify -node` ***`node_name`*** **`-adapter`** ***`adapter_port`*** **`-state up`**

Related information

NetApp Hardware Universe

Displaying information about an FC target adapter

You can use the `network fcp adapter show` command to display system configuration and adapter information for any FC adapter in the system.

Step

1. Display information about the FC adapter by using the `network fcp adapter show` command.

   #### Example

   The output displays system configuration information and adapter information for each slot that is used.

   `network fcp adapter show -instance -node node1 -adapter 0a`

Supported port configurations for X1143A-R6 adapters

The FC target mode is the default configuration for X1143A-R6 adapter ports. However, ports on this adapter can be configured as either 10-Gb Ethernet and FCoE ports or as 16-Gb FC ports.

When configured for Ethernet and FCoE, X1143A-R6 adapters support concurrent NIC and FCoE target traffic on the same 10-GBE port. When configured for FC, each two-port pair that shares the same ASIC can be individually configured for FC target or FC initiator mode. This means that a single X1143A-R6 adapter can support FC target mode on one two-port pair and FC initiator mode on another two-port pair.

Related information

NetApp Hardware Universe
SAN configuration

Configuring the ports

To configure the unified target adapter (X1143A-R6), you must configure the two adjacent ports on the same chip in the same personality mode.

Steps

1. Configure the ports as needed for Fibre Channel (FC) or Converged Network Adapter (CNA) using the `system node hardware unified-connect modify` command.

2. Attach the appropriate cables for FC or 10 Gb Ethernet.

3. Verify that you have the correct SFP+ installed:

   `network fcp adapter show -instance -node -adapter`

   For CNA, you should use a 10 Gb Ethernet SFP. For FC, you should either use an 8 Gb SFP or a 16 Gb SFP, based on the FC fabric being connected to.

Changing the UTA2 port from CNA mode to FC mode

You should change the UTA2 port from Converged Network Adapter (CNA) mode to Fibre Channel (FC) mode to support the FC initiator and FC target mode. You should change the personality from

CNA mode to FC mode when you need to change the physical medium that connects the port to its network.

Steps

1. Take the adapter offline:

   `network fcp adapter modify -node` ***`node_name`*** **`-adapter`** ***`adapter_name`*** **`-status-admin down`**

2. Change the port mode:

   `ucadmin modify -node` ***`node_name`*** **`-adapter`** ***`adapter_name`*** **`-mode fcp`**

3. Reboot the node, and then bring the adapter online:

   `network fcp adapter modify -node` ***`node_name`*** **`-adapter`** ***`adapter_name`*** **`-status-admin up`**

4. Notify your admin or VIF manager to delete or remove the port, as applicable:

   - If the port is used as a home port of a LIF, is a member of an interface group (ifgrp), or hosts VLANs, then an admin should do the following:

     a. Move the LIFs, remove the port from the ifgrp, or delete the VLANs, respectively.

     b. Manually delete the port by running the `network port delete` command.
        If the `network port delete` command fails, the admin should address the errors, and then run the command again.

   - If the port is not used as the home port of a LIF, is not a member of an ifgrp, and does not host VLANs, then the VIF manager should remove the port from its records at the time of reboot.
     If the VIF manager does not remove the port, then the admin must remove it manually after the reboot by using the `network port delete` command.

Example

```
net-f8040-34::> network port show

    Node: net-f8040-34-01
                                                             Speed(Mbps) Health
    Port      IPspace      Broadcast Domain Link MTU  Admin/Oper  Status
    --------- ------------ ---------------- ---- ---- ----------- --------
    ...
    e0i       Default      Default          down 1500  auto/10    -
    e0f       Default      Default          down 1500  auto/10    -
    ...

    net-f8040-34::> ucadmin show
                           Current  Current    Pending  Pending    Admin
    Node          Adapter  Mode     Type       Mode     Type       Status
    ------------  -------  -------  ---------  -------  ---------  -----------
    net-f8040-34-01
                  0e       cna      target     -        -          offline
    net-f8040-34-01
                  0f       cna      target     -        -          offline
    ...

    net-f8040-34::> network interface create -vs net-f8040-34 -lif m -role
node-mgmt-home-node net-f8040-34-01 -home-port e0e -address 10.1.1.1
-netmask 255.255.255.0


    net-f8040-34::> network interface show -fields home-port, curr-port

    vserver lif                   home-port curr-port
    ------- --------------------- --------- ---------
    Cluster net-f8040-34-01_clus1 e0a       e0a
    Cluster net-f8040-34-01_clus2 e0b       e0b
    Cluster net-f8040-34-01_clus3 e0c       e0c
```

```
    Cluster net-f8040-34-01_clus4 e0d       e0d
    net-f8040-34
            cluster_mgmt          e0M       e0M
    net-f8040-34
            m                     e0e       e0i
    net-f8040-34
            net-f8040-34-01_mgmt1 e0M       e0M
    7 entries were displayed.

    net-f8040-34::> ucadmin modify local 0e fc

    Warning: Mode on adapter 0e and also adapter 0f will be changed to fc.
    Do you want to continue? {y|n}: y
    Any changes will take effect after rebooting the system. Use the
"system node reboot" command to reboot.

    net-f8040-34::> reboot local
      (system node reboot)

    Warning: Are you sure you want to reboot node "net-f8040-34-01"?
    {y|n}: y
```

