# Volume administration

## ONTAP 9

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# Volume administration

## Volume and LUN management with System Manager

### Volume administration overview with System Manager

Beginning with ONTAP 9.7, you can use System Manager to manage logical storage, such as FlexVol volumes and LUNs, qtrees, storage efficiency, and quotas.

If you are using the classic System Manager (available only in ONTAP 9.7 and earlier), refer to Managing logical storage

### Manage volumes

After you display a list of volumes in System Manager, you can perform various actions to manage the volumes.

**Steps**

1. In System Manager, click **Storage > Volumes**.

   The list of volumes is displayed.

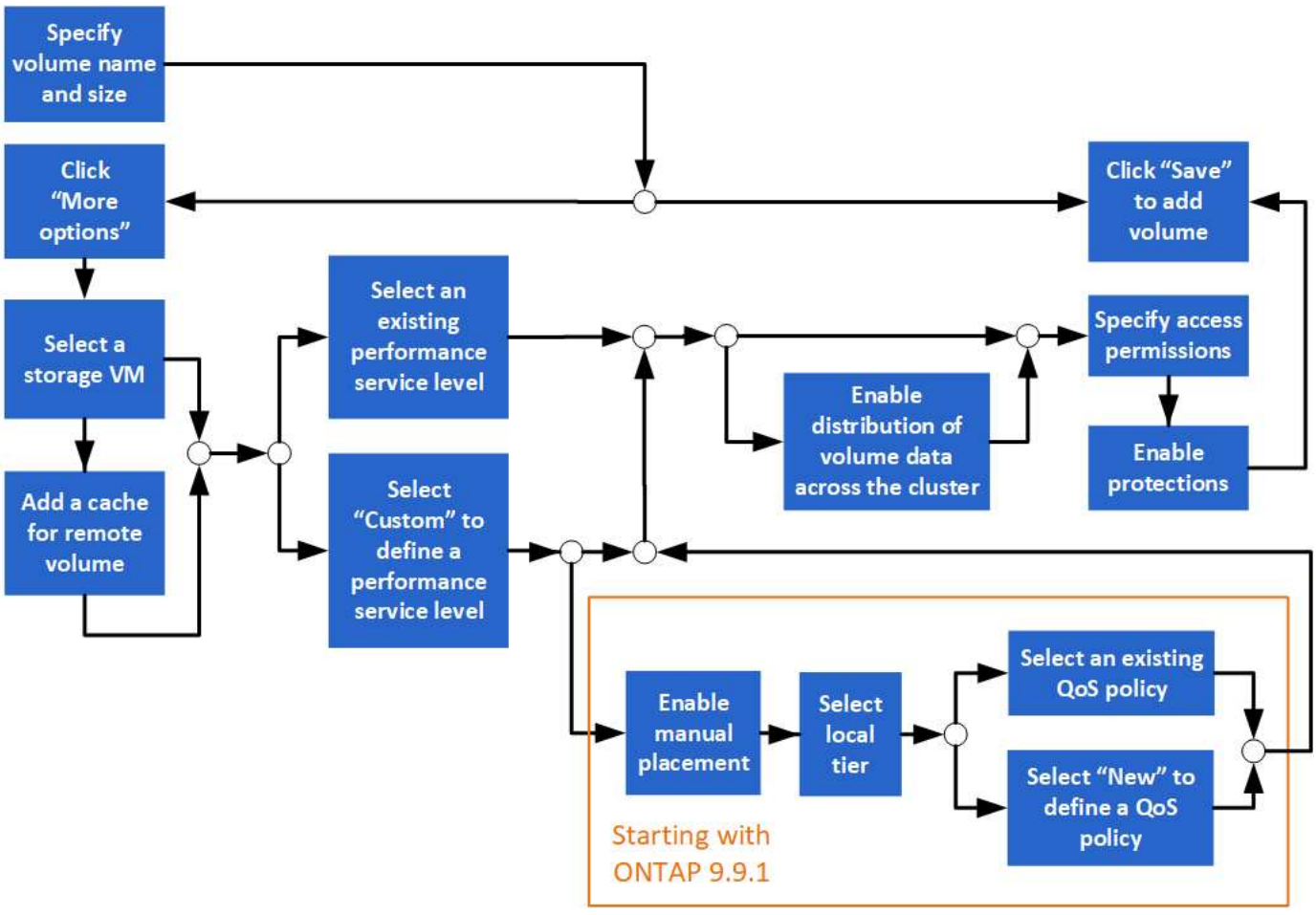
2. You can perform the following:

| To perform this task… | Take these actions… |
| --- | --- |
| Add a volume | Click + Add . See Add a volume. |
| Manage multiple volumes | Check the boxes next to the volumes.<br>• Click Delete to delete the selected volumes.<br>• Click Protect to assign a protection policy to the selected volumes.<br>• Click More to select one of the following actions to perform for all selected volumes:<br>◦ Enable quota<br>◦ Take offline<br>◦ Move<br>◦ Show Deleted Volumes |

| | |
|---|---|
| Manage a single volume | Next to the volume, click ⋮, then select one of the following actions to perform:<br>• Edit<br>• Resize (Beginning with ONTAP 9.10.1, and only for online volumes and DP FlexVol volumes)<br>• Delete<br>• Clone<br>• Take Offline (or Bring Online)<br>• Enable Quota (or Disable Quota)<br>• Edit Export Policy<br>• Edit Mount Path<br>• Move<br>• Edit Cloud Tier Settings<br>• Protect |

## Add a volume

You can create an NFS volume and add it to an existing storage VM that is configured for NFS or SMB service.



**Before you Start**

A storage VM that is configured for NFS or SMB service should exist in the cluster.

**Steps**

1. Go to **Storage > Volumes**.
2. Click + Add .
3. Specify a name and size for the volume.
4. Perform one of the following steps:

| Click this button… | To perform this action… |
|---|---|
| **Save** | The volume is created and added using the system defaults. No additional steps are required. |
| **More Options** | Proceed to Step 5 to define the specifications for the volume. |

5. The volume name and size are shown if you previously specified them. Otherwise, enter the name and size.
6. Select a storage VM from the pull-down list.

   Only storage VMs configured with the NFS protocol are listed. If only one storage VM configured with the NFS protocol is available, the **Storage VM** field is not shown.

7. To add a cache for the remote volume, select **Add a cache for remote volume** and specify the following values:
   - Select a cluster.
   - Select a storage VM.
   - Select the volume that you want to be a cache volume.
8. In the **Storage and Optimization** section, specify the following values:
   a. The capacity of the volume is already shown, but you can modify it.
   b. In the **Performance Service Level** field, select a service level:

| When you select this service level… | This occurs… |
|---|---|
| An existing service level, such as "Extreme", "Performance", or "Value".<br><br>Only the service levels that are valid for the system platform (AFF, FAS, or others) are displayed. | A local tier or tiers are automatically chosen. Proceed to Step 9. |
| Custom | Proceed to Step 8c to define a new service level. |

   c. Beginning with ONTAP 9.9.1, you can use System Manager to manually select the local tier on which you want to place the volume you are creating (if you have selected the "Custom" service level).

   This option is not available if you select **Add as a cache for a remote volume** or **Distribute volume data across the cluster** (see below).

| When you make this choice… | You perform these steps… |
| --- | --- |
| **Manual placement** | Manual placement is enabled. The **Distribute volume data across the cluster** selection is disabled (see below). Proceed to Step 8d to complete the process. |
| No selection | Manual placement is not enabled. The local tier is automatically selected. Proceed to Step 9. |

d. Select a local tier from the pull-down menu.

e. Select a QoS policy.

Select "Existing" to choose from a list of existing policies, or select "New" to enter the specifications of a new policy.

9. In the **Optimization options** section, determine if you want to distribute the volume data across the cluster:

| When you make this choice… | This occurs… |
| --- | --- |
| **Distribute volume data across the cluster** | The volume you are adding becomes a FlexGroup volume. This option is not available if you previously selected **Manual placement**. |
| No selection | The volume you are adding becomes a FlexVol volume by default. |

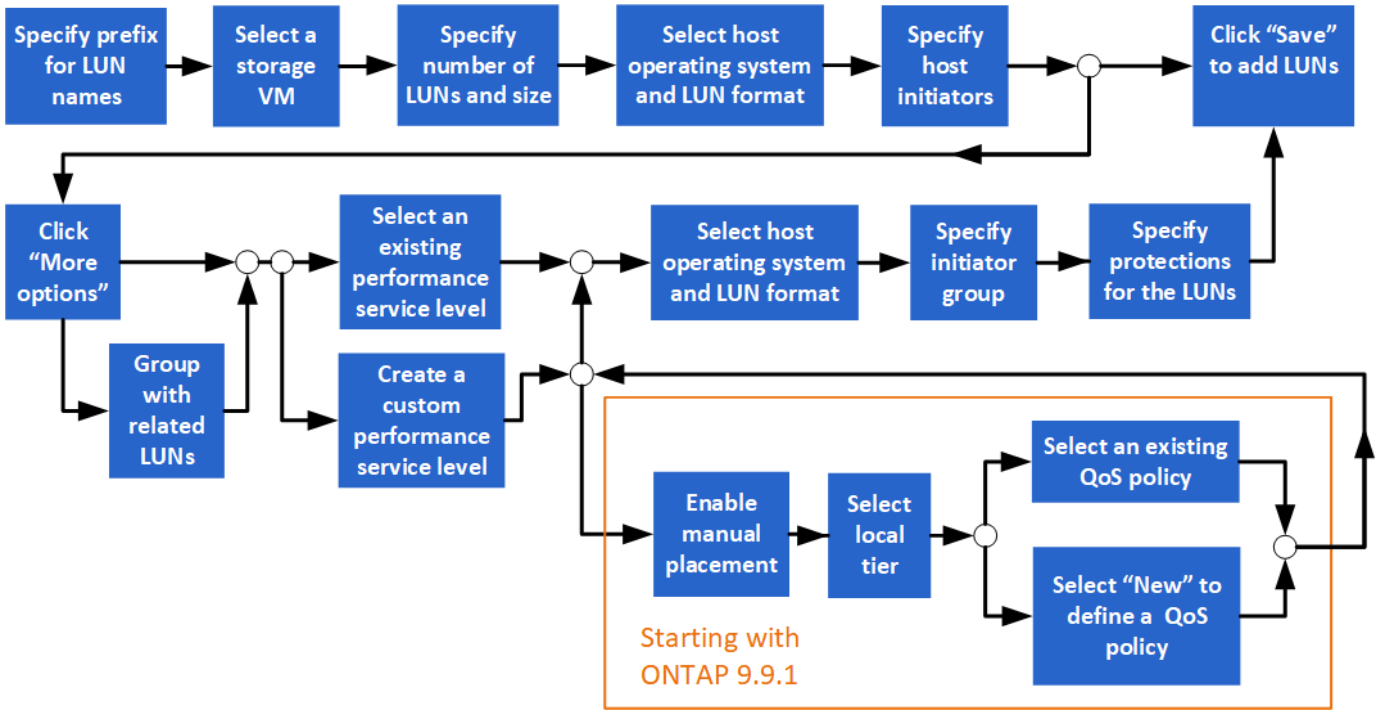
10. In the **Access Permissions** section, specify the access permissions for the protocols for which the volume is configured.
11. In the **Protection** section, specify the protections for the volume. If you select **Enable SnapMirror (Local or Remote)**, then specify the protection policy and settings for the destination cluster from the pull-down lists.
12. Click **Save**.

The volume is created and added to the cluster and storage VM.

ⓘ You can also save the specifications of this volume to an Ansible Playbook. For more details, go to Use Ansible Playbooks to add or edit volumes or LUNs.

## Add LUNs

You can create LUNs and add them to an existing storage VM that is configured with the SAN protocol.




**Before you Start**

A storage VM that is configured for SAN service should exist in the cluster.

**Steps**

1. Go to **Storage > LUNs**.
2. Click + Add .
3. Specify a prefix that will be used at the start of each LUN name. (If you are creating only one LUN, enter the LUN name.)
4. Select a storage VM from the pull-down list.

   Only storage VMs that are configured for the SAN protocol are listed. If only one storage VM that is configured for the SAN protocol is available, then the **Storage VM** field is not displayed.

5. Indicate how many LUNs you want to create and the size of each LUN.
6. Select the host operating system and LUN format from the pull-down lists.
7. Enter the host initiators, and separate them with commas.
8. Perform one of the following actions:

| Click this button… | To perform this action… |
|---|---|
| **Save** | The LUNs are created with the specifications you entered. System defaults are used for other specifications. No additional steps are required. |
| **More Options** | Proceed to Step 9 to define additional specifications for the LUNs. |

9. The LUN prefix is already shown if you previously entered it, but you can modify it. Otherwise, enter the prefix.
10. Select a storage VM from the pull-down list.

Only storage VMs that are configured for the SAN protocol are listed. If only one storage VM that is configured for the SAN protocol is available, then the **Storage VM** field is not displayed.

11. Determine how you want the LUNs to be grouped:

| When you make this choice… | This occurs… |
|---|---|
| **Group with related LUNs** | The LUNs will be grouped together with related LUNs on an existing volume on the storage VM. |
| No selection | The LUNs will be grouped together on a volume called "container". |

12. In the **Storage and Optimization** section, specify the following values:
    a. The number and capacity of the LUNs are already shown if you previously entered them, but you can modify them. Otherwise, enter the values.
    b. In the **Performance Service Level** field, select a service level:

| When you select this service level… | This occurs… |
|---|---|
| An existing service level, such as "Extreme", "Performance", or "Value".<br><br>Only the service levels that are valid for the system platform (AFF, FAS, or others) are displayed. | A local tier is automatically chosen. Proceed to Step 13. |
| Custom | Proceed to Step 12c to define a new service level. |

    c. Beginning with ONTAP 9.9.1, you can use System Manager to manually select the local tier on which you want to place the LUNs you are creating (if you have selected the "Custom" service level).

| When you make this choice… | You perform these steps… |
|---|---|
| **Manual placement** | Manual placement is enabled. Proceed to Step 12d to complete the process. |
| No selection | Manual selection is not enabled. The local tier is automatically selected. Proceed to Step 13. |

    d. Select a local tier from the pull-down menu.
    e. Select a QoS policy.

    Select "Existing" to choose from a list of existing policies, or select "New" to enter the specifications of a new policy.

13. In the **Host Information** section, the host operating system and LUN format are already shown, but you can modify them.
14. Under **Host Mapping**, select the type of initiators for the LUNs:
    - **Existing initiator group**: Select an initiator group for the list that displays.
    - **New initiator group using existing initiator groups**: Specify the name of the new group, and select

the group or groups that you want to use to create the new group.

- **Host initiators**: Specify a name from the new initiator group, and click **+Add Initiator** to add initiators to the group.

15. In the **Protection** section, specify the protections for the LUNs.

    If you select **Enable SnapMirror (Local or Remote)**, then specify the protection policy and settings for the destination cluster from the pull-down lists.

16. Click **Save**.

    The LUNs are created and added to the cluster and storage VM.

> You can also save the specifications of these LUNs to an Ansible Playbook. For more details, go to Use Ansible Playbooks to add or edit volumes or LUNs.

## Expand storage

Using System Manager, you can increase the size of your volume or LUN so that more space is available to your host. The size of a LUN cannot exceed the size of the containing volume.

- Increase the size of a volume
- Increase the size of a LUN

Also, you can add a LUN to an existing volume. The processes are different when using System Manager with ONTAP 9.7 or 9.8

- Add a LUN to an existing volume (ONTAP 9.7)
- Add a LUN to an existing volume (ONTAP 9.8)

Also, beginning with ONTAP 9.8, you can use System Manager to add a LUN to an existing volume.

### Increase the size of a volume

#### Steps

1. Click **Storage > Volumes**.
2. Hover over the name of the volume you want to increase in size.
3. Click ⋮.
4. Select **Edit**.
5. Increase the capacity value.

### Increase the size of a LUN

#### Steps

1. Click **Storage > LUNs**.
2. Hover over the name of the LUN you want to increase in size.
3. Click ⋮.

4. Select **Edit**.
5. Increase the capacity value.

#### Add a LUN to an existing volume (ONTAP 9.7)

To use System Manager with ONTAP 9.7 to add a LUN to an existing volume, you should switch to the Classical View first.

**Steps**

1. Log in to System Manager in ONTAP 9.7.
2. Click **Classical View**.
3. Select **Storage > LUNs > Create**
4. Specify the details to create the LUN.
5. Specify to which existing volume or qtree the LUN should be added.

