SAN volumes

ONTAP 9

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Table of Contents

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About SAN 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.

> 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.

> 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).

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

Configure 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 and for non-AFF DP volumes. Otherwise, it defaults to `volume`. For existing FlexVol volumes, use the `volume modify` command to configure provisioning options.

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

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

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

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

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

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

Determine space usage in a volume or aggregate

Enabling a feature in ONTAP might consume space that you are not aware of or more space than you expected. ONTAP helps you determine how space is being consumed by

providing three perspectives from which to view space: the volume, a volume's footprint within the aggregate, and the aggregate.

A volume can run out of space due to space consumption or insufficient space within the volume, aggregate, or a combination of both. By seeing a feature-oriented breakdown of space usage from different perspectives, you can assess which features you might want to adjust or turn off, or take other action (such as increase the size of the aggregate or volume).

You can view space usage details from any of these perspectives:

- The volume's space usage

  This perspective provides details about space usage within the volume, including usage by Snapshot copies.

  You see a volume's space usage by using the `volume show-space` command.

- The volume's footprint within the aggregate

  This perspective provides details about the amount of space each volume is using in the containing aggregate, including the volume's metadata.

  You see a volume's footprint with the aggregate by using the `volume show-footprint` command.

- The aggregate's space usage

  This perspective includes totals of the volume footprints of all of the volumes contained in the aggregate, space reserved for aggregate Snapshot copies, and other aggregate metadata.

  You can see the aggregate's space usage by using the `storage aggregate show-space` command.

Certain features, such as tape backup and deduplication, use space for metadata both from the volume and directly from the aggregate. These features show different space usage between the volume and volume footprint perspectives.

Delete Snapshot copies automatically

You can define and enable a policy for automatically deleting Snapshot copies and FlexClone LUNs. Automatically deleting Snapshot copies and FlexClone LUNs can help you manage space utilization.

About this task

You can automatically delete Snapshot copies from read-write volumes and FlexClone LUNs from read-write parent volumes. You cannot set up automatic deletion of Snapshot copies from read-only volumes, for example, SnapMirror destination volumes.

Step

1. Define and enable a policy for automatically deleting Snapshot copies by using the `volume snapshot autodelete modify` command.

   See the `volume snapshot autodelete modify` man page for information about the parameters that you can use with this command to define a policy that meets your needs.

The following command enables the automatic deletion of Snapshot copies and sets the trigger to `snap_reserve` for the vol3 volume, which is part of the vs0.example.com storage virtual machine (SVM):

```
cluster1::> volume snapshot autodelete modify -vserver vs0.example.com
-volume vol3 -enabled true -trigger snap_reserve
```

The following command enables the automatic deletion of Snapshot copies and of FlexClone LUNs marked for autodeletion for the vol3 volume, which is part of the vs0.example.com storage virtual machine (SVM):

```
cluster1::> volume snapshot autodelete modify -vserver vs0.example.com
-volume vol3 -enabled true -trigger volume -commitment try -delete-order
oldest_first -destroy-list lun_clone,file_clone
```

Aggregate-level Snapshot copies work differently than volume-level Snapshot copies and are managed automatically by ONTAP. The option to delete aggregate Snapshot copies is always enabled and helps in managing space utilization.

If the trigger parameter is set to `snap_reserve` for an aggregate, the Snapshot copies are maintained until the space reserved crosses the threshold capacity. Therefore, even if the trigger parameter is not set to `snap_reserve`, the space used by the Snapshot copy in the command will be listed as `0` because these Snapshot copies are automatically deleted. Also, the space used by Snapshot copies in an aggregate is considered as free and is included in the available space parameter of the command.

Configure volumes to automatically provide more space when they are full

When FlexVol volumes get full, ONTAP can use various methods to attempt to automatically provide more free space for the volume. You choose which methods ONTAP can use, and in which order, depending on the requirements imposed by your application and storage architecture.

About this task

ONTAP can automatically provide more free space for a full volume by using one or both of the following methods:

- Increase the size of the volume (known as *autogrow*).

  This method is useful if the volume's containing aggregate has enough space to support a larger volume. You can configure ONTAP to set a maximum size for the volume. The increase is automatically triggered based on the amount of data being written to the volume in relation to the current amount of used space and any thresholds set.

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

- Delete Snapshot copies, FlexClone files, or FlexClone LUNs.

  For example, you can configure ONTAP to automatically delete Snapshot copies that are not linked to Snapshot copies in cloned volumes or LUNs, or you can define which Snapshot copies you want ONTAP to delete first—your oldest or newest Snapshot copies. You can also determine when ONTAP should begin deleting Snapshot copies—for example, when the volume is nearly full or when the volume's Snapshot reserve is nearly full.

If you enable both of these methods, you can specify which method ONTAP tries first when a volume is nearly full. If the first method does not provide sufficient additional space to the volume, ONTAP tries the other method next.