5. Verify that you have the correct SFP+ installed:

   `network fcp adapter show -instance -node -adapter`

   For CNA, you should use a 10 Gb Ethernet SFP. For FC, you should either use an 8 Gb SFP or a 16 Gb SFP, before changing the configuration on the node.

Changing the CNA/UTA2 target adapter optical modules

You should change the optical modules on the unified target adapter (CNA/UTA2) to support the personality mode you have selected for the adapter.

Steps

1. Verify the current SFP+ used in the card. Then, replace the current SFP+ with the appropriate SFP+ for the preferred personality (FC or CNA).

2. Remove the current optical modules from the X1143A-R6 adapter.

3. Insert the correct modules for your preferred personality mode (FC or CNA) optics.

4. Verify that you have the correct SFP+ installed:

   `network fcp adapter show -instance -node -adapter`

   Supported SFP+ modules and Cisco-branded Copper (Twinax) cables are listed in the *Hardware Universe*.

Related information

NetApp Hardware Universe

Viewing adapter settings

To view the settings for your unified target adapter (X1143A-R6), you must run the `system hardware unified-connect show` command to display all modules on your controller.

Steps

1. Boot your controller without the cables attached.

2. Run the `system hardware unified-connect show` command to see the port configuration and modules.

3. View the port information before configuring the CNA and ports.

How to prevent loss of connectivity when using the X1133A-R6 adapter

You can prevent loss of connectivity during a port failure by configuring your system with redundant paths to separate X1133A-R6 HBAs.

The X1133A-R6 HBA is a 4-port, 16 Gb FC adapter consisting of two 2-port pairs. The X1133A-R6 adapter can be configured as target mode or initiator mode. Each 2-port pair is supported by a single ASIC (for example, Port 1 and Port 2 on ASIC 1 and Port 3 and Port 4 on ASIC 2). Both ports on a single ASIC must be configured to operate in the same mode, either target mode or initiator mode. If an error occurs with the ASIC supporting a pair, both ports in the pair go offline.

To prevent this loss of connectivity, you configure your system with redundant paths to separate X1133A-R6 HBAs, or with redundant paths to ports supported by different ASICs on the HBA.

Storage virtualization with VMware and Microsoft copy offload

VMware and Microsoft support copy offload operations to increase performance and network throughput. You must configure your system to meet the requirements of the VMware and Windows operating system environments to use their respective copy offload functions.

When using VMware and Microsoft copy offload in virtualized environments, your LUNs must be aligned. Unaligned LUNs can degrade performance.

Related concepts

I/O misalignments might occur on properly aligned LUNs on page 34
How to achieve I/O alignment using LUN OS types on page 35
Special I/O alignment considerations for Linux on page 36
Special I/O alignment considerations for Solaris LUNs on page 36
ESX boot LUNs report as misaligned on page 36

Advantages of using a virtualized SAN environment

Creating a virtualized environment by using storage virtual machines (SVMs) and LIFs enables you to expand your SAN environment to all of the nodes in your cluster.

- Distributed management
  You can log in to any node in the SVM to administer all of the nodes in a cluster.
- Increased data access
  With MPIO and ALUA, you have access to your data through any active iSCSI or FC LIFs for the SVM.
- Controlled LUN access
  If you use SLM and portsets, you can limit which LIFs an initiator can use to access LUNs.