#### Add a LUN to an existing volume (ONTAP 9.8)

Beginning with ONTAP 9.8, you can use System Manager to add a LUN to an existing volume that already has a least one LUN.

**Steps**

1. Click **Storage > LUNs**.
2. Click **Add+**.
3. Complete the fields in the **Add LUNs** window.
4. Select **More Options**.
5. Select the checkbox labeled **Group with related LUNs**.
6. In the drop-down field, select a LUN that exists on the volume to which you want to add another LUN.
7. Complete the rest of the fields. For **Host Mapping**, click one of the radio buttons:
   - **Existing initiator group** lets you select an existing group from a list.
   - **New initiator group** lets you enter a new group in the field.

## Recover deleted volumes

If you have accidently deleted one or more FlexVol volumes, you can use System Manager to recover these volumes. Beginning with ONTAP 9.8, you can also user System Manager to recover FlexGroup volumes. You can also delete the volumes permanently by purging the volumes.

The volume retention time can be set on a storage VM level. By default, the volume retention time is set to 12 hours.

#### Selecting deleted volumes

**Steps**

1. Click **Storage > Volumes**.
2. Click **More > Show Deleted Volumes**.

3. Select the volumes and click the desired action to recover or permanently delete the volumes.

#### Resetting the volume configurations

Deleting a volume deletes the associated configurations of the volume. Recovering a volume does not reset all the configurations. Perform the following tasks manually after recovering a volume to bring the volume back to its original state:

#### Steps

1. Rename the volume.
2. Set up a junction path (NAS).
3. Create mappings for LUNs in the volume (SAN).
4. Associate a Snapshot policy and export policy with the volume.
5. Add new quota policy rules for the volume.
6. Add a QOS policy for the volume.

## Save storage space using compression, compaction, and deduplication

For volumes on non-AFF clusters, you can run deduplication, data compression, and data compaction together or independently to achieve optimal space savings.

- Deduplication eliminates duplicate data blocks.
- Data compression compresses the data blocks to reduce the amount of physical storage that is required.
- Data compaction stores more data in less space to increase storage efficiency.

> These tasks are supported for volumes on non-AFF clusters. Beginning with ONTAP 9.2, all inline storage efficiency features, such as inline deduplication and inline compression, are enabled by default on AFF volumes.

#### Steps

1. Click **Storage > Volumes**.
2. Next to the name of the volume for which you want to save storage, click ⋮.
3. Click **Edit** and scroll to **Storage Efficiency**.
4. *Optional*: If you want to enable background deduplication, ensure the checkbox is checked.
5. *Optional*: If you want to enable background compression, specify the storage efficiency policy and ensure the checkbox is checked.
6. *Optional*: If you want to enable inline compression, ensure the checkbox is checked.

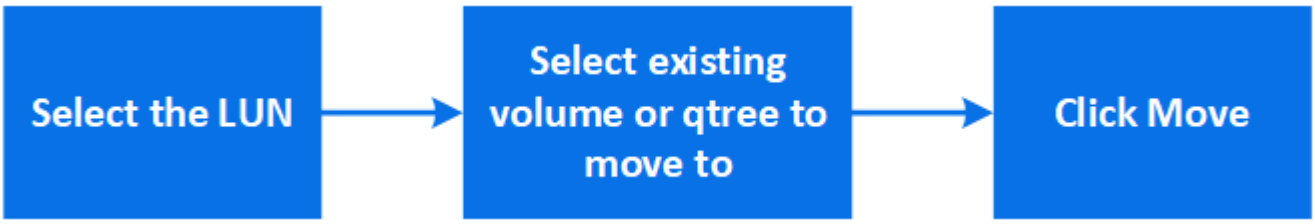
## Balance loads by moving LUNs

You can move a LUN to another volume within the storage VM to balance the load, or you can move it to a volume with a higher performance service level to improve performance.

#### Move restrictions

- A LUN cannot be moved to a qtree within the same volume.

- A LUN created from a file using the CLI cannot be moved with System Manager.
- LUNs that are online and serving data cannot be moved.
- LUNs cannot be moved if the allocated space in the destination volume cannot contain the LUN (even if autogrow is enabled on the volume).
- LUNs on SnapLock volumes cannot be moved with System Manager.




**Steps**

1. Click **Storage > LUNs**.
2. Select the LUN that you want to move and click **Move**.
3. Select an existing volume to which you want to move the LUN. If the volume contains qtrees, select the qtree.

While the Move operation is in progress, the LUN is displayed on both the origin and destination volume.

## Balance loads by moving volumes to another tier

Beginning with ONTAP 9.8, you can use System Manager to move a volume to another tier to balance the load.

Beginning with ONTAP 9.9.1, you can also move volumes based on analysis of active and inactive data storage. For more information, see File System Analytics overview.

**Steps**

1. Click **Storage > Volumes**.
2. Select the volume or volumes that you want to move, and then click **Move**.
3. Select an existing tier (aggregate) to which you want to move the volume or volumes.

## Use Ansible Playbooks to add or edit volumes or LUNs

Beginning with ONTAP 9.9.1, you can use Ansible Playbooks with System Manager when you want to add or edit volumes or LUNs.

This feature lets you use the same configuration multiple times or use the same configuration with slight changes when you add or edit volumes or LUNs.

### Enable or disable Ansible Playbooks

You can enable or disable the use of Ansible Playbooks with System Manager.

**Steps**

1. In System Manager, go to the UI settings in the cluster settings page:

   **Cluster > Settings**

2. Under **UI Settings**, change the slider switch to "Enabled" or "Disabled".

### Save a volume configuration to an Ansible Playbook

When you create or modify the configuration of a volume, you can save the configuration as Ansible Playbook files.

#### Steps

1. Add or Edit the volume:

   **Volume > Add** (or **Volume > Edit**)

2. Specify or edit the configuration values of the volume.
3. Select **Save to Ansible Playbook** to save the configuration to Ansible Playbook files.

   A zip file is downloaded that contains the following files:

   - **`variable.yaml`**: The values you entered or modified to add or edit the volume.
   - **`volumeAdd.yaml`** (or **`volumeEdit.yaml`**): The test cases that are required to create or modify the values when reading the inputs from the `variable.yaml` file.

### Save a LUN configuration to an Ansible Playbook

When you create or modify the configuration of a LUN, you can save the configuration as Ansible Playbook files.

#### Steps

1. Add or Edit the LUN:

   **LUN > Add** (or **LUN > Edit**)

2. Specify or edit the configuration values of the LUN.
3. Select **Save to Ansible Playbook** to save the configuration to Ansible Playbook files:

   A zip file is downloaded that contains the following files:

   - **`variable.yaml`**: The values you entered or modified to add or edit the LUN.
   - **`lunAdd.yaml`** (or **`lunEdit.yaml`**): The test cases that are required to create or modify the values when reading the inputs from the `variable.yaml` file.

### Download Ansible Playbook files from global search results

You can download Ansible Playbook files when you do a global search.

#### Steps

1. In the search field, enter “volume” or “LUN” or “Playbook”.
2. Find the search result, either “Volume Management (Ansible Playbook)” or “LUN Management (Ansible

Playbook)”.

3. Click on to download the Ansible Playbook files.

### Work with Ansible Playbook files

Ansible Playbook files can be modified and run to specify configurations for volumes and LUNs.

#### About this task

You use two files to perform an operation (either an “add” or an “edit”):

| If you want to… | Use this variable file… | And use this run file… |
|---|---|---|
| Add a volume | `volumeAdd-varible.yaml` | `valueAdd.yaml` |
| Edit a volume | `volumeEdit-variable.yaml` | `volumeEdit.yaml` |
| Add a LUN | `lunAdd-variable.yaml` | `lunAdd.yaml` |
| Edit a LUN | `lunEdit-variable.yaml` | `lunEdit.yaml` |

#### Steps

1. Modify the variables file.

   The file contains the various values that you use to configure the volume or LUN.

   - If you do not change the values, leave them commented.
   - If you modify the values, remove the commenting.

2. Run the associated run file.

   The run file contains the test cases that are required to create or modify the values when reading the inputs from the variable file.

3. Enter your user login credentials.

## Manage storage efficiency policies

Beginning with ONTAP 9.8, you can use System Manager to enable, disable, add, edit, or delete efficiency policies for storage VMs on FAS systems.

This function is not available on AFF systems.

#### Steps

1. Select **Storage > Storage VMs**
2. Select the storage VM for which you want to manage efficiency policies.
3. On the **Settings** tab, select → in the **Efficiency Policy** section. The efficiency policies for that storage VM are displayed.

You can perform the following tasks:

- **Enable or disable** an efficiency policy by clicking the toggle button in the Status column.

- **Add** an efficiency policy by clicking on **Add+**.
- **Edit** an efficiency policy by clicking on ⋮ to the right of the policy name and selecting **Edit**.
- **Delete** an efficiency policy by clicking on ⋮ to the right of the policy name and selecting **Delete**.

## Manage resources using quotas

Beginning with ONTAP 9.7, you can configure and manage usage quotas with System Manager.

If you are using the ONTAP CLI to configure and manage usage quotas, refer to the Logical Storage Management Guide.

If you are using legacy OnCommand System Manager for ONTAP 9.7 and earlier releases to configure and manage usage quotas, see the following for your release:

- ONTAP 9.6 and 9.7 Documentation
- ONTAP 9.5 Documentation
- ONTAP 9.4 Documentation
- ONTAP 9.3 Documentation
- ONTAP 9.2 Archived Documentation
- ONTAP 9.0 Archived Documentation

### Quota overview

Quotas provide a way to restrict or track the disk space and number of files used by a user, group, or qtree. Quotas are applied to a specific volume or qtree.

You can use quotas to track and limit resource usage in volumes and provide notification when resource usage reaches specific levels.

Quotas can be soft or hard. Soft quotas cause ONTAP to send a notification when specified limits are exceeded, and hard quotas prevent a write operation from succeeding when specified limits are exceeded.

## Set quotas to limit resource use

Add quotas to limit the amount of disk space the quota target can use.

You can set a hard limit and a soft limit for a quota.

Hard quotas impose a hard limit on system resources; any operation that would result in exceeding the limit fails. Soft quotas send a warning message when resource usage reaches a certain level, but they do not affect data access operations, so you can take appropriate action before the quota is exceeded.

### Steps

1. Click **Storage > Quotas**.
2. Click **Add**.

## Clone volumes and LUNs for testing

You can clone volumes and LUNs to create temporary, writable copies for testing. The clones reflect the current, point-in-time state of the data. You can also use clones to give additional users access to data without giving them access to production data.

The FlexClone license should be installed on the storage system.

### Cloning a volume

Create a clone of a volume, as follows:

#### Steps

1. Click **Storage > Volumes**.
2. Click ⋮ next to the name of the volume you want to clone.
3. Select **Clone** from the list.
4. Specify a name for the clone and complete the other selections.
5. Click **Clone** and verify that the volume clone appears in the list of volumes.

Alternatively, you can clone a volume from the **Overview** that displays when you view volume details.

### Cloning a LUN

Create a clone of a LUN, as follows:

#### Steps

1. Click **Storage > LUNs**.
2. Click ⋮ next to the name of the LUN you want to clone.
3. Select **Clone** from the list.
4. Specify a name for the clone and complete the other selections.
5. Click **Clone** and verify that the LUN clone appears in the list of LUNs.

Alternatively, you can clone a LUN from the **Overview** that displays when you view LUN details.

When you create a LUN clone, System Manager automatically enables the deletion of the clone when space is needed.

## Search, filter, and sort information in System Manager

You can search for various actions and objects in System Manager. You can also search table data for specific entries.

System Manager provides two types of searching:

- Global searching

  When you enter a search argument in the field at the top of each page, System Manager searches throughout the interface to find matches. You can then sort and filter the results.

- Table-grid searching

  Beginning with ONTAP 9.8, when you enter a search argument in the field at the top of a table grid, System Manager searches only the columns and rows of that table to find matches.

### Global searching

At the top of each page in System Manager, you can use a global search field to search various objects and actions in the interface. For example, you can search for different objects by name, pages available in the navigator column (on the left side), various action items, like "Add Volume" or "Add License", and links to external help topics. You can also filter and sort the results.

For better results, perform searching, filtering, and sorting one minute after logging in and five minutes after creating, modifying, or deleting an object.

#### Getting search results

The search is not case-sensitive. You can enter a variety of text strings to find the page, actions, or topics you need. Up to 20 results are listed. If more results are found, you can click **Show more** to view all results. The following examples describe typical searches:

| Type of search | Sample search string | Sample search results |
|---|---|---|
| By object name | vol_ | vol_lun_dest on storage VM: svm0 (Volume)<br>/vol/vol…est1/lun on storage VM: svm0 (LUN)<br>svm0:vol_lun_dest1 role: Destination (Relationship) |
| By location in interface | volume | Add Volume (Action)<br>Protection – Overview (Page)<br>Recover deleted volume (Help) |
| By actions | add | Add Volume (Action)<br>Network – Overview (Page)<br>Expand volumes and LUNs (Help) |
| By help content | san | Storage – Overview (Page)<br>SAN overview (Help)<br>Provision SAN storage for databases (Help) |

#### Filtering search results

You can narrow the results with filters, as shown in the following examples:

| Filter | Syntax | Sample search string |
|---|---|---|
| By object type | <type>:<objectName> | volume:vol_2 |
| By object size | <type><size-symbol><number><units> | luns<500mb |
| By broken disks | “broken disk” or “unhealthy disk” | unhealthy disk |

| | | |
|---|---|---|
| By network interface | <IP address> | 172.22.108.21 |

#### Sorting search results

When you view all the search results, they are sorted alphabetically. You can sort the results by clicking Filter and selecting how you want to sort the results.

#### Table-grid searching

Beginning with ONTAP 9.8, whenever System Manager displays information in a table-grid format, a search button appears at the top of the table.

When you click **Search**, a text field appears in which you can enter a search argument. System Manager searches the entire table and displays only the rows that contain text that matches your search argument.

You can use an asterisk ( * ) as a "wildcard" character as a substitute for characters. For example, searching for `vol*` might provide rows that contain the following:

- vol_122_D9
- vol_lun_dest1
- vol2866
- volspec1
- volum_dest_765
- volume
- volume_new4
- volume9987

## Monitor capacity in System Manager

Using System Manager, you can view how much storage capacity has been used and how much is still available for a cluster. Also, beginning with ONTAP 9.10.1, you can use System Manager to view historical data about the cluster's capacity and projections about how much capacity will be used or available in the future.

- Capacity measurements in System Manager
- Measurements of used capacity
- Measurement terms
- Capacity measurement units
- View capacity measurements for the cluster

#### Capacity measurements in System Manager

System capacity can be measured as physical space or logical space. Recent versions of System Manager use measurements of both physical and logical capacity.

The differences between the two measurements are explained in the following descriptions:

- **Physical capacity**: Physical space refers to the physical blocks of storage used in the volume. The value for physical used capacity is typically smaller than the value for logical used capacity due to the reduction of data from storage efficiency features (such as deduplication and compression).
- **Logical capacity**: Logical space refers to the usable space (the logical blocks) in a volume. Logical space refers to how theoretical space can be used, without accounting for results of deduplication or compression. The value for logical space used is derived from the amount of physical space used plus the savings from storage efficiency features (such as deduplication and compression) that have been configured. This measurement often appears larger than the physical used capacity because it includes Snapshot copies, clones, and other components, and it does not reflect the data compression and other reductions in the physical space. Thus, the total logical capacity could be higher than the provisioned space.

In System Manager, capacity representations do not account for root storage tier (aggregate) capacities.

### Measurements of used capacity

Measurements of used capacity are displayed differently depending on the version of System Manager you are using, as explained in the following table:

| Version of System Manager | Term used for capacity | Type of capacity referred to |
|---|---|---|
| 9.5 and 9.6<br>(Classic view) | Used | Physical space used |
| 9.7 and 9.8 | Used | Logical space used<br>(if storage efficiency settings have been enabled) |
| 9.9.1 and later | Logical Used | Logical space used<br>(if storage efficiency settings have been enabled) |

### Measurement terms

The following terms are used when describing capacity:

- **Physical used**: Displays the amount of capacity used in the physical blocks of a volume.
- **Physical used %**: Displays the percentage of capacity used in the physical blocks of a volume compared to the provisioned size.
- **Logical used**: Displays the amount of used space without considering the space saved by storage efficiency features.
- **Logical used %**: Displays the percentage of the current logical used capacity compared to the provisioned size, excluding the Snapshot reserve of the volume. This value can be greater than 100%, because it includes efficiency savings in the volume.