By default, ONTAP tries to increase the size of the volume first. In most cases, the default configuration is preferable, because when a Snapshot copy is deleted, it cannot be restored. However, if you need to avoid growing the size of a volume whenever possible, you can configure ONTAP to delete Snapshot copies before increasing the size of the volume.

Steps

1. If you want ONTAP to attempt to increase the size of the volume when it gets full, enable the autogrow capability for the volume by using the `volume autosize` command with `grow` mode.

   Remember that when the volume grows, it consumes more free space from its associated aggregate. If you are depending on the volume's ability to grow whenever it needs to, you must monitor the free space in the associated aggregate and add more when needed.

2. If you want ONTAP to delete Snapshot copies, FlexClone files, or FlexClone LUNs when the volume gets full, enable autodelete for those object types.
3. If you enabled both the volume autogrow capability and one or more autodelete capabilities, select the first method that ONTAP should use to provide free space to a volume by using the `volume modify` command with the `-space-mgmt-try-first` option.

   To specify increasing the size of the volume first (the default), use `volume_grow`. To specify deleting Snapshot copies first, use `snap_delete`.

Configure volumes to automatically grow and shrink their size

You can configure FlexVol volumes to automatically grow and shrink according to how much space they currently require. Automatic growing helps prevent a volume from running out of space, if the aggregate can supply more space. Automatic shrinking prevents a volume from being larger than needed, freeing space in the aggregate for use by other volumes.

What you'll need

The FlexVol volume must be online.

About this task

Autoshrink can only be used in combination with autogrow to meet changing space demands and is not available alone. When autoshrink is enabled, ONTAP automatically manages the shrinking behavior of a volume to prevent an endless loop of autogrow and autoshrink actions.

As a volume grows, the maximum number of files it can contain might be automatically increased. When a volume is shrunk, the maximum number of files it can contain is left unchanged, and a volume cannot be automatically shrunk below the size that corresponds to its current maximum number of files. For this reason, it might not be possible to automatically shrink a volume all the way to its original size.

By default, the maximum size a volume can grow to is 120% of the size at which autogrow is enabled. If you need to ensure that the volume can grow to be larger than that, you must set the maximum size for the volume accordingly.

Step

1. Configure the volume to grow and shrink its size automatically:

   `volume autosize -vserver vserver_namevol_name -mode grow_shrink`

   The following command enables automatic size changes for a volume called test2. The volume is configured to begin shrinking when it is 60% full. The default values are used for when it will begin to grow and its maximum size.

   ```
   cluster1::> volume autosize -vserver vs2 test2 -shrink-threshold-percent
   60
   vol autosize: Flexible volume "vs2:test2" autosize settings UPDATED.

   Volume modify successful on volume: test2
   ```

Requirements for enabling both autoshrink and automatic Snapshot copy deletion

The autoshrink functionality can be used with automatic Snapshot copy deletion if certain configuration requirements are met.

If you want to enable both the autoshrink functionality and automatic Snapshot copy deletion, your configuration must meet the following requirements:

- ONTAP must be configured to attempt to increase volume size before trying to delete Snapshot copies(the `-space-mgmt-try-first` option must be set to `volume_grow`).
- The trigger for automatic Snapshot copy deletion must be volume fullness(the `trigger` parameter must be set to `volume`).

How the autoshrink functionality interacts with Snapshot copy deletion

Because the autoshrink functionality shrinks the size of a FlexVol volume, it can also affect when volume Snapshot copies are automatically deleted.

The autoshrink functionality interacts with automatic volume Snapshot copy deletion in the following ways:

- If both the `grow_shrink` autosize mode and automatic Snapshot copy deletion are enabled, when a

volume size shrinks it can trigger an automatic Snapshot copy deletion.

This is because the Snapshot reserve is based on a percentage of the volume size (5 percent by default), and that percentage is now based on a smaller volume size. This can cause Snapshot copies to spill out of the reserve and be deleted automatically.

- If the `grow_shrink` autosize mode is enabled and you manually delete a Snapshot copy, it might trigger an automatic volume shrinkage.

Address FlexVol volume fullness and overallocation alerts

ONTAP issues EMS messages when FlexVol volumes are running out of space so that you can take corrective action by providing more space for the full volume. Knowing the types of alerts and how to address them helps you ensure your data availability.

When a volume is described as *full*, it means that the percentage of the space in the volume available for use by the active file system (user data) has fallen below a (configurable) threshold. When a volume becomes *overallocated*, the space used by ONTAP for metadata and to support basic data access has been exhausted. Sometimes space normally reserved for other purposes can be used to keep the volume functioning, but space reservation or data availability can be at risk.