Related concepts

Ways to limit LUN access with port sets and igroups on page 29

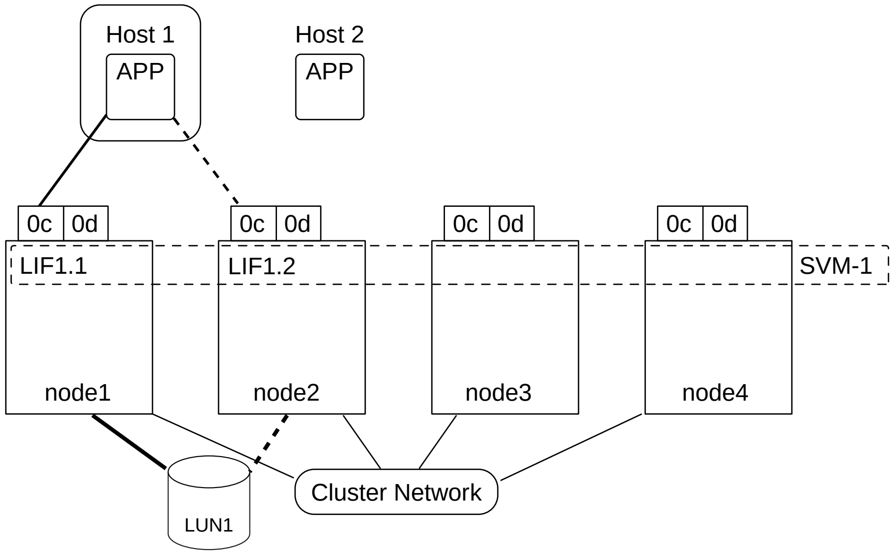
How LUN access works in a virtualized environment

In a virtualized environment, LIFs enable hosts (clients) to access LUNs through optimized and unoptimized paths.

A LIF is a logical interface that connects the SVM to a physical port. Although multiple SVMs can have multiple LIFs on the same port, a LIF belongs to one SVM. You can access LUNs through the SVMs LIFs.

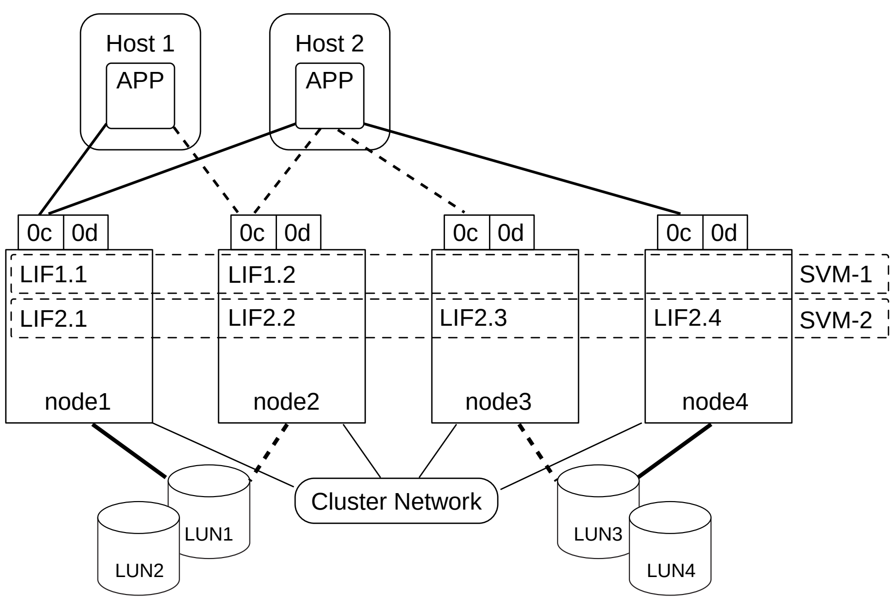
Example of LUN access with a single SVM in a cluster

In the following example, Host 1 connects to LIF1.1 and LIF1.2 in SVM-1 to access LUN1. LIF1.1 uses the physical port node1:0c and LIF1.2 uses the node2:0c. LIF1.1 and LIF1.2 belongs only to SVM-1. If a new LUN is created on node 1 or node 2, for SVM-1, then it can use these same LIFs. If a new SVM is created, then new LIFs can be created using physical ports 0c or 0d on both the nodes.