### Capacity measurement units

System Manager calculates storage capacity based on binary units of 1024 ($2^{10}$) bytes. In ONTAP 9.10.0 and earlier, these units were displayed in System Manager as KB, MB, GB, TB, and PB. Beginning with ONTAP

9.10.1, they are displayed in System Manager as KiB, MiB, GiB, TiB, and PiB.

The units used in System Manager for throughput continue to be KB/s, MB/s, GB/s, TB/s, and PB/s for all releases of ONTAP.

| Capacity unit displayed in System Manager for ONTAP 9.10.0 and earlier | Capacity unit displayed in System Manager for ONTAP 9.10.1 | Calculation | Value in bytes |
|---|---|---|---|
| KB | KiB | 1024 | 1024 bytes |
| MB | MiB | 1024 * 1024 | 1,048,576 bytes |
| GB | GiB | 1024 * 1024 * 1024 | 1,073,741,824 bytes |
| TB | TiB | 1024 * 1024 * 1024 * 1024 | 1,099,511,627,776 bytes |
| PB | PiB | 1024 * 1024 * 1024 * 1024 * 1024 | 1,125,898,010,834,824 bytes |

**Additional information:**

Logical space reporting and enforcement for volumes

### View capacity measurements for the cluster

You can view capacity measurements for the cluster on the Dashboard in System Manager.

**Before you begin**

To view data related to the capacity in the cloud, you must have an account with Active IQ Digital Advisor and be connected.

**Steps**

1. In System Manager, click **Dashboard**.
2. In the **Capacity** section, you can view the following:
   - Total used capacity of the cluster
   - Total available capacity of the cluster
   - Percentages of used and available capacity.
   - Ratio of data reduction.
   - Amount of capacity used in the cloud.
   - History of capacity usage.
   - Projection of capacity usage
3. Click → to view more details about the capacity of the cluster.

# Logical storage management with the CLI

## Logical storage management overview with the CLI

Using the ONTAP CLI, you can create and manage FlexVol volumes, use FlexClone technology to create efficient copies of volumes, files, and LUNs, create qtrees and quotas, and manage efficiency features like deduplication and compression.

You should use these procedures under the following circumstances:

- You want to understand the range of ONTAP FlexVol volume capabilities and storage efficiency features.
- You want to use the command-line interface (CLI), not System Manager or an automated scripting tool.

## Create and manage volumes

### Create a volume

You can create a volume and specify its junction point and other properties by using the `volume create` command.

#### What you'll need

The SVM for the new volume and the aggregate that will supply the storage to the volume must already exist.

If the SVM has a list of associated aggregates, the aggregate must be included in the list.

#### About this task

A volume must include a *junction path* for its data to be made available to clients. You can specify the junction path when you create a new volume. If you create a volume without specifying a junction path, you must *mount* the volume in the SVM namespace using the `volume mount` command.

#### Steps

1. Create a volume:

   ```
   volume create -vserver vserver_name -volume volume_name -aggregate
   aggregate_name -size {integer[KB|MB|GB|TB|PB]} -security-style
   {ntfs|unix|mixed} -user user_name_or_number -group group_name_or_number
   -junction-path junction_path [-policy export_policy_name]
   ```

   The `-security style`, `-user`, `-group`, `-junction-path`, and `-policy` options are for NAS namespaces only.

   The choices for `-junction-path` are the following:

   - Directly under root, for example, `/new_vol`

     You can create a new volume and specify that it be mounted directly to the SVM root volume.

   - Under an existing directory, for example, `/existing_dir/new_vol`

     You can create a new volume and specify that it be mounted to an existing volume (in an existing hierarchy), expressed as a directory.

If you want to create a volume in a new directory (in a new hierarchy under a new volume), for example, `/new_dir/new_vol`, then you must first create a new parent volume that is junctioned to the SVM root volume. You would then create the new child volume in the junction path of the new parent volume (new directory).

2. Verify that the volume was created with the desired junction point:

   ```
   volume show -vserver vserver_name -volume volume_name -junction
   ```

**Examples**

The following command creates a new volume named users1 on the SVM vs1.example.com and the aggregate aggr1. The new volume is made available at `/users`. The volume is 750 GB in size, and its volume guarantee is of type volume (by default).

```
cluster1::> volume create -vserver vs1.example.com -volume users1
-aggregate aggr1 -size 750g -junction-path /users
[Job 1642] Job succeeded: Successful

cluster1::> volume show -vserver vs1.example.com -volume users1 -junction
                           Junction                 Junction
Vserver           Volume   Active   Junction Path   Path Source
----------------- -------  -------- --------------- -----------
vs1.example.com   users1   true     /users          RW_volume
```

The following command creates a new volume named “home4” on the SVM"`vs1.example.com`" and the aggregate “aggr1”. The directory `/eng/` already exists in the namespace for the vs1 SVM, and the new volume is made available at `/eng/home`, which becomes the home directory for the `/eng/` namespace. The volume is 750 GB in size, and its volume guarantee is of type `volume` (by default).

```
cluster1::> volume create -vserver vs1.example.com -volume home4
-aggregate aggr1 -size 750g -junction-path /eng/home
[Job 1642] Job succeeded: Successful

cluster1::> volume show -vserver vs1.example.com -volume home4 -junction
                          Junction                 Junction
Vserver          Volume   Active   Junction Path   Path Source
---------------- -------  -------- --------------- -----------
vs1.example.com  home4    true     /eng/home       RW_volume
```

## SAN volumes

### 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<br>• Reducing user data | No risk to write operations or data availability yet. |
| 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<br>• 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<br>• Deleting Snapshot copies<br>• Reducing user data<br>• Disabling space reservation for files or LUNs | Write operations to unreserved files could fail. |

| Alert type | EMS level | Configurable? | Definition | Ways to address | Risk if no action taken |
|---|---|---|---|---|---|
| Physically overallocated | Node Error | N | The volume is running out of physical blocks it can write to. | • Increasing volume size<br>• Deleting Snapshot copies<br>• 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<br>• Shrinking or deleting volumes<br>• Moving volumes to another aggregate with more space<br>• Removing volume guarantees (setting them to `none`) | 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 | 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<br>• Shrinking or deleting volumes<br>• Moving volumes to another aggregate with more space<br>• 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<br>• Shrinking or deleting volumes<br>• Moving volumes to another aggregate with more space<br>• 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. |
| Physically overallocated | Node Error | N | The aggregate is running out of physical blocks it can write to. | • Adding storage to the aggregate<br>• Shrinking or deleting volumes<br>• 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 |

### Display file or inode usage

FlexVol volumes have a maximum number of files that they can contain. Knowing how many files are contained by your volumes helps you determine whether you need to increase the number of (public) inodes for your volumes to prevent them from hitting their maximum file limit.

#### About this task

Public inodes can be either free (they are not associated with a file) or used (they point to a file). The number of free inodes for a volume is the total number of inodes for the volume minus the number of used inodes (the number of files).

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.

#### Step

1. To display inode usage for a volume, enter the following command:

   ```
   df -i volume_name
   ```

   You can omit the volume name; in this case, ONTAP displays the inode usage for all volumes in the cluster. You can also specify a storage virtual machine (SVM) to see only volumes on that SVM.

#### Example

```
cm320c-rst::> df -i -vserver vs1
Filesystem               iused      ifree  %iused  Mounted on
/vol/cifs_test/            105       2928      3%  /home
/vol/root/                  98        468     17%  ---
/vol/vola/                 103      12047      0%  /nfsv4
3 entries were displayed.
```

### Control and monitor I/O performance to FlexVol volumes by using Storage QoS

You can control input/output (I/O) performance to FlexVol volumes by assigning volumes 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 SVMs, LUNs, and files to policy groups.

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

- The volume 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 volume to a policy group, then you cannot assign the volume's containing SVM or any child LUNs or files 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 `volume create` command or the `volume modify` command with the `-qos-policy-group` parameter to assign a volume 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.

### Delete a FlexVol volume

You can delete a FlexVol volume that is no longer required or if it contains corrupted data.

**What you'll need**

No applications must be accessing the data in the volume you want to delete.

If you accidentally delete a volume, contact technical support for assistance.

**Steps**

1. If the volume has been mounted, unmount it:

   ```
   volume unmount -vserver vserver_name -volume volume_name
   ```

2. If the volume is part of a SnapMirror relationship, delete the relationship by using the `snapmirror delete` command.
3. If the volume is online, take the volume offline:

   ```
   volume offline -vserver vserver_name volume_name
   ```

4. Delete the volume:

   ```
   volume delete -vserver vserver_name volume_name
   ```

**Result**

The volume is deleted, along with any associated quota policies and qtrees.

### Protection against accidental volume deletion

Default volume delete behavior aids the recovery of accidentally deleted FlexVol volumes.

A `volume delete` request against a volume that has type `RW` or `DP` (as seen in `volume show` command output) causes that volume to be moved to a partially deleted state. By default, it is retained in a recovery

queue for at least 12 hours before being fully deleted.

## Delete directories

### Delete directories overview

Beginning with ONTAP 9.8, you can delete large directories with lower latencies. This improved method of directory delete can be implemented through a new REST API or using the ONTAP command line interface (CLI).

Beginning with ONTAP 9.9.1, you can also use System Manager to perform a fast directory delete. For more information, see Take corrective action based on analytics.

### Perform a fast directory delete using the CLI

It is recommended that you use the REST API to delete your directory. You can also use ONTAP command line interface (CLI) to delete your directory.

**Steps**

1. Enter advanced privilege mode:

   ```
   -privilege advance
   ```

2. Delete the directory:

   ```
   volume file async-delete start volume volume_name vserver vserver_name path
   directory_path -throttle throttle
   ```

   The minimum throttle value is 10, the maximum is 100,000, and the default is 5000.

   The following example creates a new directory async delete job with the default throttle.

   ```
   cluster-cli::*> volume file async-delete start -vserver vs1 -volume vol1
   -path d1

   [Job 32] Job is queued: Asynchronous directory delete job.
   ```

3. Verify that the directory was deleted:

   ```
   event log show
   ```

   The following example shows output for the event log when the directory is successfully deleted.

```
cluster-cli::*> event log show
Time              Node             Severity      Event
------------------- ---------------- ------------ --------------------
MM/DD/YYYY 00:11:11  cluster-vsim     INFORMATIONAL
asyncDelete.message.success: Async delete job on path d1 of volume
(MSID: 2162149232) was completed.
```

#### Cancel a directory delete job

If you need to cancel the deletion of a directory, you can do so while the job is still in progress.

**Steps**

1. Enter advanced privilege mode:

   ```
   -privilege advanced
   ```

2. Verify that the directory delete is in progress:

   ```
   volume file async-delete show
   ```

   If the SVM, volume, JobID and path of your directory is displayed, you can cancel the job.

3. Cancel the directory delete:

   ```
   volume file async-delete cancel -vserver SVM_name -volume volume_name -jobid
   job_id
   ```

#### Commands for managing FlexVol volumes

There are specific commands for managing FlexVol volumes using the ONTAP CLI.

| If you want to… | Use this command… |
|---|---|
| Bring a volume online | `volume online` |
| Change the size of a volume | `volume size` |
| Determine the associated aggregate of a volume | `volume show` |
| Determine the associated aggregate for all volumes on a storage virtual machine (SVM) | `volume show -vserver -fields aggregate` |
| Determine the format of a volume | `volume show -fields block-type` |
| Mount a volume onto another volume using a junction | `volume mount` |

| If you want to… | Use this command… |
| --- | --- |
| Put a volume into the restricted state | `volume restrict` |
| Rename a volume | `volume rename` |
| Take a volume offline | `volume offline` |

See the man page for each command for more information.

#### Commands for displaying space usage information

You use the `storage aggregate` and `volume` commands to see how space is being used in your aggregates and volumes and their Snapshot copies.

| To display information about… | Use this command… |
| --- | --- |
| Aggregates, including details about used and available space percentages, Snapshot reserve size, and other space usage information | `storage aggregate show` `storage aggregate show-space -fields snap-size-total,used-including-snapshot-reserve` |
| How disks and RAID groups are used in an aggregate, and RAID status | `storage aggregate show-status` |
| The amount of disk space that would be reclaimed if you deleted a specific Snapshot copy | `volume snapshot compute-reclaimable` (advanced) |
| The amount of space used by a volume | `volume show -fields size,used,available,percent-used` `volume show-space` |
| The amount of space used by a volume in the containing aggregate | `volume show-footprint` |

## Move and copy volumes

#### Move a FlexVol volume overview

You can move or copy volumes for capacity utilization, improved performance, and to satisfy service-level agreements.

Knowing how moving a FlexVol volume works helps you to determine whether the volume move satisfies service-level agreements and to understand where a volume move is in the volume move process.

FlexVol volumes are moved from one aggregate or node to another within the same storage virtual machine (SVM). A volume move does not disrupt client access during the move.

Moving a volume occurs in multiple phases:

- A new volume is made on the destination aggregate.
- The data from the original volume is copied to the new volume.

  During this time, the original volume is intact and available for clients to access.

- At the end of the move process, client access is temporarily blocked.

  During this time the system performs a final replication from the source volume to the destination volume, swaps the identities of the source and destination volumes, and changes the destination volume to the source volume.

- After completing the move, the system routes client traffic to the new source volume and resumes client access.

The move is not disruptive to client access because the time in which client access is blocked ends before clients notice a disruption and time out. Client access is blocked for 35 seconds by default. If the volume move operation cannot finish in the time that access is denied, the system aborts this final phase of the volume move operation and allows client access. The system attempts the final phase three times by default. After the third attempt, the system waits an hour before attempting the final phase sequence again. The system runs the final phase of the volume move operation until the volume move is complete.

#### Considerations and recommendations when moving volumes

Moving a volume has many considerations and recommendations that are influenced by the volume you are moving or by the system configuration, such as a MetroCluster configuration. You should understand the considerations and recommendations associated with moving volumes.

##### General considerations and recommendations

- If you are upgrading the release family for a cluster, do not move a volume until after you upgrade all of the nodes in the cluster.

  This recommendation prevents you from inadvertently attempting to move a volume from a newer release family to an older release family.

- The source volume must be consistent.
- If you have assigned one or more aggregates to the associated storage virtual machine (SVM), the destination aggregate must be one of the assigned aggregates.
- You cannot move a volume to or from a taken-over CFO aggregate.
- If a volume that contains LUNs is not NVFAIL enabled before you move it, the volume will be NVFAIL enabled after you move it.
- You can move a volume from a Flash Pool aggregate to another Flash Pool aggregate.
  - The caching policies of that volume are also moved.
  - The move might affect volume performance.
- You can move volumes between a Flash Pool aggregate and a non-Flash Pool aggregate.
  - If you move a volume from a Flash Pool aggregate to a non-Flash Pool aggregate, ONTAP displays a message warning you that the move might affect volume performance and asks whether you want to continue.

    - If you move a volume from a non-Flash Pool aggregate to a Flash Pool aggregate, ONTAP assigns the `auto` caching policy.
- Volumes have the data-at-rest protections of the aggregate they reside on. If you move a volume from an aggregate that consists of NSE drives to one that does not, the volume no longer has NSE data-at-rest protection.

#### FlexClone volume considerations and recommendations

- FlexClone volumes cannot be offline when they are being moved.
- You can move FlexClone volumes from one aggregate to another aggregate on the same node or another node in the same SVM without splitting.
- FlexClone volume Snapshot copies are not lost after moving a clone.
- You can move FlexClone parent volumes from one aggregate to another aggregate.

  When you move a FlexClone parent volume, a temporary volume is left behind that acts as a parent volume for all FlexClone volumes. No operations are allowed on the temporary volume except to take it offline or to delete it. After all FlexClone volumes are either split or destroyed, the temporary volume is cleaned up automatically.

- After you move a FlexClone child volume, the volume is no longer a FlexClone volume.
- FlexClone move operations are mutually exclusive from FlexClone copy or split operations.
- If a clone-splitting operation is in progress, moving a volume might fail.

  You should not move a volume until clone-splitting operations are completed.