Overallocation can be either logical or physical. *Logical overallocation* means that space reserved to honor future space commitments, such as space reservation, has been used for another purpose. *Physical overallocation* means that the volume is running out of physical blocks to use. Volumes in this state are at risk for refusing writes, going offline, or potentially causing a controller disruption.

A volume can be more than 100% full due to space used or reserved by metadata. However, a volume that is more than 100% full might or might not be overallocated. If qtree-level and volume-level shares exist on the same FlexVol or SCVMM pool, the qtrees appear as directories on the FlexVol share. Therefore, you need to be careful not to delete them accidentally.

The following table describes the volume fullness and overallocation alerts, the actions you can take to address the issue, and the risks of not taking action:

Alert type	EMS level	Configurable?	Definition	Ways to address	Risk if no action taken
Nearly full	Debug	Y	The file system has exceeded the threshold set for this alert (the default is 95%). The percentage is the `Used` total minus the size of the Snapshot reserve.	• Increasing volume size • Reducing user data	No risk to write operations or data availability yet.

Alert type	EMS level	Configurable?	Definition	Ways to address	Risk if no action taken
Full	Debug	Y	The file system has exceeded the threshold set for this alert (the default is 98%). The percentage is the `Used` total minus the size of the Snapshot reserve.	• Increasing volume size • Reducing user data	No risk to write operations or data availability yet, but the volume is approaching the stage where write operations could be at risk.
Logically overallocated	SVC Error	N	In addition to the file system being full, the space in the volume used for metadata has been exhausted.	• Increasing volume size • Deleting Snapshot copies • Reducing user data • Disabling space reservation for files or LUNs	Write operations to unreserved files could fail.
Physically overallocated	Node Error	N	The volume is running out of physical blocks it can write to.	• Increasing volume size • Deleting Snapshot copies • Reducing user data	Write operations are at risk, as well as data availability; the volume could go offline.

Every time a threshold is crossed for a volume, whether the fullness percentage is rising or falling, an EMS message is generated. When the fullness level of the volume falls below a threshold, a `volume ok` EMS message is generated.

Address aggregate fullness and overallocation alerts

ONTAP issues EMS messages when aggregates are running out of space so that you can take corrective action by providing more space for the full aggregate. Knowing the types of alerts and how you can address them helps you ensure your data availability.

When an aggregate is described as *full*, it means that the percentage of the space in the aggregate available for use by volumes has fallen below a predefined threshold. When an aggregate becomes *overallocated*, the space used by ONTAP for metadata and to support basic data access has been exhausted. Sometimes space normally reserved for other purposes can be used to keep the aggregate functioning, but volume guarantees

for volumes associated with the aggregate or data availability can be at risk.

Overallocation can be either logical or physical. *Logical overallocation* means that space reserved to honor future space commitments, such as volume guarantees, has been used for another purpose. *Physical overallocation* means that the aggregate is running out of physical blocks to use. Aggregates in this state are at risk for refusing writes, going offline, or potentially causing a controller disruption.

The following table describes the aggregate fullness and overallocation alerts, the actions you can take to address the issue, and the risks of not taking action.

Alert type	EMS Level	Configurable?	Definition	Ways to address	Risk if no action taken
Nearly full	Debug	N	The amount of space allocated for volumes, including their guarantees, has exceeded the threshold set for this alert (95%). The percentage is the `Used` total minus the size of the Snapshot reserve.	• Adding storage to the aggregate • Shrinking or deleting volumes • Moving volumes to another aggregate with more space • Removing volume guarantees (setting them to `none`)	No risk to write operations or data availability yet.
Full	Debug	N	The file system has exceeded the threshold set for this alert (98%). The percentage is the `Used` total minus the size of the Snapshot reserve.	• Adding storage to the aggregate • Shrinking or deleting volumes • Moving volumes to another aggregate with more space • Removing volume guarantees (setting them to `none`)	Volume guarantees for volumes in the aggregate might be at risk, as well as write operations to those volumes.
Logically overallocated	SVC Error	N	In addition to the space reserved for volumes being full, the space in the aggregate used for metadata has been exhausted.	• Adding storage to the aggregate • Shrinking or deleting volumes • Moving volumes to another aggregate with more space • Removing volume guarantees (setting them to `none`)	Volume guarantees for volumes in the aggregate are at risk, as well as write operations to those volumes.

Alert type	EMS Level	Configurable?	Definition	Ways to address	Risk if no action taken
Physically overallocated	Node Error	N	The aggregate is running out of physical blocks it can write to.	• Adding storage to the aggregate • Shrinking or deleting volumes • Moving volumes to another aggregate with more space	Write operations to volumes in the aggregate are at risk, as well as data availability; the aggregate could go offline. In extreme cases, the node could experience a disruption.

Every time a threshold is crossed for an aggregate, whether the fullness percentage is rising or falling, an EMS message is generated. When the fullness level of the aggregate falls below a threshold, an `aggregate ok` EMS message is generated.

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

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