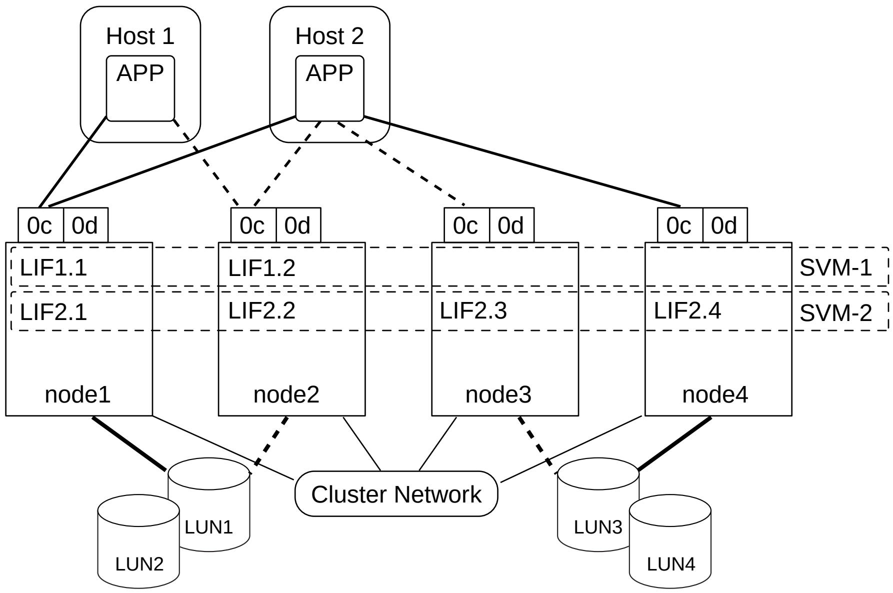
Example of LUN access with multiple SVMs in a cluster

A physical port can support multiple LIFs serving different SVMs. Because LIFs are associated with a particular SVM, the cluster nodes can send the incoming data traffic to the correct SVM. In the following example, each node from 1 through 4 has a LIF for SVM-2 using the physical port 0c on each node. Host 1 connects to LIF1.1 and LIF1.2 in SVM-1 to access LUN1. Host 2 connects to LIF2-1 and LIF2-2 in SVM-2 to access LUN2. Both SVMs are sharing the physical port 0c on the nodes 1 and 2. SVM-2 has additional LIFs that Host 2 is using to access LUNs 3 and 4. These LIFs are using physical port 0c on nodes 3 and 4. Multiple SVMs can share the physical ports on the nodes.



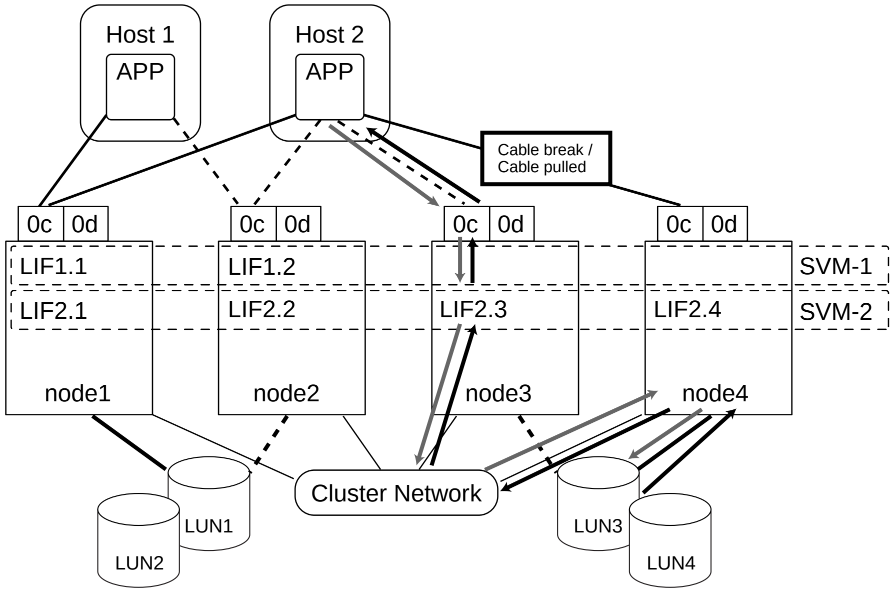
Example of an active or optimized path to a LUN from a host system

In an active or optimized path, the data traffic does not travel over the cluster network; it travels the most direct route to the LUN. The active or optimized path to LUN1 is through LIF1.1 in node1, using physical port 0c. Host 2 has two active or optimized paths, one path to node1, LIF2.1, which is sharing physical port 0c and the other path to node4, LIF2.4, which is using physical port 0c.



Example of an active or unoptimized path (indirect) path to a LUN from a host system

In an active or unoptimized path (indirect) path, the data traffic travels over the cluster network. This issue occurs only if all the active or optimized paths from a host are unavailable to handle traffic. If the path from Host 2 to SVM-2 LIF2.4 is lost, then access to LUN3 and LUN4 traverses the cluster network. Access from Host 2 uses LIF2.3 on node3. Then the traffic enters the cluster network switch and backs up to node4 for access to the LUN3 and LUN4. It will then traverse back over the cluster network switch and then back out through LIF2.3 to Host 2. This active or unoptimized path is used until the path to LIF2.4 is restored or a new LIF is established for SVM-2 on another physical port on node 4.



Considerations for LIFs in cluster SAN environments

You must be aware of certain LIF considerations in a SAN environment.