#### MetroCluster configuration considerations

- During a volume move in a MetroCluster configuration, when a temporary volume is created on the destination aggregate on the source cluster a record of the temporary volume corresponding to the volume in the mirrored, but unassimilated, aggregate is also created on the surviving cluster.
- If a MetroCluster switchover occurs before the cutover, the destination volume has a record and is a temporary volume (a volume of type TMP).

  Move job restarts on the surviving (disaster recovery) cluster, reports a failure, and cleans up all move-related items including the temporary volume. In any event where cleanup cannot be done correctly, an EMS is generated alerting the system administrator to do the necessary cleanup.

- If a MetroCluster switchover occurs after the cutover phase has started but before the move job has completed (that is, the move reached a stage where it can update the cluster to point to the destination aggregate), the move job restarts on the surviving (disaster recovery) cluster and runs to completion.

  All move-related items are cleaned up including the temporary volume (original source). In any event where cleanup cannot be done correctly, an EMS is generated alerting the system administrator to do the necessary cleanup.

- Neither forced nor unforced MetroCluster switchbacks are allowed if there are any volume move operations in progress for volumes belonging to the switched over site.

  Switchbacks are not blocked when volume move operations are in progress for volumes local to the surviving site.

- Unforced MetroCluster switchovers are blocked, but forced MetroCluster switchovers are not blocked if there are any volume move operations in progress.

#### 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.

#### Move a volume

You can move a FlexVol volume to a different aggregate, node, or both within the same storage virtual machine (SVM) to balance storage capacity after determining that there is a storage capacity imbalance.

##### About this task

By default, if the cutover operation fails to complete within 30 seconds, it will retry. You can adjust the default behavior by using the `-cutover-window` and `-cutover-action` parameters, both of which require advanced privilege level access. For details, see the `volume move start` man page.

##### Steps

1. If you are moving a data protection mirror and you have not initialized the mirror relationship, initialize the mirror relationship by using the `snapmirror initialize` command.

   Data protection mirror relationships must be initialized before you can move one of the volumes.

2. Determine an aggregate to which you can move the volume by using the `volume move target-aggr show` command.

   The aggregate that you select must have enough space for the volume; that is, the available size is bigger than the volume that you are moving.

   The following example shows that the vs2 volume can be moved to any of the listed aggregates:

```
cluster1::> volume move target-aggr show -vserver vs2 -volume user_max
Aggregate Name   Available Size   Storage Type
--------------   --------------   ------------
aggr2            467.9GB          hdd
node12a_aggr3    10.34GB          hdd
node12a_aggr2    10.36GB          hdd
node12a_aggr1    10.36GB          hdd
node12a_aggr4    10.36GB          hdd
5 entries were displayed.
```

3. Verify that the volume can be moved to the intended aggregate by using the `volume move start -perform-validation-only` command to run a validation check.
4. Move the volume by using the `volume move start` command.

   The following command moves the user_max volume on the vs2 SVM to the node12a_aggr3 aggregate. The move runs as a background process.

```
cluster1::> volume move start -vserver vs2 -volume user_max
-destination-aggregate node12a_aggr3
```

5. Determine the status of the volume move operation by using the `volume move show` command.

   The following example shows the state of a volume move that completed the replication phase and is in the cutover phase:

```
cluster1::> volume move show
Vserver   Volume     State    Move Phase  Percent-Complete Time-To-
Complete
--------- ---------- -------- ----------  ----------------
----------------
vs2       user_max   healthy  cutover     -                -
```

   The volume move is complete when it no longer appears in the `volume move show` command output.

#### Commands for moving volumes

There are specific ONTAP commands for managing volume movement.

| If you want to… | Use this command… |
| --- | --- |
| Abort an active volume move operation. | `volume move abort` |

| If you want to… | Use this command… |
| --- | --- |
| Show status of a volume moving from one aggregate to another aggregate. | `volume move show` |
| Start moving a volume from one aggregate to another aggregate. | `volume move start` |
| Manage target aggregates for volume move. | `volume move target-aggr` |
| Trigger cutover of a move job. | `volume move trigger-cutover` |
| Change the amount of time client access is blocked if the default is not adequate. | `volume move start` or `volume move modify` with the `-cutover-window` parameter. The `volume move modify` command is an advanced command and the `-cutover-window` is an advanced parameter. |
| Determine what the system does if the volume move operation cannot be completed during the time client access is blocked. | `volume move start` or `volume move modify` with the `-cutover-action` parameter. The `volume move modify` command is an advanced command and the `-cutover-action` is an advanced parameter. |

See the man page for each command for more information.

#### Methods for copying a volume

Copying a volume creates a stand-alone copy of a volume that you can use for testing and other purposes. The method you use to copy a volume depends on the use case.

The method you use for copying a volume depends on whether you are copying it to the same aggregate or a different aggregate, and whether you want to retain Snapshot copies from the original volume. The following table lists characteristics of the copy and the methods used to create that copy.

| If you want to copy a volume… | Then the method you use is… |
| --- | --- |
| Within the same aggregate and you do not want to copy Snapshot copies from the original volume. | Creating a FlexClone volume of the original volume. |
| To another aggregate and you do not want to copy Snapshot copies from the original volume. | Creating a FlexClone volume of the original volume, and then moving the volume to another aggregate by using the `volume move` command. |
| To another aggregate and preserve all of the Snapshot copies from the original volume. | Replicating the original volume using SnapMirror, and then breaking the SnapMirror relationship to make a read-write volume copy. |

# Use FlexClone volumes to create efficient copies of your FlexVol volumes

## Use FlexClone volumes to create efficient copies of your FlexVol volumes overview

FlexClone volumes are writable, point-in-time copies of a parent FlexVol volume. FlexClone volumes are space-efficient because they share the same data blocks with their parent FlexVol volumes for common data. The Snapshot copy used to create a FlexClone volume is also shared with the parent volume.

You can clone an existing FlexClone volume to create another FlexClone volume. You can also create a clone of a FlexVol volume containing LUNs and LUN clones.

You can also split a FlexClone volume from its parent volume. As a result, the FlexClone volume becomes an independent FlexVol volume with its own disk space, instead of sharing disk space with its parent.

You can create two types of FlexClone volumes: read-write FlexClone volumes and data protection FlexClone volumes. While you can create a read-write FlexClone volume of a regular FlexVol volume, you must use only a SnapVault secondary volume to create a data protection FlexClone volume.

## Create a FlexClone volume

You can create a data protection FlexClone volume from a SnapMirror destination volume or from a parent FlexVol volume that is a SnapVault secondary volume. After you create a FlexClone volume, you cannot delete the parent volume while the FlexClone volume exists.

### What you'll need

- The FlexClone license must be installed on the cluster.
- The volume that you want to clone must be online.

### Step

1. Create a FlexClone volume:

   ```
   volume clone create
   ```

   > While creating a read-write FlexClone volume from the read-write parent volume, you do not need to specify the base Snapshot copy. ONTAP creates a Snapshot copy if you do not name any specific Snapshot copy that is to be used as the base Snapshot copy for the clone. You must specify the base Snapshot copy for creating a FlexClone volume when the parent volume is a data protection volume.

### Example

- The following command creates a read-write FlexClone volume vol1_clone from the parent volume vol1:

  ```
  volume clone create -vserver vs0 -flexclone vol1_clone -type RW -parent-volume
  vol1
  ```

- The following command creates a data protection FlexClone volume vol_dp_clone from the parent volume dp_vol by using the base Snapshot copy snap1:

```
volume clone create -vserver vs1 -flexclone vol_dp_clone -type DP -parent
-volume dp_vol -parent-snapshot snap1
```

### Split a FlexClone volume from its parent volume

If you want a read-write FlexClone volume to have its own disk space rather than using that of its parent volume, you can split the FlexClone volume from its parent volume. Because this operation creates a copy of the data that is currently shared between the parent volume and the FlexClone volume, the operation can take some time to complete.

#### About this task

Splitting a FlexClone volume from its parent volume consumes free space from the containing aggregate. If you do not have sufficient privileges to view the space available in your aggregate, you must contact your storage administrator to verify that there is sufficient space in the aggregate for the split operation to finish.

Beginning with ONTAP 9.4, for non-guaranteed volumes on AFF systems, the split operation for FlexClone volumes shares the physical blocks and does not copy the data. Therefore, splitting of FlexClone volumes on AFF systems is faster than the FlexClone splitting operation in other FAS systems in ONTAP 9.4. The improved FlexClone splitting operation on AFF systems has the following benefits:

- Storage efficiency is preserved after splitting the clone from the parent.
- Existing Snapshot copies are not deleted.
- The operation is faster.
- The FlexClone volume can be split from any point in the clone hierarchy.

#### Steps

1. Determine the amount of free space required to complete the split operation:

   ```
   volume clone show -estimate -vserver vserver_name -flexclone clone_volume_name
   -parent-volume parent_vol_name
   ```

   The following example provides information about the free space required to split a FlexClone volume clone1 from its parent volume vol1:

   ```
   cluster1::> volume clone show -estimate -vserver vs1 -flexclone clone1
   -parent-volume volume1
                               Split
   Vserver   FlexClone       Estimate
   --------- ------------- ----------
   vs1       clone1           40.73MB
   ```

2. Verify that the aggregate containing the FlexClone volume and its parent has sufficient space:
   a. Determine the amount of free space in the aggregate that contains the FlexClone volume and its parent:

      ```
      storage aggregate show
      ```

   b. If the containing aggregate does not have enough free space available, add storage to the aggregate:

```
storage aggregate add-disks
```

3. Start the split operation:

   ```
   volume clone split start -vserver vserver_name -flexclone clone_volume_name
   ```

   The following example shows how you can initiate the process to split the FlexClone volume clone1 from its parent volume vol1:

   ```
   cluster1::> volume clone split start -vserver vs1 -flexclone clone1

   Warning: Are you sure you want to split clone volume clone1 in Vserver
   vs1 ?
   {y|n}: y
   [Job 1617] Job is queued: Split clone1.
   ```

4. Monitor the status of the FlexClone split operation:

   ```
   volume clone split show -vserver vserver_name -flexclone clone_volume_name
   ```

   The following example shows the status of the FlexClone split operation on an AFF system:

   ```
   cluster1::> volume clone split show -vserver vs1 -flexclone clone1
                                                 Inodes
   Blocks
                                        ---------------------
   ----------------------
   Vserver   FlexClone    Processed Total    Scanned  Updated      % Inode
   % Block

   Complete  Complete
   vs1       clone1        0         0       411247   153600         0
   37
   ```

5. Verify that the split volume is no longer a FlexClone volume:

   ```
   volume show -volume volume_name -fields clone-volume
   ```

   The value of the `clone-volume` option is `false` for a volume that is not a FlexClone volume.

   The following example shows how you can verify whether the volume clone1 that is split from its parent is not a FlexClone volume.

```
cluster1::> volume show -volume clone1 -fields clone-volume
vserver volume **clone-volume**
------- ------ **------------**
vs1     clone1 **false**
```

#### Determine the space used by a FlexClone volume

You can determine the space used by a FlexClone volume based on its nominal size and the amount of space it shares with the parent FlexVol volume. When a FlexClone volume is created, it shares all of its data with its parent volume. Therefore, although the nominal size of the FlexVol volume is the same as its parent's size, it uses very little free space from the aggregate.

##### About this task

The free space used by a newly-created FlexClone volume is approximately 0.5 percent of its nominal size. This space is used to store the FlexClone volume's metadata.

New data written to either the parent or the FlexClone volume is not shared between the volumes. The increase in the amount of new data that gets written to the FlexClone volume leads to an increase in the space the FlexClone volume requires from its containing aggregate.

##### Step

1. Determine the actual physical space used by the FlexClone volume using the `volume show` command.

   The following example shows the total physical space used by the FlexClone volume:

```
cluster1::> volume show -vserver vs01 -volume clone_vol1 -fields
size,used,available,
percent-used,physical-used,physical-used-percent
vserver    volume     size  available  used   percent-used   physical-
used     physical-used-percent
-------   ----------  ----  ---------  -----  ------------
-------------   ---------------------
vs01     clone_vol1   20MB   18.45MB   564KB       7%             196KB
1%
```

#### Considerations for creating a FlexClone volume from a SnapMirror source or destination volume

You can create a FlexClone volume from the source or destination volume in an existing volume SnapMirror relationship. However, doing so could prevent future SnapMirror replication operations from completing successfully.

Replication might not work because when you create the FlexClone volume, you might lock a Snapshot copy that is used by SnapMirror. If this happens, SnapMirror stops replicating to the destination volume until the FlexClone volume is destroyed or is split from its parent. You have two options for addressing this issue:

- If you require the FlexClone volume on a temporary basis and can accommodate a temporary stoppage of the SnapMirror replication, you can create the FlexClone volume and either delete it or split it from its parent when possible.

  The SnapMirror replication continues normally when the FlexClone volume is deleted or is split from its parent.

- If a temporary stoppage of the SnapMirror replication is not acceptable, you can create a Snapshot copy in the SnapMirror source volume, and then use that Snapshot copy to create the FlexClone volume. (If you are creating the FlexClone volume from the destination volume, you must wait until that Snapshot copy replicates to the SnapMirror destination volume.)

  This method of creating a Snapshot copy in the SnapMirror source volume allows you to create the clone without locking a Snapshot copy that is in use by SnapMirror.

## Use FlexClone files and FlexClone LUNs to create efficient copies of files and LUNs

### Use FlexClone files and FlexClone LUNs to create efficient copies of files and LUNs overview

FlexClone files and FlexClone LUNs are writable, space-efficient clones of parent files and parent LUNs, and help in efficient utilization of the physical aggregate space. FlexClone files and FlexClone LUNs are supported only for FlexVol volumes.

FlexClone files and FlexClone LUNs utilize 0.4 percent of their size to store the metadata. Clones share the data blocks of their parent files and parent LUNs and occupy negligible storage space until clients write new data either to the parent file or LUN, or to the clone.

Clients can perform all file and LUN operations on both the parent and the clone entities.

You can use multiple methods to delete FlexClone files and FlexClone LUNs.

### Create a FlexClone file or FlexClone LUN

You can create space-efficient and time-efficient clones of files and LUNs present in FlexVol volumes or FlexClone volumes by using the `volume file clone create` command.

#### What you'll need

- The FlexClone license must be installed on the cluster.
- If multiple block ranges are used for sub-LUN cloning or sub-file cloning, the block numbers must not overlap.
- If you are creating a sub-LUN or sub-file on volumes with adaptive compression enabled, the block ranges must not be misaligned.

  This means that the source start block number and destination start block number must either be even aligned or odd aligned.

#### About this task

Depending on the privileges assigned by the cluster administrator, an SVM administrator can create FlexClone files and FlexClone LUNs.

You can specify the autodelete setting for FlexClone files and FlexClone LUNs when you create and modify clones. By default, the autodelete setting is disabled.

You can overwrite an existing FlexClone file or FlexClone LUN when you create a clone by using the `volume file clone create` command with the `-overwrite-destination` parameter.

When the node reaches its maximum split load, the node temporarily stops accepting requests to create FlexClone files and FlexClone LUNs and issues an `EBUSY` error message. When the split load for the node falls below the maximum, the node accepts requests to create FlexClone files and FlexClone LUNs again. You should wait until the node has capacity to create the clones before trying the create request again.

**Steps**

1. Create a FlexClone file or FlexClone LUN by using the `volume file clone create` command.

   The following example shows how you can create a FlexClone file file1_clone of the parent file file1_source in the volume vol1:

   ```
   cluster1::> volume file clone create -vserver vs0 -volume vol1 -source
   -path /file1_source -destination-path /file1_clone
   ```

   For more information about using this command, see the man pages.

**Related information**

ONTAP 9 commands

### View node capacity for creating and deleting FlexClone files and FlexClone LUNs

You can view whether a node has capacity to receive new requests to create and delete FlexClone files and FlexClone LUNs by viewing the split load for the node. If the maximum split load is reached, no new requests are accepted until the split load falls below the maximum.

**About this task**

When the node reaches its maximum split load, an `EBUSY` error message is issued in response to create and delete requests. When the split load for the node falls below the maximum, the node accepts requests to create and delete FlexClone files and FlexClone LUNs again.

A node can accept new requests when the Allowable Split Load field displays capacity, and the create request fits in the available capacity.

**Step**

1. View how much capacity a node has to create and delete FlexClone files and FlexClone LUNs by using the `volume file clone split load show` command.

   In the following example, the split load is displayed for all of the nodes in cluster1. All nodes in the cluster have capacity to create and delete FlexClone files and FlexClone LUNs as indicated by the Allowable Split Load field:

```
cluster1::> volume file clone split load show
Node       Max         Current    Token          Allowable
           Split Load  Split Load Reserved Load  Split Load
---------- ----------  ---------- -------------  ----------
node1         15.97TB          0B          100MB    15.97TB
node2         15.97TB          0B          100MB    15.97TB
2 entries were displayed.
```

#### View the space savings due to FlexClone files and FlexClone LUNs

You can view the percentage of disk space saved by block sharing within a volume containing FlexClone files and LUNs.

**Step**

1. To view the space saving achieved due to FlexClone files and FlexClone LUNs, enter the following command:

   `df -s volname`

   `volname` is the name of the FlexVol volume.

   If you run the `df -s` command on a deduplication-enabled FlexVol volume, you can view the space saved by both deduplication and FlexClone files and LUNs.

**Example**

The following example shows the space saving on a FlexClone volume test1:

```
systemA> df -s test1

Filesystem          used   saved   %saved Vserver
/vol/test1/         4828    5744     54%  vs1
```

#### Methods to delete FlexClone files and FlexClone LUNs

You can use multiple methods to delete FlexClone files and FlexClone LUNs. Understanding what methods are available helps you plan how to manage clones.

You can use the following methods to delete FlexClone files and FlexClone LUNs:

- You can configure a FlexVol volume to automatically delete clones with autodelete enabled when the free space in a FlexVol volume decreases below a particular threshold.
- You can configure clients to delete clones by using the NetApp Manageability SDK.
- You can use clients to delete clones by using the NAS and SAN protocols.

  The slower deletion method is enabled by default because this method does not use the NetApp

Manageability SDK. However, you can configure the system to use the faster deletion method when you delete FlexClone files by using the `volume file clone deletion` commands.

## How a FlexVol volume can reclaim free space with autodelete setting

### How a FlexVol volume can reclaim free space with autodelete setting overview

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.

### Configure 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.

#### What you'll need

- 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.
     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
```

> 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.

   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.

      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.

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.

#### Prevent 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.

**What you'll need**

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.

> 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.

   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.

   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
```

#### Commands for configuring deletion of FlexClone files

When clients delete FlexClone files without using the NetApp Manageability SDK, you can use the `volume file clone deletion` commands to enable faster deletion of FlexClone files from a FlexVol volume. Extensions for and minimum size of FlexClone files are used to enable faster deletion.

You can use the `volume file clone deletion` commands to specify a list of supported extensions and a minimum size requirement for FlexClone files in a volume. The faster deletion method is used only for FlexClone files that meet the requirements. For FlexClone files that do not meet the requirements, the slower deletion method is used.

When clients delete FlexClone files and FlexClone LUNs from a volume by using the NetApp Manageability SDK, the extension and size requirements do not apply because the faster deletion method is always used.

| To… | Use this command… |
|---|---|
| Add an extension to the supported list of extensions for the volume | `volume file clone deletion add-extension` |
| Change the minimum size of FlexClone files that can be deleted from the volume by using the faster deletion method | `volume file clone deletion modify` |
| Remove an extension from the supported list of extensions for the volume | `volume file clone deletion remove-extension` |

| To… | Use this command… |
| --- | --- |
| View the supported list of extensions and the minimum size of FlexClone files that clients can delete from the volume by using the faster deletion method | `volume file clone deletion show` |

For detailed information about these commands, see the appropriate man page.

## Use qtrees to partition your FlexVol volumes

### Use qtrees to partition your FlexVol volumes overview

Qtrees enable you to partition your FlexVol volumes into smaller segments that you can manage individually. You can use qtrees to manage quotas, security style, and CIFS oplocks.

ONTAP creates a default qtree, called *qtree0*, for each volume. If you do not put data into a qtree, it resides in qtree0.

Qtree names must have no more than 64 characters.

Directories cannot be moved between qtrees. Only files can be moved between qtrees.

If you create qtree-level and volume-level shares 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.

### Obtain a qtree junction path

You can mount an individual qtree by obtaining the junction path or namespace path of the qtree. The qtree path displayed by the CLI command `qtree show -instance` is of the format `/vol/<volume_name>/<qtree_name>`. However, this path does not refer to the junction path or namespace path of the qtree.

#### About this task

You need to know the junction path of the volume to obtain the junction path or namespace path of the qtree.

#### Step

1. Use the `vserver volume junction-path` command to obtain the junction path of a volume.

   The following example displays the junction path of the volume named vol1 located on the storage virtual machine (SVM) named vs0:

```
cluster1::> volume show -volume vol1 -vserver vs0 -fields junction-path

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

vs0 vol1 /vol1
```

From the above output, the volume's junction path is `/vol1`. Since qtrees are always rooted at the volume, the junction path or namespace path of the qtree will be `/vol1/qtree1`.

### Qtree name restrictions

Qtree names can be no more than 64 characters in length. In addition, using some special characters in qtree names, such as commas and spaces, can cause problems with other capabilities, and should be avoided.

## Convert a directory to a qtree

### Convert a directory to a qtree overview

If you have a directory at the root of a FlexVol volume that you want to convert to a qtree, you must migrate the data contained in the directory to a new qtree with the same name, using your client application.

#### About this task

The steps you take to convert a directory to a qtree depend on what client you use. The following process outlines the general tasks you need to complete:

#### Steps

1. Rename the directory to be made into a qtree.
2. Create a new qtree with the original directory name.
3. Use the client application to move the contents of the directory into the new qtree.
4. Delete the now-empty directory.

> You cannot delete a directory if it is associated with an existing CIFS share.

### Convert a directory to a qtree using a Windows client

To convert a directory to a qtree using a Windows client, you rename the directory, create a qtree on the storage system, and move the directory's contents to the qtree.

#### About this task

You must use Windows Explorer for this procedure. You cannot use the Windows command-line interface or the DOS prompt environment.

#### Steps

1. Open Windows Explorer.
2. Click the folder representation of the directory you want to change.

> The directory must reside at the root of its containing volume.

3. From the **File** menu, select **Rename** to give this directory a different name.
4. On the storage system, use the `volume qtree create` command to create a new qtree with the original name of the directory.

5. In Windows Explorer, open the renamed directory folder and select the files inside it.
6. Drag these files into the folder representation of the new qtree.

> The more subfolders contained in the folder that you are moving, the longer the move operation takes.

7. From the **File** menu, select **Delete** to delete the renamed, now-empty directory folder.

#### Convert a directory to a qtree using a UNIX client

To convert a directory to a qtree in UNIX, you rename the directory, create a qtree on the storage system, and move the directory's contents to the qtree.

**Steps**

1. Open a UNIX client window.
2. Use the `mv` command to rename the directory.

```
client: mv /n/user1/vol1/dir1 /n/user1/vol1/olddir
```

3. From the storage system, use the `volume qtree create` command to create a qtree with the original name.

```
system1: volume qtree create /n/user1/vol1/dir1
```

4. From the client, use the `mv` command to move the contents of the old directory into the qtree.

> The more subdirectories contained in a directory that you are moving, the longer the move operation will take.

```
client: mv /n/user1/vol1/olddir/* /n/user1/vol1/dir1
```

5. Use the `rmdir` command to delete the old, now-empty directory.

```
client: rmdir /n/user1/vol1/olddir
```

**After you finish**

Depending on how your UNIX client implements the `mv` command, file ownership and permissions might not be preserved. If this occurs, update file owners and permissions to their previous values.

### Commands for managing and configuring qtrees

You can manage and configure qtrees by using specific ONTAP commands.

| If you want to… | Use this command… |
| --- | --- |
| Create a qtree | `volume qtree create` |
| Display a filtered list of qtrees | `volume qtree show` |
| Delete a qtree | `volume qtree delete`<br>The qtree command `volume qtree delete` will fail unless the qtree is empty or the `-force true` flag is added. |
| Modify a qtree's UNIX permissions | `volume qtree modify -unix-permissions` |
| Modify a qtree's CIFS oplocks setting | `volume qtree oplocks` |
| Modify a qtree's security setting | `volume qtree security` |
| Rename a qtree | `volume qtree rename` |
| Display a qtree's statistics | `volume qtree statistics` |
| Reset a qtree's statistics | `volume qtree statistics -reset` |

The `volume rehost` command can cause other concurrent administrative operations targeted at that volume to fail.

## Logical space reporting and enforcement for volumes

### Logical space reporting and enforcement for volumes overview

Beginning with ONTAP 9.4, you can allow the logical space used in a volume and the amount of remaining storage space to be displayed to users. Beginning with 9.5, you can limit the amount of logical space consumed by users.

Logical space reporting and enforcement are disabled by default.

The following volume types support logical space reporting and enforcement.

| Volume type | Is space reporting supported? | Is space enforcement supported? |
| --- | --- | --- |
| FlexVol volumes | Yes, beginning with ONTAP 9.4 | Yes, beginning with ONTAP 9.5 |

| Volume type | Is space reporting supported? | Is space enforcement supported? |
|---|---|---|
| SnapMirror destination volumes | Yes, beginning with ONTAP 9.8 | No |
| FlexGroup volumes | Yes, beginning with ONTAP 9.9.1 | Yes, beginning with ONTAP 9.9.1 |

#### What logical space reporting shows

When you enable logical space reporting on a volume, your system can display the amount of logical used and available space in addition to the total space in a volume. In addition, users on Linux and Windows client systems can see logical used and available space instead of physical used and physical available space.

Definitions:

- Physical space refers to the physical blocks of storage available or used in the volume.
- Logical space refers to the usable space in a volume.
- Logical space used is physical space used plus savings from storage efficiency features (such as deduplication and compression) that have been configured.

Beginning with ONTAP 9.5, you can enable logical space enforcement together with space reporting.

When enabled, logical space reporting displays the following parameters with the `volume show` command:

| Parameter | Meaning |
|---|---|
| `-logical-used` | Displays information only about the volume or volumes that have the specified logical used size. This value includes all the space saved by the storage efficiency features along with the physically used space. This does not include Snapshot reserve but does consider Snapshot spill. |
| `-logical-used-by-afs` | Displays information only about the volume or volumes that have the specified logical size used by the active file system. This value differs from the`-logical-used` value by the amount of Snapshot spill that exceeds the Snapshot reserve. |
| `-logical-available` | When only logical space reporting is enabled, only physical-available space is displayed. When both space reporting and enforcement are enabled, it displays the amount of free space currently available considering space saved by the storage efficiency features as being used. This does not include the Snapshot reserve. |
| `-logical-used-percent` | Displays the percentage of the current `-logical-used` value with the provisioned size excluding Snapshot reserve of the volume.<br><br>This value can be greater than 100%, because the `-logical-used-by-afs` value includes efficiency savings in the volume. The `-logical-used-by-afs` value of a volume does not include Snapshot spill as used space. The `-physical-used` value of a volume includes Snapshot spill as used space. |

| Parameter | Meaning |
| --- | --- |
| `-used` | Displays the amount of used space without considering the space saved by storage efficiency features. |

Enabling logical space reporting in the CLI also allows the Logical Used Space (%) and Logical Space values to display in System Manager

Client systems see logical space displayed as “used” space on the following system displays:

- **df** output on Linux systems
- Space details under Properties using Windows Explorer on Windows systems.

If logical space reporting is enabled without logical space enforcement, the total displayed on client systems can be higher than the provisioned space.

#### What logical space enforcement does

When you enable logical space enforcement in ONTAP 9.5 and later, ONTAP counts the logical-used blocks in a volume to determine the amount of space that is still available in that volume. If there is no space available in a volume, the system returns an ENOSPC (out-of-space) error message.

Logical space enforcement ensures that users are notified when a volume is full or nearly full. Logical space enforcement returns three types of alerts to inform you about the available space in a volume:

- `Monitor.vol.full.inc.sav`: This alert is triggered when 98% of the logical space in the volume has been used.
- `Monitor.vol.nearFull.inc.sav`: This alert is triggered when 95% of the logical space in the volume has been used.
- `Vol.log.overalloc.inc.sav`: This alert is triggered when the logical space used in the volume is greater than the total size of the volume.

  This alert tells you that adding to the size of the volume might not create available space since that space will already be consumed by overallocated logical blocks.

Total (logical space) should be equal to provisioned space excluding Snapshot reserve of the volume with logical space enforcement.

For more information, see Configuring volumes to automatically provide more space when they are full

#### Enable logical space reporting and enforcement

Beginning with ONTAP 9.4, you can enable logical space reporting. Beginning with 9.5, you can enable logical space enforcement, or both reporting and enforcement together.

##### About this task

In addition to enabling logical space reporting and enforcement at the individual volume level, you can enable them at the SVM level for every volume that supports the functionality. If you enable logical space features for

the entire SVM, you can also disable them for individual volumes.

Beginning with 9.8, if you enable logical space reporting on a SnapMirror source volume, it is automatically enabled on the destination volume after the transfer.

> If the enforcement option is enabled on a SnapMirror source volume, the enforcement setting is transferred to the destination volume. However, because the destination volume does not support enforcement, the destination will report logical space consumption but not honor its enforcement.

**Choices**

- Enable logical space reporting for a volume:

```
volume modify -vserver SVM-name -volume volume-name -size volume-size -is
-space-reporting-logical true
```

- Enable logical space enforcement for a volume:

```
volume modify -vserver SVM-name -volume volume-name -size volume-size -is
-space-enforcement-logical true
```

- Enable logical space reporting and enforcement together for a volume:

```
volume modify -vserver SVM-name -volume volume-name -size volume-size -is
-space-reporting-logical true -is-space-enforcement-logical true
```

- Enable logical space reporting or enforcement for a new SVM:

```
vserver create -vserver SVM-name -rootvolume root-volume-name -rootvolume
-security-style unix -data-services {desired-data-services} [-is-space-
reporting-logical true] [-is-space-enforcement-logical true]
```

- Enable logical space reporting or enforcement for an existing SVM:

```
vserver modify -vserver SVM-name {desired-data-services} [-is-space-reporting-
logical true] [-is-space-enforcement-logical true]
```

## Use quotas to restrict or track resource usage

### Overview of the quota process

#### Quota process

Quotas provide a way to restrict or track the disk space and number of files used by a user, group, or qtree. Quotas are applied to a specific FlexVol volume or qtree.

Quotas can be soft or hard. Soft quotas cause ONTAP to send a notification when specified limits are exceeded, and hard quotas prevent a write operation from succeeding when specified limits are exceeded.

When ONTAP receives a request from a user or user group to write to a FlexVol volume, it checks to see whether quotas are activated on that volume for the user or user group and determines the following:

- Whether the hard limit will be reached

  If yes, the write operation fails when the hard limit is reached and the hard quota notification is sent.

- Whether the soft limit will be breached

  If yes, the write operation succeeds when the soft limit is breached and the soft quota notification is sent.

- Whether a write operation will not exceed the soft limit

  If yes, the write operation succeeds and no notification is sent.

#### Differences among hard, soft, and threshold quotas

## Hard quotas prevent operations while soft quotas trigger notifications.

Hard quotas impose a hard limit on system resources; any operation that would result in exceeding the limit fails. The following settings create hard quotas:

- Disk Limit parameter
- Files Limit parameter

Soft quotas send a warning message when resource usage reaches a certain level, but do not affect data access operations, so you can take appropriate action before the quota is exceeded. The following settings create soft quotas:

- Threshold for Disk Limit parameter
- Soft Disk Limit parameter
- Soft Files Limit parameter

Threshold and Soft Disk quotas enable administrators to receive more than one notification about a quota. Typically, administrators set the Threshold for Disk Limit to a value that is only slightly smaller than the Disk Limit, so that the threshold provides a "final warning" before writes start to fail.

#### About quota notifications

## Quota notifications are messages that are sent to the event management system (EMS) and also configured as SNMP traps.

Notifications are sent in response to the following events:

- A hard quota is reached; in other words, an attempt is made to exceed it
- A soft quota is exceeded
- A soft quota is no longer exceeded

Thresholds are slightly different from other soft quotas. Thresholds trigger notifications only when they are exceeded, not when they are no longer exceeded.

Hard-quota notifications are configurable byusing the volume quota modify command. You can turn them off completely, and you can change their frequency, for example, to prevent sending of redundant messages.

Soft-quota notifications are not configurable because they are unlikely to generate redundant messages and

their sole purpose is notification.