- Initiators must use Multipath I/O (MPIO) and asymmetric logical unit access (ALUA) for failover capability for clusters in a SAN iSCSI or FC environment because SAN does not support automatic failover for LIFs.
- At least one SAN LIF of the appropriate protocol must be configured on each node that hosts a mapped LUN and the node's HA partner.

  You can configure two LIFs per node, one for each fabric being used with FC and to separate Ethernet networks for iSCSI.
- Some options are not applicable for iSCSI or FC.

  For example, you cannot use IP addresses with FC.

Improving VMware VAAI performance for ESX hosts

ONTAP supports certain VMware vStorage APIs for Array Integration (VAAI) features when the ESX host is running ESX 4.1 or later. These features help offload operations from the ESX host to the storage system and increase the network throughput. The ESX host enables the features automatically in the correct environment.

The VAAI feature supports the following SCSI commands:

- `EXTENDED_COPY`

  This feature enables the host to initiate the transfer of data between the LUNs or within a LUN without involving the host in the data transfer. This results in saving ESX CPU cycles and increasing the network throughput. The extended copy feature, also known as "copy offload," is used in scenarios such as cloning a virtual machine. When invoked by the ESX host, the copy offload feature copies the data within the storage system rather than going through the host network. Copy offload transfers data in the following ways:

  - Within a LUN
  - Between LUNs within a volume

  - Between LUNs on different volumes within a storage virtual machine (SVM)
  - Between LUNs on different SVMs within a cluster

  If this feature cannot be invoked, the ESX host automatically uses the standard READ and WRITE commands for the copy operation.

- `WRITE_SAME`
  This feature offloads the work of writing a repeated pattern, such as all zeros, to a storage array. The ESX host uses this feature in operations such as zero-filling a file.
- `COMPARE_AND_WRITE`
  This feature bypasses certain file access concurrency limits, which speeds up operations such as booting up virtual machines.

Requirements for using the VAAI environment

The VAAI features are part of the ESX operating system and are automatically invoked by the ESX host when you have set up the correct environment.

The environment requirements are as follows:

- The ESX host must be running ESX 4.1 or later.
- The NetApp storage system that is hosting the VMware datastore must be running ONTAP.
- (Copy offload only) The source and the destination of the VMware copy operation must be hosted on the same storage system within the same cluster.

  Note: The copy offload feature currently does not support copying data between VMware datastores that are hosted on different storage systems.

How to determine if VAAI features are supported by ESX

To confirm whether the ESX operating system supports the VAAI features, you can check the vSphere Client or use any other means of accessing the host. ONTAP supports the SCSI commands by default.

You can check your ESX host advanced settings to determine whether VAAI features are enabled. The table indicates which SCSI commands correspond to ESX control names.

SCSI command	ESX control name (VAAI feature)
EXTENDED_COPY	`HardwareAcceleratedMove`
WRITE_SAME	`HardwareAcceleratedInit`
COMPARE_AND_WRITE	`HardwareAcceleratedLocking`

Microsoft Offloaded Data Transfer (ODX)

Microsoft Offloaded Data Transfer (ODX), also known as *copy offload*, enables direct data transfers within a storage device or between compatible storage devices without transferring the data through the host computer.

ONTAP supports ODX for both the CIFS and SAN protocols.

In non-ODX file transfers, the data is read from the source and is transferred across the network to the host. The host transfers the data back over the network to the destination. In ODX file transfer, the data is copied directly from the source to the destination without passing through the host.

Because ODX offloaded copies are performed directly between the source and destination, significant performance benefits are realized, including faster copy time, reduced utilization of CPU and memory on the client, and reduced network I/O bandwidth utilization.

For SAN environments, ODX is only available when it is supported by both the host and the storage system. Client computers that support ODX and have ODX enabled automatically and transparently use offloaded file transfer when moving or copying files. ODX is used regardless of whether you drag-and-drop files through Windows Explorer or use command-line file copy commands, or whether a client application initiates file copy requests.

Requirements for using ODX

If you plan to use ODX for copy offloads, you need to be familiar with volume support considerations, system requirements, and software capability requirements.