The following table lists the events that quotas send to the EMS system:

| When this occurs… | This event is sent to the EMS… |
|---|---|
| A hard limit is reached in a tree quota | `wafl.quota.qtree.exceeded` |
| A hard limit is reached in a user quota on the volume | `wafl.quota.user.exceeded` (for a UNIX user)<br>`wafl.quota.user.exceeded.win` (for a Windows user) |
| A hard limit is reached in a user quota on a qtree | `wafl.quota.userQtree.exceeded` (for a UNIX user)<br>`wafl.quota.userQtree.exceeded.win` (for a Windows user) |
| A hard limit is reached in a group quota on the volume | `wafl.quota.group.exceeded` |
| A hard limit is reached in a group quota on a qtree | `wafl.quota.groupQtree.exceeded` |
| A soft limit, including a threshold, is exceeded | `quota.softlimit.exceeded` |
| A soft limit is no longer exceeded | `quota.softlimit.normal` |

The following table lists the SNMP traps that quotas generate:

| When this occurs… | This SNMP trap is sent… |
|---|---|
| A hard limit is reached | quotaExceeded |
| A soft limit, including a threshold, is exceeded | quotaExceeded and softQuotaExceeded |
| A soft limit is no longer exceeded | quotaNormal and softQuotaNormal |

Notifications contain qtree ID numbers rather than qtree names. You can correlate qtree names to ID numbers by using the `volume qtree show -id` command.

#### Why you use quotas

## You can use quotas to limit resource usage in FlexVol volumes, to provide notification when resource usage reaches specific levels, or to track resource usage.

You specify a quota for the following reasons:

- To limit the amount of disk space or the number of files that can be used by a user or group, or that can be contained by a qtree

- To track the amount of disk space or the number of files used by a user, group, or qtree, without imposing a limit
- To warn users when their disk usage or file usage is high

Use default, explicit, derived and tracking quotas to manage disk usage in the most efficient manner.

#### What quota rules, quota policies, and quotas are

Quotas are defined in quota rules specific to FlexVol volumes. These quota rules are collected together in a quota policy of a storage virtual machine (SVM), and then activated on each volume on the SVM.

A quota rule is always specific to a volume. Quota rules have no effect until quotas are activated on the volume defined in the quota rule.

A quota policy is a collection of quota rules for all the volumes of an SVM. Quota policies are not shared among SVMs. An SVM can have up to five quota policies, which enable you to have backup copies of quota policies. One quota policy is assigned to an SVM at any given time.

A quota is the actual restriction that ONTAP enforces or the actual tracking that ONTAP performs. A quota rule always results in at least one quota, and might result in many additional derived quotas. The complete list of enforced quotas is visible only in quota reports.

Activation is the process of triggering ONTAP to create enforced quotas from the current set of quota rules in the assigned quota policy. Activation occurs on a volume-by-volume basis. The first activation of quotas on a volume is called initialization. Subsequent activations are called either reinitialization or resizing, depending on the scope of the changes.

When you initialize or resize quotas on a volume, you are activating the quota rules in the quota policy that is currently assigned to the SVM.

#### Quota targets and types

Quotas have a type: they can be either user, group, or tree. Quota targets specify the user, group, or qtree for which the quota limits are applied.

The following table lists the kinds of quota targets, what types of quotas each quota target is associated with, and how each quota target is represented:

| Quota target | Quota type | How target is represented | Notes |
|---|---|---|---|
| user | user quota | UNIX user name UNIX UID<br><br>A file or directory whose UID matches the user<br><br>Windows user name in pre-Windows 2000 format<br><br>Windows SID<br><br>A file or directory with an ACL owned by the user's SID | User quotas can be applied for a specific volume or qtree. |
| group | group quota | UNIX group name UNIX GID<br><br>A file or directory whose GID matches the group | Group quotas can be applied for a specific volume or qtree.<br><br>ONTAP does not apply group quotas based on Windows IDs. |
| qtree | tree quota | qtree name | Tree quotas are applied to a particular volume and do not affect qtrees in other volumes. |
| "" | user quotagroup quota<br><br>tree quota | Double quotation marks ("") | A quota target of "" denotes a *default quota*. For default quotas, the quota type is determined by the value of the type field. |

#### Special kinds of quotas

### How default quotas work

You can use default quotas to apply a quota to all instances of a given quota type. For example, a default user quota affects all users on the system for the specified FlexVol volume or qtree. In addition, default quotas enable you to modify your quotas easily.

You can use default quotas to automatically apply a limit to a large set of quota targets without having to create separate quotas for each target. For example, if you want to limit most users to 10 GB of disk space, you can specify a default user quota of 10 GB of disk space instead of creating a quota for each user. If you have specific users for whom you want to apply a different limit, you can create explicit quotas for those users. (Explicit quotas—quotas with a specific target or list of targets—override default quotas.)

In addition, default quotas enable you to use resizing rather than reinitialization when you want quota changes to take effect. For example, if you add an explicit user quota to a volume that already has a default user quota, you can activate the new quota by resizing.

Default quotas can be applied to all three types of quota target (users, groups, and qtrees).

Default quotas do not necessarily have specified limits; a default quota can be a tracking quota.

A quota is indicated by a target that is either an empty string ("") or an asterisk (*), depending on the context:

- When you create a quota using the `volume quota policy rule create` command, setting the `-target` parameter to an empty string ("") creates a default quota.
- In the output of the `volume quota policy rule show` command, a default quota appears with an empty string ("") as the Target.
- In the output of the `volume quota report` command, a default quota appears with an asterisk (*) as the ID and Quota Specifier.

#### Default user quota example

The following quotas file uses a default user quota to apply a 50-MB limit on each user for vol1:

```
#Quota target type           disk  files  thold  sdisk  sfile
#------------  ----           ----  -----  -----  -----  -----
*              user@/vol/vol1  50M
```

If any user on the system enters a command that would cause that user's data to take up more than 50 MB in vol1 (for example, writing to a file from an editor), the command fails.

#### How you use explicit quotas

You can use explicit quotas to specify a quota for a specific quota target, or to override a default quota for a specific target.

An explicit quota specifies a limit for a particular user, group, or qtree. An explicit quota replaces any default quota that is in place for the same target.

When you add an explicit user quota for a user that has a derived user quota, you must use the same user mapping setting as the default user quota. Otherwise, when you resize quotas, the explicit user quota is rejected because it is considered a new quota.

Explicit quotas only affect default quotas at the same level (volume or qtree). For example, an explicit user quota for a qtree does not affect the default user quota for the volume that contains that qtree. However, the explicit user quota for the qtree overrides (replaces the limits defined by) the default user quota for that qtree.

##### Examples of explicit quotas

The following quotas file contains a default user quota that limits all users in vol1 to 50 MB of space. However, one user, jsmith, is allowed 80 MB of space, because of the explicit quota (shown in bold):

```
#Quota target type            disk  files  thold  sdisk  sfile
#------------  ----            ----  -----  -----  -----  -----
*              user@/vol/vol1  50M
**jsmith       user@/vol/vol1  80M**
```

The following quotas entry restricts the specified user, represented by four IDs, to 500MB of disk space and

10,240 files in the vol1 volume:

```
jsmith,corp\jsmith,engineering\”john smith”,
S-1-5-32-544   user@/vol/vol1         500M      10K
```

The following quotas entry restricts the eng1 group to 150 MB of disk space and an unlimited number of files in the /vol/vol2/proj1 qtree:

```
eng1        group@/vol/vol2/proj1  150M
```

The following quotas entry restricts the proj1 qtree in the vol2 volume to 750 MB of disk space and 76,800 files:

```
/vol/vol2/proj1   tree                750M      75K
```

#### How derived quotas work

A quota enforced as a result of a default quota, rather than an explicit quota (a quota with a specific target), is referred to as a *derived quota*.

The number and location of the derived quotas depends on the quota type:

- A default tree quota on a volume creates derived tree quotas for every qtree on the volume.
- A default user or group quota creates a derived user or group quota for every user or group that owns a file at the same level (volume or qtree).
- A default user or group quota on a volume creates a default user or group quota on every qtree that also has a tree quota.

The settings—including limits and user mapping—of derived quotas are the same as the settings of the corresponding default quotas. For example, a default tree quota with a 20-GB disk limit on a volume creates derived tree quotas with 20-GB disk limits on the qtrees in the volume. If a default quota is a tracking quota (with no limits), the derived quotas are also tracking quotas.

To see derived quotas, you can generate a quota report. In the report, a derived user or group quota is indicated by a Quota Specifier that is either blank or an asterisk (*). A derived tree quota, however, has a Quota Specifier; to identify a derived tree quota, you must look for a default tree quota on the volume with the same limits.

Explicit quotas interact with derived quotas in the following ways:

- Derived quotas are not created if an explicit quota already exists for the same target.
- If a derived quota exists when you create an explicit quota for a target, you can activate the explicit quota by resizing rather than having to perform a full quota initialization.

#### How you use tracking quotas

Tracking quotas generate reports of disk and file usage and do not limit resource usage. When tracking quotas are used, modifying quota values is less disruptive, because you

can resize quotas rather than turning them off and back on.

To create a tracking quota, you omit the Disk Limit and Files Limit parameters. This tells ONTAP to monitor disk and files usage for that target at that level (volume or qtree), without imposing any limits. Tracking quotas are indicated in the output of `show` commands and the quota report with a dash ("-") for all limits.

You can also specify a *default tracking quota*, which applies to all instances of the target. Default tracking quotas enable you to track usage for all instances of a quota type (for example, all qtrees or all users). In addition, they enable you use resizing rather than reinitialization when you want quota changes to take effect.

**Examples**

The following quotas file shows tracking quotas in place for a specific user, group, and qtree:

```
#Quota target   type           disk files thold sdisk sfile
#-----------    ----           ---- ----- ----- ----- -----
kjones          user@/vol/vol1    -  -
eng1            group@/vol/vol1   -  -
proj1           tree@/vol/vol1    -  -
```

The following quotas file contains the three possible default tracking quotas (users, groups, and qtrees):

```
#Quota target   type           disk  files thold sdisk sfile
#-----------    ----           ----  ----- ----- ----- -----
*               user@/vol/vol1    -   -
*               group@/vol/vol1   -   -
*               tree@/vol/vol1    -   -
```

#### How quotas are applied

## Understanding how quotas are applied enables you to configure quotas and set the expected limits.

Whenever an attempt is made to create a file or write data to a file in a FlexVol volume that has quotas enabled, the quota limits are checked before the operation proceeds. If the operation exceeds either the disk limit or the files limit, the operation is prevented.

Quota limits are checked in the following order:

1. The tree quota for that qtree (This check is not relevant if the file is being created or written to qtree0.)
2. The user quota for the user that owns the file on the volume
3. The group quota for the group that owns the file on the volume
4. The user quota for the user that owns the file on the qtree (This check is not relevant if the file is being created or written to qtree0.)
5. The group quota for the group that owns the file on the qtree (This check is not relevant if the file is being created or written to qtree0.)

The quota with the smallest limit might not be the one that is exceeded first. For example, if a user quota for

volume vol1 is 100 GB, and the user quota for qtree q2 contained in volume vol1 is 20 GB, the volume limit could be reached first if that user has already written more than 80 GB of data in volume vol1 (but outside of qtree q2).

#### Considerations for assigning quota policies

A quota policy is a grouping of the quota rules for all the FlexVol volumes of an SVM. You must be aware of certain considerations when assigning the quota policies.

- An SVM has one assigned quota policy at any given time. When an SVM is created, a blank quota policy is created and assigned to the SVM. This default quota policy has the name "default" unless a different name is specified when the SVM is created.
- An SVM can have up to five quota policies. If an SVM has five quota policies, you cannot create a new quota policy for the SVM until you delete an existing quota policy.
- When you need to create a quota rule or change quota rules for a quota policy, you can choose either of the following approaches:
  - If you are working in a quota policy that is assigned to an SVM, you need not assign the quota policy to the SVM.
  - If you are working in an unassigned quota policy and then assigning the quota policy to the SVM, you must have a backup of the quota policy that you can revert to if required.

    For example, you can make a copy of the assigned quota policy, change the copy, assign the copy to the SVM, and rename the original quota policy.
- You can rename a quota policy even when it is assigned to the SVM.

#### How quotas work with users and groups

### How quotas work with users and groups overview

When you specify a user or group as the target of a quota, the limits imposed by that quota are applied to that user or group. However, some special groups and users are handled differently. There are different ways to specify IDs for users, depending on your environment.

### How you specify UNIX users for quotas

You can specify a UNIX user for a quota using one of three formats: the user name, the UID, or a file or directory owned by the user.

To specify a UNIX user for a quota, you can use one of the following formats:

- The user name, such as jsmith.

  > You cannot use a UNIX user name to specify a quota if that name includes a backslash (\) or an @ sign. This is because ONTAP treats names containing these characters as Windows names.

- The UID, such as 20.
- The path of a file or directory owned by that user, so that the file's UID matches the user.

If you specify a file or directory name, you must select a file or directory that will last as long as the user account remains on the system.

Specifying a file or directory name for the UID does not cause ONTAP to apply a quota to that file or directory.

#### How you specify Windows users for quotas

You can specify a Windows user for a quota using one of three formats: the Windows name in pre-Windows 2000 format, the SID, or a file or directory owned by the SID of the user.

To specify a Windows user for a quota, you can use one of the following formats:

- The Windows name in pre-Windows 2000 format.
- The security ID (SID), as displayed by Windows in text form, such as S-1-5-32-544.
- The name of a file or directory that has an ACL owned by that user's SID.

If you specify a file or directory name, you must select a file or directory that will last as long as the user account remains on the system.

For ONTAP to obtain the SID from the ACL, the ACL must be valid.

If the file or directory exists in a UNIX-style qtree, or if the storage system uses UNIX mode for user authentication, ONTAP applies the user quota to the user whose **UID**, not SID, matches that of the file or directory.

Specifying a file or directory name to identify a user for a quota does not cause ONTAP to apply a quota to that file or directory.

#### How default user and group quotas create derived quotas

When you create default user or group quotas, corresponding derived user or group quotas are automatically created for every user or group that owns files at the same level.

Derived user and group quotas are created in the following ways:

- A default user quota on a FlexVol volume creates derived user quotas for every user that owns a file anywhere on the volume.
- A default user quota on a qtree creates derived user quotas for every user that owns a file in the qtree.
- A default group quota on a FlexVol volume creates derived group quotas for every group that owns a file anywhere on the volume.
- A default group quota on a qtree creates derived group quotas for every group that owns a file in the qtree.

If a user or group does not own files at the level of a default user or group quota, derived quotas are not created for the user or group. For example, if a default user quota is created for qtree proj1 and the user jsmith owns files on a different qtree, no derived user quota is created for jsmith.

The derived quotas have the same settings as the default quotas, including limits and user mapping. For

example, if a default user quota has a 50-MB disk limit and has user mapping turned on, any resulting derived quotas also have a 50-MB disk limit and user mapping turned on.

However, no limits exist in derived quotas for three special users and groups. If the following users and groups own files at the level of a default user or group quota, a derived quota is created with the same user-mapping setting as the default user or group quota, but it is only a tracking quota (with no limits):

- UNIX root user (UID 0)
- UNIX root group (GID 0)
- Windows BUILTIN\Administrators group

  Since quotas for Windows groups are tracked as user quotas, a derived quota for this group is a user quota that is derived from a default user quota, not a default group quota.

**Example of derived user quotas**

If you have volume where three users—root, jsmith, and bob—own files, and you create a default user quota on the volume, ONTAP automatically creates three derived user quotas. Therefore, after you reinitialize quotas on the volume, four new quotas appear in the quota report:

```
cluster1::> volume quota report
  Vserver: vs1
                                     ----Disk----  ----Files-----   Quota
Volume   Tree      Type    ID        Used  Limit    Used   Limit
Specifier
-------  --------  ------  -------  -----  -----  ------  ------
---------
vol1               user    *          0B   50MB       0       -   *
vol1               user    root       5B      -       1       -
vol1               user    jsmith    30B   50MB      10       -   *
vol1               user    bob       40B   50MB      15       -   *
4 entries were displayed.
```

The first new line is the default user quota that you created, which is identifiable by the asterisk (*) as the ID. The other new lines are the derived user quotas. The derived quotas for jsmith and bob have the same 50-MB disk limit as the default quota. The derived quota for the root user is a tracking quota without limits.

**How quotas are applied to the root user**

The root user (UID=0) on UNIX clients is subject to tree quotas, but not user quotas or group quotas. This allows the root user to take actions on behalf of other users that would otherwise be prevented by a quota.

When root carries out a file or directory ownership change or other operation (such as the UNIX `chown` command) on behalf of a user with less privileges, ONTAP checks the quotas based on the new owner but does not report errors or stop the operation, even if the hard quota restrictions of the new owner are exceeded. This can be useful when an administrative action, such as recovering lost data, results in temporarily exceeding quotas.

After the ownership transfer is carried out, however, a client system will report a disk space error if the user attempts to allocate more disk space while the quota is still exceeded.

#### How quotas work with special Windows groups

Quotas are applied to the Everyone group and the BUILTIN\Administrators group differently than to other Windows groups.

The following list describes what happens if the quota target is a special Windows group ID:

- If the quota target is the Everyone group, a file whose ACL shows that the owner is Everyone is counted under the SID for Everyone.
- If the quota target is BUILTIN\Administrators, the entry is considered a user quota, for tracking only.

  You cannot impose restrictions on BUILTIN\Administrators.

  If a member of BUILTIN\Administrators creates a file, the file is owned by BUILTIN\Administrators and is counted under the SID for BUILTIN\Administrators, not the user's personal SID.

ONTAP does not support group quotas based on Windows group IDs. If you specify a Windows group ID as the quota target, the quota is considered to be a user quota.

#### How quotas are applied to users with multiple IDs

A user can be represented by multiple IDs. You can set up a single user quota for such a user by specifying a list of IDs as the quota target. A file owned by any of these IDs is subject to the restriction of the user quota.

Suppose a user has the UNIX UID 20 and the Windows IDs corp\john_smith and engineering\jsmith. For this user, you can specify a quota where the quota target is a list of the UID and Windows IDs. When this user writes to the storage system, the specified quota applies, regardless of whether the write originates from UID 20, corp\john_smith, or engineering\jsmith.

Separate quota file entries are considered separate targets, even if the IDs belong to the same user. For example, for the same user you can specify one quota that limits UID 20 to 1 GB of disk space and another quota that limits corp\john_smith to 2 GB of disk space, even though both IDs represent the same user. ONTAP applies quotas to UID 20 and corp\john_smith separately.

In this case, no limits are applied to engineering\jsmith, even though limits are applied to the other IDs used by the same user.

#### How ONTAP determines user IDs in a mixed environment

If you have users accessing your ONTAP storage from both Windows and UNIX clients, then both Windows and UNIX security are used to determine file ownership. Several factors determine whether ONTAP uses a UNIX or Windows ID when applying user quotas.

If the security style of the qtree or FlexVol volume that contains the file is only NTFS or only UNIX, then the

security style determines the type of ID used when applying user quotas. For qtrees with the mixed security style, the type of ID used is determined by whether the file has an ACL.

The following table summarizes what type of ID is used:

| Security Style | ACL | No ACL |
|---|---|---|
| UNIX | UNIX ID | UNIX ID |
| Mixed | Windows ID | UNIX ID |
| NTFS | Windows ID | Windows ID |

#### How quotas with multiple users work

When you put multiple users in the same quota target, the quota limits defined by that quota are not applied to each individual user; in this case, the quota limits are shared among all users listed in the quota target.

Unlike with commands for managing objects, such as volumes and qtrees, you cannot rename a quota target, including a multi-user quota. This means that after a multi-user quota is defined, you cannot modify the users in the quota target, and you cannot add users to a target or remove users from a target. If you want to add or remove a user from a multi-user quota, then the quota containing that user must be deleted and a new quota rule with the set of users in the target defined.

If you combine separate user quotas into one multi-user quota, you can activate the change by resizing quotas. However, if you want to remove users from a quota target with multiple users, or add users to a target that already has multiple users, you must reinitialize quotas before the change takes effect.

#### Example of more than one user in a quotas file entry

In the following example, there are two users listed in the quota entry. The two users can use up to 80 MB of space combined. If one uses 75 MB, then the other one can use only 5 MB.

```
#Quota       target type    disk files thold sdisk sfile
#----------  ----           ---- ----- ----- ----- -----
jsmith,chen  user@/vol/vol1 80M
```

#### How you link UNIX and Windows names for quotas

In a mixed environment, users can log in as either Windows users or UNIX users. You can configure quotas to recognize that a user's UNIX id and Windows ID represent the same user.

Quotas for Windows user name are mapped to a UNIX user name, or vice versa, when both of the following conditions are met:

- The `user-mapping` parameter is set to "on" in the quota rule for the user.

- The user names have been mapped with the `vserver name-mapping` commands.

When a UNIX and Windows name are mapped together, they are treated as the same person for determining quota usage.

#### How quotas work with qtrees

You can create quotas with a qtree as their target; these quotas are called *tree quotas*. You can also create user and group quotas for a specific qtree. In addition, quotas for a FlexVol volume are sometimes inherited by the qtrees contained by that volume.

#### How tree quotas work

#### How tree quotas work overview

You can create a quota with a qtree as its target to limit how large the target qtree can become. These quotas are also called *tree quotas*.

When you apply a quota to a qtree, the result is similar to a disk partition, except that you can change the qtree's maximum size at any time by changing the quota. When applying a tree quota, ONTAP limits the disk space and number of files in the qtree, regardless of their owners. No users, including root and members of the BUILTIN\Administrators group, can write to the qtree if the write operation causes the tree quota to be exceeded.

> The size of the quota does not guarantee any specific amount of available space. The size of the quota can be larger than the amount of free space available to the qtree. You can use the `volume quota report` command to determine the true amount of available space in the qtree.

#### How user and group quotas work with qtrees

Tree quotas limit the overall size of the qtree. To prevent individual users or groups from consuming the entire qtree, you specify a user or group quota for that qtree.

##### Example user quota in a qtree

Suppose you have the following quotas file:

```
#Quota target type            disk files thold sdisk sfile
#------------  ----            ---- ----- ----- ----- -----
*              user@/vol/vol1  50M   -     45M
jsmith         user@/vol/vol1  80M   -     75M
```

It comes to your attention that a certain user, kjones, is taking up too much space in a critical qtree, qt1, which resides in vol2. You can restrict this user's space by adding the following line to the quotas file:

```
kjones         user@/vol/vol2/qt1  20M  -   15M
```

#### How default tree quotas on a FlexVol volume create derived tree quotas

When you create a default tree quota on a FlexVol volume, corresponding derived tree quotas are automatically created for every qtree in that volume.

These derived tree quotas have the same limits as the default tree quota. If no additional quotas exist, the limits have the following effects:

- Users can use as much space in a qtree as they are allotted for the entire volume (provided they did not exceed the limit for the volume by using space in the root or another qtree).
- Each of the qtrees can grow to consume the entire volume.

The existence of a default tree quota on a volume continues to affect all new qtrees that are added to the volume. Each time a new qtree is created, a derived tree quota is also created.

Like all derived quotas, derived tree quotas display the following behaviors:

- Are created only if the target does not already have an explicit quota.
- Appear in quota reports but do not appear when you show quota rules with the `volume quota policy rule show` command.

#### Example of derived tree quotas

You have a volume with three qtrees (proj1, proj2, and proj3) and the only tree quota is an explicit quota on the proj1 qtree limiting its disk size to 10 GB. If you create a default tree quota on the volume and reinitialize quotas on the volume, the quota report now contains four tree quotas:

```
                                    ----Disk----  ----Files-----   Quota
Volume   Tree      Type    ID        Used  Limit    Used   Limit
Specifier
-------  --------  ------  -------  -----  -----  ------  ------
---------
vol1     proj1     tree    1           0B   10GB       1       -   proj1
vol1               tree    *           0B   20GB       0       -   *
vol1     proj2     tree    2           0B   20GB       1       -   proj2
vol1     proj3     tree    3           0B   20GB       1       -   proj3
...
```

The first line shows the original explicit quota on the proj1 qtree. This quota remains unchanged.

The second line shows the new default tree quota on the volume. The asterisk (*) Quota Specifier indicates it is a default quota. This quota is a result of the quota rule that you created.

The last two lines show new derived tree quotas for the proj2 and proj3 qtrees. ONTAP automatically created these quotas as a result of the default tree quota on the volume. These derived tree quotas have the same 20-GB disk limit as the default tree quota on the volume. ONTAP did not create a derived tree quota for the proj1 qtree because the proj1 qtree already had an explicit quota.

#### How default user quotas on a FlexVol volume affect quotas for the qtrees in that volume

If a default user quota is defined for a FlexVol volume, a default user quota is

automatically created for every qtree contained by that volume for which an explicit or derived tree quota exists.

If a default user quota on the qtree already exists, it remains unaffected when the default user quota on the volume is created.

The automatically created default user quotas on the qtrees have the same limits as the default user quota you create for the volume.

An explicit user quota for a qtree overrides (replaces the limits applied by) the automatically created default user quota, the same way as it overrides a default user quota on that qtree that was created by an administrator.

#### How qtree changes affect quotas

#### How qtree changes affect quotas overview

When you delete, rename, or change the security style of a qtree, the quotas applied by ONTAP might change, depending on the current quotas being applied.

#### How deleting a qtree affects tree quotas

When you delete a qtree, all quotas applicable to that qtree, whether they are explicit or derived, are no longer applied by ONTAP.

Whether the quota rules persist depends on where you delete the qtree:

- If you delete a qtree using ONTAP, the quota rules for that qtree are automatically deleted, including tree quota rules and any user and group quota rules configured for that qtree.
- If you delete a qtree using your CIFS or NFS client, you must delete any quota rules for that qtree to avoid getting errors when you reinitialize quotas. If you create a new qtree with the same name as the one you deleted, the existing quota rules are not applied to the new qtree until you reinitialize quotas.

#### How renaming a qtree affects quotas

When you rename a qtree using ONTAP, the quota rules for that qtree are automatically updated. If you rename a qtree using your CIFS or NFS client, you must update any quota rules for that qtree.

If you rename a qtree using your CIFS or NFS client and do not update quota rules for that qtree with the new name before you reinitialize quotas, quotas will not be applied to the qtree and explicit quotas for the qtree—including tree quotas and user or group quotas for the qtree—might be converted into derived quotas.

#### How changing the security style of a qtree affects user quotas

You can apply Access Control Lists (ACLs) on qtrees by using NTFS or mixed security styles, but not by using the UNIX security style. Therefore, changing the security style of a qtree might affect how quotas are calculated. You should always reinitialize quotas after you change the security style of a qtree.

If you change the security style of a qtree from NTFS or mixed to UNIX, any ACLs on files in that qtree are ignored and the file usage is charged against the UNIX user IDs.

If you change the security style of a qtree from UNIX to either mixed or NTFS, the previously hidden ACLs become visible. In addition, any ACLs that were ignored become effective again, and the NFS user information is ignored. If no ACL existed before, the NFS information continues to be used in the quota calculation.

To make sure that quota usages for both UNIX and Windows users are properly calculated after you change the security style of a qtree, you must reinitialize quotas for the volume containing that qtree.

**Example**

The following example shows how a change in the security style of a qtree results in a different user being charged for the usage of a file in the particular qtree.

Suppose NTFS security is in effect on qtree A, and an ACL gives Windows user corp\joe ownership of a 5 MB file. User corp\joe is charged with 5 MB of disk space usage for qtree A.

Now you change the security style of qtree A from NTFS to UNIX. After quotas are reinitialized, Windows user corp\joe is no longer charged for this file; instead, the UNIX user corresponding to the UID of the file is charged for the file. The UID could be a UNIX user mapped to corp\joe or the root user.

#### How quotas are activated

### How quotas are activated overview

New quotas and changes to quotas do not take effect until they are activated. Knowing how quota activation works can help you manage your quotas less disruptively.

You can activate quotas at the volume level.

Your quotas file does not need to be free of all errors to activate quotas. Invalid entries are reported and skipped. If the quotas file contains any valid entries, the quotas are activated.

Quotas are activated either by *initializing* (turning them on) or by *resizing*. Turning off quotas and turning them on again is called reinitializing.

The length of the activation process and its impact on quota enforcement depends on the type of activation:

- The initialization process involves two parts: a `quota on` job and a quota scan of the volume's entire file system. The scan begins after the `quota on` job completes successfully. The quota scan can take some time; the more files that the volume has, the longer it takes. Until the scan is finished, quota activation is not complete and quotas are not enforced.
- The resize process involves only a `quota resize` job. Because it does not involve a quota scan, resizing takes less time than a quota initialization. During a resize process, quotas are enforced.

By default, the `quota on` and `quota resize` jobs run in the background, which permits you to use other commands at the same time.

Errors and warnings from the activation process are sent to the event management system. If you use the `-foreground` parameter with the `volume quota on` or `volume quota resize` commands, the command does not return until the job is complete; this is useful if you are reinitializing from a script. To display errors and warnings later, you can use the `volume quota show` command with the `-instance` parameter.

Quota activation persists across halts and reboots. The process of quota activation does not affect the availability of the storage system data.

**When you can use resizing**

## Because quota resizing is faster than quota initialization, you should use resizing whenever possible. However, resizing only works for certain types of quota changes.

You can resize quotas when making the following types of changes to the quota rules:

- Changing an existing quota.

  For example, changing the limits of an existing quota.

- Adding a quota for a quota target for which a default quota or a default tracking quota exists.
- Deleting a quota for which a default quota or default tracking quota entry is specified.
- Combining separate user quotas into one multi-user quota.

> After you have made extensive quotas changes, you should perform a full reinitialization to ensure that all of the changes take effect.

> If you attempt to resize and not all of your quota changes can be incorporated by using a resize operation, ONTAP issues a warning. You can determine from the quota report whether your storage system is tracking disk usage for a particular user, group, or qtree. If you see a quota in the quota report, it means that the storage system is tracking the disk space and the number of files owned by the quota target.

**Example quotas changes that can be made effective by resizing**

Some quota rule changes can be made effective by resizing. Consider the following quotas:

```
#Quota Target type             disk  files thold sdisk sfile
#------------ ----              ----  ----- ----- ----- -----
*             user@/vol/vol2    50M   15K
*             group@/vol/vol2  750M   85K
*             tree@/vol/vol2      -     -
jdoe          user@/vol/vol2/  100M   75K
kbuck         user@/vol/vol2/  100M   75K
```

Suppose you make the following changes:

- Increase the number of files for the default user target.
- Add a new user quota for a new user, boris, that needs more disk limit than the default user quota.
- Delete the kbuck user's explicit quota entry; the new user now needs only the default quota limits.

These changes result in the following quotas:

```
#Quota Target type             disk  files thold sdisk sfile
#------------ ----              ----  ----- ----- ----- -----
*            user@/vol/vol2     50M   25K
*            group@/vol/vol2   750M   85K
*            tree@/vol/vol2      -     -
jdoe         user@/vol/vol2/   100M   75K
boris        user@/vol/vol2/   100M   75K
```

Resizing activates all of these changes; a full quota reinitialization is not necessary.

#### When a full quota reinitialization is required

Although resizing quotas is faster, you must do a full quota reinitialization if you make certain small or extensive changes to your quotas.

A full quota reinitialization is necessary in the following circumstances:

- You create a quota for a target that has not previously had a quota.
- You change user mapping in the `usermap.cfg` file and you use the QUOTA_PERFORM_USER_MAPPING entry in the quotas file.
- You change the security style of a qtree from UNIX to either mixed or NTFS.
- You change the security style of a qtree from mixed or NTFS to UNIX.
- You remove users from a quota target with multiple users, or add users to a target that already has multiple users.
- You make extensive changes to your quotas.

#### Example of quotas changes that require initialization

Suppose you have a volume that contains three qtrees and the only quotas in the volume are three tree quotas. You decide to make the following changes:

- Add a new qtree and create a new tree quota for it.
- Add a default user quota for the volume.

Both of these changes require a full quota initialization. Resizing does not make the quotas effective.

##### How you can view quota information

#### How you can view quota information overview

You can use quota reports to view details such as the configuration of quota rules and policies, enforced and configured quotas, and errors that occur during quota resizing and reinitialization.

Viewing quota information is useful in situations such as the following:

- Configuring quotas—for example, to configure quotas and verify the configurations
- Responding to notifications that disk space or file limits will soon be reached or that they have been

reached

- Responding to requests for more space

#### How you can use the quota report to see what quotas are in effect

Because of the various ways that quotas interact, more quotas are in effect than just the ones you have explicitly created. To see what quotas are in effect, you can view the quota report.