To use ODX, your system must have the following:

- ONTAP
  ODX is automatically enabled in supported versions of ONTAP.
- Minimum source volume of 2 GB
  For optimal performance, the source volume should be greater than 260 GB.
- Deduplication
  ODX uses deduplication as part of the copy process. If you do not want deduplication on your SVM, you should disable ODX on that SVM.
- ODX support on the Windows client
  ODX is supported in Windows Server 2012 or later and in Windows 8 or later. The Interoperability Matrix contains the latest information about supported Windows clients.
  NetApp Interoperability Matrix Tool
- Copy application support for ODX
  The application that performs the data transfer must support ODX. Application operations that support ODX include the following:
  - Hyper-V management operations, such as creating and converting virtual hard disks (VHDs), managing Snapshot copies, and copying files between virtual machines
  - Windows Explorer operations
  - Windows PowerShell copy commands
  - Windows command prompt copy commands

  The Microsoft TechNet Library contains more information about supported ODX applications on Windows servers and clients.
- If you use compressed volumes, the compression group size must be 8K.
  32K compression group size is not supported.

ODX does not work with the following volume types:

- Source volumes with capacities of less than 2 GB
- Sparse volumes
- Read-only volumes
- Semi-thick provisioned volumes

Use cases for ODX

You should be aware of the use cases for using ODX on SVMs so that you can determine under what circumstances ODX provides you with performance benefits.

Windows servers and clients that support ODX use copy offload as the default way of copying data across remote servers. If the Windows server or client does not support ODX or the ODX copy offload fails at any point, the copy or move operation falls back to traditional reads and writes for the copy or move operation.

The following use cases support using ODX copies and moves:

- Intra-volume
  The source and destination files or LUNs are within the same volume.
- Inter-volume, same node, same SVM
  The source and destination files or LUNs are on different volumes that are located on the same node. The data is owned by the same SVM.
- Inter-volume, different nodes, same SVM
  The source and destination files or LUNs are on different volumes that are located on different nodes. The data is owned by the same SVM.
- Inter-SVM, same node
  The source and destination file or LUNs are on different volumes that are located on the same node. The data is owned by different SVMs.
- Inter-SVM, different nodes
  The source and destination file or LUNs are on different volumes that are located on different nodes. The data is owned by different SVMs.
- Inter-cluster
  The source and destination LUNs are on different volumes that are located on different nodes across clusters. This is only supported for SAN and does not work for CIFS.

There are some additional special use cases:

- With the ONTAP ODX implementation, you can use ODX to copy files between SMB shares and FC or iSCSI attached virtual drives.
  You can use Windows Explorer, the Windows CLI or PowerShell, Hyper-V, or other applications that support ODX to copy or move files seamlessly using ODX copy offload between SMB shares and connected LUNs, provided that the SMB shares and LUNs are on the same cluster.
- Hyper-V provides some additional use cases for ODX copy offload:
  - You can use ODX copy offload pass-through with Hyper-V to copy data within or across virtual hard disk (VHD) files or to copy data between mapped SMB shares and connected iSCSI LUNs within the same cluster.
    This allows copies from guest operating systems to pass through to the underlying storage.
  - When creating fixed-sized VHDs, ODX is used for initializing the disk with zeros, using a well-known zeroed token.
  - ODX copy offload is used for virtual machine storage migration if the source and destination storage is on the same cluster.

  Note: To take advantage of the use cases for ODX copy offload pass-through with Hyper-V, the guest operating system must support ODX and the guest operating system's disks must be SCSI disks backed by storage (either SMB or SAN) that supports ODX. IDE disks on the guest operating system do not support ODX pass-through.

Special system file requirements

You can delete ODX files found in qtrees. You must not remove or modify any other ODX system files unless you are told by technical support to do so.

When using the ODX feature, there are ODX system files that exist in every volume of the system. These files enable point-in-time representation of data used during the ODX transfer. The following system files are in the root level of each volume that contains LUNs or files to which data was offloaded:

- `.copy-offload` (a hidden directory)
- `.tokens` (file under the hidden `.copy-offload` directory)

You can use the `copy-offload delete-tokens -path dir_path -node node_name` command to delete a qtree containing an ODX file.

Considerations for SAN configurations in a MetroCluster environment

You must be aware of certain considerations when using SAN configurations in a MetroCluster environment.

- Two-node, four-node, and eight-node MetroCluster configurations do not support front-end FC fabric “routed” vSAN configurations.
- Two-node, four-node, and eight-node MetroCluster configurations support SAN protocols.
- When using SAN client configurations, you must check whether any special considerations for MetroCluster configurations are included in the notes that are provided in the Interoperability Matrix Tool (IMT).
- The NVMe protocol is not supported on MetroCluster configurations.

For further MetroCluster-specific host information, refer to the following NetApp Knowledgebase articles:

NetApp Knowledgebase Answer 1001318: What are AIX Host support considerations in a MetroCluster configuration?

NetApp Knowledgebase Answer 1001373: FAQ: Solaris host support considerations in a MetroCluster configuration

Related information

NetApp Interoperability Matrix Tool

Appendix: Recommended volume and file or LUN configuration combinations

There are specific combinations of FlexVol volume and file or LUN configurations you can use, depending on your application and administration requirements. Understanding the benefits and costs of these combinations can help you determine the right volume and LUN configuration combination for your environment.

The following volume and LUN configuration combinations are recommended:

- Space-reserved files or LUNs with thick volume provisioning
- Non-space-reserved files or LUNs with thin volume provisioning
- Space-reserved files or LUNs with semi-thick volume provisioning

You can use SCSI thin provisioning on your LUNs in conjunction with any of these configuration combinations.

Space-reserved files or LUNs with thick volume provisioning

Benefits:

- All write operations within space-reserved files are guaranteed; they will not fail due to insufficient space.
- There are no restrictions on storage efficiency and data protection technologies on the volume.

Costs and limitations:

- Enough space must be set aside from the aggregate up front to support the thickly provisioned volume.
- Space equal to twice the size of the LUN is allocated from the volume at LUN creation time.

Non-space-reserved files or LUNs with thin volume provisioning

Benefits:

- There are no restrictions on storage efficiency and data protection technologies on the volume.
- Space is allocated only as it is used.

Costs and restrictions:

- Write operations are not guaranteed; they can fail if the volume runs out of free space.
- You must manage the free space in the aggregate effectively to prevent the aggregate from running out of free space.

Space-reserved files or LUNs with semi-thick volume provisioning

Benefits:

Less space is reserved up front than for thick volume provisioning, and a best-effort write guarantee is still provided.

Costs and restrictions:

- Write operations can fail with this option.
  You can mitigate this risk by properly balancing free space in the volume against data volatility.

- You cannot rely on retention of data protection objects such as Snapshot copies and FlexClone files and LUNs.
- You cannot use ONTAP block-sharing storage efficiency capabilities that cannot be automatically deleted, including deduplication, compression, and ODX/Copy Offload.

Determining the correct volume and LUN configuration combination for your environment

Answering a few basic questions about your environment can help you determine the best FlexVol volume and LUN configuration for your environment.

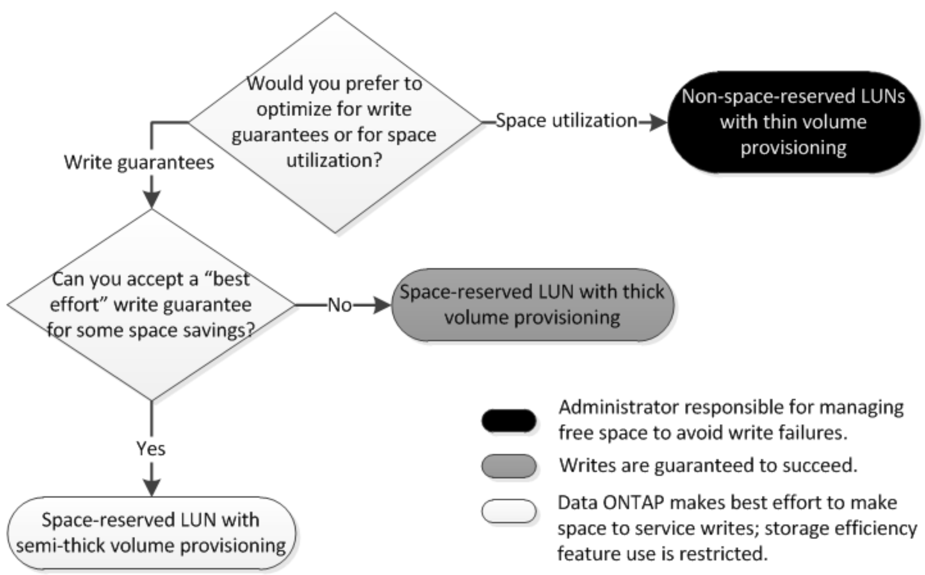
About this task

You can optimize your LUN and volume configurations for maximum storage utilization or for the security of write guarantees. Based on your requirements for storage utilization and your ability to monitor and replenish free space quickly, you must determine the FlexVol volume and LUN volumes appropriate for your installation.

Note: You do not need a separate volume for each LUN.

Step

1. Use the following decision tree to determine the best volume and LUN configuration combination for your environment:



Calculating rate of data growth for LUNs

You need to know the rate at which your LUN data is growing over time to determine whether you should use space-reserved LUNs or non-space-reserved LUNs.

About this task

If you have a consistently high rate of data growth, then space-reserved LUNs might be a better option for you. If you have a low rate of data growth, then you should consider non-space-reserved LUNs.

You can use tools such as OnCommand Insight to calculate your rate of data growth or you can calculate it manually. The following steps are for manual calculation.

Steps

1. Set up a space-reserved LUN.
2. Monitor the data on the LUN for a set period of time, such as one week.

   Make sure that your monitoring period is long enough to form a representative sample of regularly occurring increases in data growth. For instance, you might consistently have a large amount of data growth at the end of each month.
3. Each day, record in GB how much your data grows.
4. At the end of your monitoring period, add the totals for each day together, and then divide by the number of days in your monitoring period.

   This calculation yields your average rate of growth.

In this example, you need a 200 GB LUN. You decide to monitor the LUN for a week and record the following daily data changes:

- Sunday: 20 GB
- Monday: 18 GB
- Tuesday: 17 GB
- Wednesday: 20 GB
- Thursday: 20 GB
- Friday: 23 GB
- Saturday: 22 GB

In this example, your rate of growth is (20+18+17+20+20+23+22) / 7 = 20 GB per day.

Configuration settings for space-reserved files or LUNs with thick-provisioned volumes

This FlexVol volume and file or LUN configuration combination provides the ability to use storage efficiency technologies and does not require you to actively monitor your free space, because sufficient space is allocated up front.

The following settings are required to configure a space-reserved file or LUN in a volume using thick provisioning:

Volume setting	**Value**
Guarantee	Volume
Fractional reserve	100
Snapshot reserve	Any
Snapshot autodelete	Optional
Autogrow	Optional; if enabled, aggregate free space must be actively monitored.

File or LUN setting	**Value**
Space reservation	Enabled

Configuration settings for non-space-reserved files or LUNs with thin-provisioned volumes

This FlexVol volume and file or LUN configuration combination requires the smallest amount of storage to be allocated up front, but requires active free space management to prevent errors due to lack of space.

The following settings are required to configure a non-space-reserved files or LUN in a thin-provisioned volume:

Volume setting	**Value**
Guarantee	None
Fractional reserve	0
Snapshot reserve	Any
Snapshot autodelete	Optional
Autogrow	Optional

File or LUN setting	**Value**
Space reservation	Disabled

Additional considerations

When the volume or aggregate runs out of space, write operations to the file or LUN can fail.

If you do not want to actively monitor free space for both the volume and the aggregate, you should enable Autogrow for the volume and set the maximum size for the volume to the size of the aggregate. In this configuration, you must monitor aggregate free space actively, but you do not need to monitor the free space in the volume.

Configuration settings for space-reserved files or LUNs with semi-thick volume provisioning

This FlexVol volume and file or LUN configuration combination requires less storage to be allocated up front than the fully provisioned combination, but places restrictions on the efficiency technologies you can use for the volume. Overwrites are fulfilled on a best-effort basis for this configuration combination.

The following settings are required to configure a space-reserved LUN in a volume using semi-thick provisioning:

Volume setting	Value
Guarantee	Volume
Fractional reserve	0
Snapshot reserve	0
Snapshot autodelete	On, with a commitment level of destroy, a destroy list that includes all objects, the trigger set to volume, and all FlexClone LUNs and FlexClone files enabled for automatic deletion.
Autogrow	Optional; if enabled, aggregate free space must be actively monitored.

File or LUN setting	Value
Space reservation	Enabled

Technology restrictions

You cannot use the following volume storage efficiency technologies for this configuration combination:

- Compression
- Deduplication
- ODX and FlexClone Copy Offload
- FlexClone LUNs and FlexClone files not marked for automatic deletion (active clones)
- FlexClone subfiles
- ODX/Copy Offload

Additional considerations

The following facts must be considered when employing this configuration combination:

- When the volume that supports that LUN runs low on space, protection data (FlexClone LUNs and files, Snapshot copies) is destroyed.
- Write operations can time out and fail when the volume runs out of free space.

Compression is enabled by default for AFF platforms. You must explicitly disable compression for any volume for which you want to use semi-thick provisioning on an AFF platform.

Where to find additional information

You can learn more about the tasks and concepts described in this guide in NetApp's extensive documentation library.

The following documentation is available:

- *SAN configuration*
  Describes supported FC, iSCSI, and FCoE topologies for connecting host computers to storage controllers in clusters.
- *NetApp Documentation: Host Utilities (current releases)*
  Describes how to install and setup Host Utilities software.
- *NetApp Technical Report 4684: Implementing and Configuring Modern SANs with NVMe/FC*
  Describes how to implement and configure SAN with NVME/FC.
- *ONTAP 9 commands*
  Describes ONTAP commands in reference format.
- *NetApp Hardware Universe*
  Describes SAN host and controller configuration limits.

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