The following examples show quota reports for different types of quotas applied on a FlexVol volume vol1, and a qtree q1 contained in that volume:

#### Example with no user quotas specified for the qtree

In this example, there is one qtree, q1, which is contained by the volume vol1. The administrator has created three quotas:

- A default tree quota limit on vol1 of 400 MB
- A default user quota limit on vol1 of 100 MB
- An explicit user quota limit on vol1 of 200 MB for the user jsmith

The quotas file for these quotas looks similar to the following excerpt:

```
#Quota target type            disk files  thold sdisk  sfile
#------------  ----            ---  -----  ----  -----  -----
*              tree@/vol/vol1  400M
*              user@/vol/vol1  100M
jsmith         user@/vol/vol1  200M
```

The quota report for these quotas looks similar to the following excerpt:

```
cluster1::> volume quota report
Vserver: vs1
                                     ----Disk----  ----Files-----   Quota
Volume   Tree      Type    ID        Used  Limit    Used   Limit
Specifier
-------  --------  ------  -------  -----  -----  ------  ------
---------
vol1     -          tree   *           0B  400MB       0       -   *
vol1     -          user   *           0B  100MB       0       -   *
vol1     -          user   corp/jsmith
                                     150B  200MB       7       -
corp/jsmith
vol1     q1         tree   1           0B  400MB       6       -   q1
vol1     q1         user   *           0B  100MB       0       -
vol1     q1         user   corp/jsmith 0B  100MB       5       -
vol1     -          user   root        0B   0MB        1       -
vol1     q1         user   root        0B   0MB        8       -
```

The first three lines of the quota report display the three quotas specified by the administrator. Since two of these quotas are default quotas, ONTAP automatically creates derived quotas.

The fourth line displays the tree quota that is derived from the default tree quota for every qtree in vol1 (in this example, only q1).

The fifth line displays the default user quota that is created for the qtree as a result of the existence of the default user quota on the volume and the qtree quota.

The sixth line displays the derived user quota that is created for jsmith on the qtree because there is a default user quota for the qtree (line 5) and the user jsmith owns files on that qtree. Note that the limit applied to the user jsmith in the qtree q1 is not determined by the explicit user quota limit (200 MB). This is because the explicit user quota limit is on the volume, so it does not affect limits for the qtree. Instead, the derived user quota limit for the qtree is determined by the default user quota for the qtree (100 MB).

The last two lines display more user quotas that are derived from the default user quotas on the volume and on the qtree. A derived user quota was created for the root user on both the volume and the qtree because the root user owned files on both the volume and the qtree. Since the root user gets special treatment in terms of quotas, its derived quotas are tracking quotas only.

**Example with user quotas specified for the qtree**

This example is similar to the previous one, except that the administrator has added two quotas on the qtree.

There is still one volume, vol1, and one qtree, q1. The administrator has created the following quotas:

- A default tree quota limit on vol1 of 400 MB
- A default user quota limit on vol1 of 100 MB
- An explicit user quota limit on vol1 for the user jsmith of 200 MB
- A default user quota limit on qtree q1 of 50 MB
- An explicit user quota limit on qtree q1 for the user jsmith of 75 MB

The quotas file for these quotas looks like this:

```
#Quota target type             disk files  thold sdisk  sfile
#------------  ----             ---  -----  ----  -----  -----
*              tree@/vol/vol1   400M
*              user@/vol/vol1   100M
jsmith         user@/vol/vol1   200M
*              user@/vol/vol1/q1 50M
jsmith         user@/vol/vol1/q1 75M
```

The quota report for these quotas looks like this:

```
cluster1::> volume quota report
Vserver: vs1
                                     ----Disk----  ----Files-----   Quota
Volume   Tree      Type    ID        Used  Limit    Used   Limit
Specifier
-------  --------  ------  -------  -----  -----  ------  ------
---------
vol1     -          tree   *           0B  400MB       0       -   *
vol1     -          user   *           0B  100MB       0       -   *
vol1     -          user   corp/jsmith
                                    2000B  200MB       7       -
corp/jsmith
vol1     q1         user   *           0B   50MB       0       -   *
vol1     q1         user   corp/jsmith 0B  75MB        5       -
corp/jsmith
vol1     q1         tree   1           0B 400MB        6       -   q1
vol1     -          user   root        0B   0MB        2       -
vol1     q1         user   root        0B   0MB        1       -
```

The first five lines of the quota report display the five quotas created by the administrator. Since some of these quotas are default quotas, ONTAP automatically creates derived quotas.

The sixth line displays the tree quota that is derived from the default tree quota for every qtree in vol1 (in this example, only q1).

The last two lines display the user quotas that are derived from the default user quotas on the volume and on the qtree. A derived user quota was created for the root user on both the volume and the qtree because the root user owned files on both the volume and the qtree. Since the root user gets special treatment in terms of quotas, its derived quotas are tracking quotas only.

No other default quotas or derived quotas were created for the following reasons:

- A derived user quota was not created for the jsmith user even though the user owns files on both the volume and the qtree because the user already has explicit quotas at both levels.

- No derived user quotas were created for other users because no other users own files on either the volume or the qtree.
- The default user quota on the volume did not create a default user quota on the qtree because the qtree already had a default user quota.

#### Why enforced quotas differ from configured quotas

Enforced quotas differ from configured quotas because derived quotas are enforced without being configured but configured quotas are enforced only after they are successfully initialized. Understanding these differences can help you compare the enforced quotas that are shown in quota reports to the quotas that you configured.

Enforced quotas, which appear in quota reports, might differ from the configured quota rules for the following reasons:

- Derived quotas are enforced without being configured as quota rules; ONTAP creates derived quotas automatically in response to default quotas.
- Quotas might not have been reinitialized on a volume after quota rules were configured.
- Errors might have occurred when quotas were initialized on a volume.

#### Use the quota report to determine which quotas limit writes to a specific file

You can use the volume quota report command with a specific file path to determine which quota limits affect write operations to a file. This can help you understand which quota is preventing a write operation.

**Step**

1. Use the volume quota report command with the -path parameter.

#### Example of showing quotas affecting a specific file

The following example shows the command and output to determine what quotas are in effect for writes to the file file1, which resides in the qtree q1 in the FlexVol volume vol2:

```
cluster1:> volume quota report -vserver vs0 -volume vol2 -path
/vol/vol2/q1/file1
Virtual Server: vs0
                                       ----Disk----  ----Files-----   Quota
Volume   Tree      Type    ID        Used  Limit    Used   Limit
Specifier
-------  --------  ------  -------  -----  -----  ------  ------
---------
vol2     q1        tree    jsmith     1MB  100MB       2   10000   q1
vol2     q1        group   eng        1MB  700MB       2   70000
vol2               group   eng        1MB  700MB       6   70000   *
vol2               user    corp\jsmith
                                      1MB   50MB       1       -   *
vol2     q1        user    corp\jsmith
                                      1MB   50MB       1       -
5 entries were displayed.
```

#### Commands for displaying information about quotas

You can use commands to display a quota report containing enforced quotas and resource usage, display information about quota state and errors, or about quota policies and quota rules.

You can run the following commands only on FlexVol volumes.

| If you want to… | Use this command… |
|---|---|
| View information about enforced quotas | `volume quota report` |
| View resource usage (disk space and number of files) of quota targets | `volume quota report` |
| Determine which quota limits are affected when a write to a file is allowed | `volume quota report` with the `-path` parameter |
| Display the quota state, such as `on`, `off`, and `initializing` | `volume quota show` |
| View information about quota message logging | `volume quota show` with the `-logmsg` parameter |
| View errors that occur during quota initialization and resizing | `volume quota show` with the `-instance` parameter |
| View information about quota policies | `volume quota policy show` |

| If you want to… | Use this command… |
| --- | --- |
| View information about quota rules | `volume quota policy rule show` |
| View the name of the quota policy that is assigned to a storage virtual machine (SVM, formerly known as Vserver) | `vserver show` with the `-instance` parameter |

See the man page for each command for more information.

**When to use the volume quota policy rule show and volume quota report commands**

Although both commands show information about quotas, the `volume quota policy rule show` quickly displays configured quota rules while the `volume quota report` command, which consumes more time and resources, displays enforced quotas and resource usage.

The `volume quota policy rule show` command is useful for the following purposes:

- Check the configuration of quota rules before activating them

  This command displays all configured quota rules regardless of whether the quotas have been initialized or resized.

- Quickly view quota rules without affecting system resources

  Because it does not display disk and file usage, this command is not as resource intensive as a quota report.

- Display the quota rules in a quota policy that is not assigned to the SVM.

The `volume quota report` command is useful for the following purposes:

- View enforced quotas, including derived quotas
- View the disk space and number of files used by every quota in effect, including targets affected by derived quotas

  (For default quotas, the usage appears as "0" because the usage is tracked against the resulting derived quota.)

- Determine which quota limits affect when a write to a file will be allowed

  Add the `-path` parameter to the `volume quota report` command.

The quota report is resource-intensive operation. If you run it on many FlexVol volumes in the cluster, it might take a long time to complete. A more efficient way would be to view the quota report for a particular volume in an SVM.

### Difference in space usage displayed by a quota report and a UNIX client overview

The value of used disk space that is displayed in a quota report for a FlexVol volume or qtree can be different from the value displayed by a UNIX client for the same volume or qtree. The difference in usage values is because of the difference in methods followed by the quota report and the UNIX commands for calculating the data blocks in the volume or qtree.

For example, if a volume contains a file that has empty data blocks (to which data is not written), the quota report for the volume does not count the empty data blocks while reporting the space usage. However, when the volume is mounted on a UNIX client and the file is shown as the output of the `ls` command, the empty data blocks are also included in the space usage. Therefore, the `ls` command displays a higher file size when compared to the space usage displayed by the quota report.

Similarly, the space usage values shown in a quota report can also differ from the values shown as a result of UNIX commands such as `df` and `du`.

### How a quota report accounts for disk space and file usage

The number of files used and the amount of disk space specified in a quota report for a FlexVol volume or a qtree depend on the count of the used data blocks corresponding to every inode in the volume or the qtree.

The block count includes both direct and indirect blocks used for regular and stream files. The blocks used for directories, Access Control Lists (ACLs), stream directories, and metafiles do not get accounted for in the quota report. In case of UNIX sparse files, empty data blocks are not included in the quota report.

### How the ls command accounts for space usage

When you use the `ls` command to view the contents of a FlexVol volume mounted on a UNIX client, the file sizes displayed in the output could be lesser or more than the space usage displayed in the quota report for the volume depending on the type of data blocks for the file.

The output of the `ls` command displays only the size of a file and does not include indirect blocks used by the file. Any empty blocks of the file also get included in the output of the command.

Therefore, if a file does not have empty blocks, the size displayed by the `ls` command might be less than the disk usage specified by a quota report because of the inclusion of indirect blocks in the quota report. Conversely, if the file has empty blocks, then the size displayed by the `ls` command might be more than the disk usage specified by the quota report.

The output of the `ls` command displays only the size of a file and does not include indirect blocks used by the file. Any empty blocks of the file also get included in the output of the command.

#### Example of the difference between space usage accounted by the ls command and a quota report

The following quota report shows a limit of 10 MB for a qtree q1:

```
                                      ----Disk----  ----Files-----   Quota
  Volume   Tree      Type    ID        Used  Limit    Used   Limit
Specifier
  -------  --------  ------  -------  -----  -----  ------  ------
---------
  vol1     q1          tree    user1   10MB  10MB        1       -   q1

...
```

A file present in the same qtree can have a size exceeding the quota limit when viewed from a UNIX client by using the `ls` command, as shown in the following example:

```
[user1@lin-sys1 q1]$ ls -lh
-rwxr-xr-x  1 user1 nfsuser  **27M** Apr 09  2013 file1
```

**How the df command accounts for file size**

The way in which in the `df` command reports the space usage depends on two conditions: whether the quotas are enabled or disabled for the volume that contains the qtree, and if quota usage within the qtree is tracked.

When quotas are enabled for the volume that contains the qtree and quota usage within the qtree is tracked, the space usage reported by the `df` command equals the value specified by the quota report. In this situation, quota usage excludes blocks used by directories, ACLs, stream directories, and metafiles.

When quotas are not enabled on the volume, or when the qtree does not have a quota rule configured, the reported space usage includes blocks used by directories, ACLs, stream directories, and metafiles for the entire volume, including other qtrees within the volume. In this situation, the space usage reported by the `df` command is greater than the expected value reported when quotas are tracked.

When you run the `df` command from the mount point of a qtree for which quota usage is tracked, the command output shows the same space usage as the value specified by the quota report. In most cases, when the tree quota rule has a hard disk-limit, the total size reported by the `df` command equals the disk limit and the space available equals the difference between the quota disk limit and quota usage.

However, in some cases, the space available reported by the `df` command might equal the space available in the volume as a whole. This can occur when there is no hard disk limit configured for the qtree. Beginning with ONTAP 9.9.1, it can also occur when the space available in the volume as a whole is less than the remaining tree quota space. When either of these conditions occur, the total size reported by the `df` command is a synthesized number equal to the quota used within the qtree plus the space available in the FlexVol volume.

This total size is neither the qtree disk limit nor the volume configured size. It can also vary based on your write activity within other qtrees or on your background storage efficiency activity.

**Example of space usage accounted by the `df` command and a quota report**

The following quota report shows a disk limit of 1 GB for qtree alice, 2 GB for qtree bob, and no limit for qtree project1:

```
C1_vsim1::> quota report -vserver vs0
Vserver: vs0
                                     ----Disk----  ----Files-----   Quota
Volume   Tree      Type    ID        Used  Limit    Used   Limit
Specifier
-------  --------  ------  -------  -----  -----  ------  ------
---------
vol2     alice     tree    1
                                   502.0MB    1GB       2       -   alice
vol2     bob       tree    2
                                    1003MB    2GB       2       -   bob
vol2     project1  tree    3
                                   200.8MB      -       2       -
project1
vol2               tree    *           0B      -       0       -   *
4 entries were displayed.
```

In the following example, the output of the `df` command on qtrees alice and bob reports the same used space as the quota report, and the same total size (in terms of 1M blocks) as the disk limit. This is because the quota rules for qtrees alice and bob have a defined disk limit and the volume available space (1211 MB) is greater than the tree quota space remaining for qtree alice (523 MB) and qtree bob (1045 MB).

```
linux-client1 [~]$ df -m /mnt/vol2/alice
Filesystem          1M-blocks  Used Available Use% Mounted on
172.21.76.153:/vol2      1024   502       523  50% /mnt/vol2

linux-client1 [~]$ df -m /mnt/vol2/bob
Filesystem          1M-blocks  Used Available Use% Mounted on
172.21.76.153:/vol2      2048  1004      1045  50% /mnt/vol2
```

In the following example, the output of the `df` command on qtree project1 reports the same used space as the quota report, but the total size is synthesized by adding the available space in the volume as a whole (1211 MB) to the quota usage of qtree project1 (201 MB) to give a total of 1412 MB. This is because the quota rule for qtree project1 has no disk limit.

```
linux-client1 [~]$ df -m /mnt/vol2/project1
Filesystem          1M-blocks  Used Available Use% Mounted on
172.21.76.153:/vol2      1412   201      1211  15% /mnt/vol2
```

The following example shows how the output of the `df` command on the volume as a whole reports the same available space as project1.

```
linux-client1 [~]$ df -m /mnt/vol2
Filesystem          1M-blocks  Used Available Use% Mounted on
172.21.76.153:/vol2      2919  1709      1211  59% /mnt/vol2
```

#### How the du command accounts for space usage

## When you run the `du` command to check the disk space usage for a qtree or FlexVol volume mounted on a UNIX client, the usage value might be higher than the value displayed by a quota report for the qtree or volume.

The output of the `du` command contains the combined space usage of all the files through the directory tree beginning at the level of the directory where the command is issued. Because the usage value displayed by the `du` command also includes the data blocks for directories, it is higher than the value displayed by a quota report.

#### Example of the difference between space usage accounted by the du command and a quota report

The following quota report shows a limit of 10 MB for a qtree q1:

```
                                      ----Disk----  ----Files-----   Quota
  Volume   Tree      Type    ID        Used  Limit    Used   Limit
Specifier
  -------  --------  ------  -------  -----  -----  ------  ------
---------
  vol1     q1          tree    user1   10MB   10MB       1       -   q1

...
```

In the following example, the disk space usage as the output of the `du` command shows a higher value that exceeds the quota limit:

```
[user1@lin-sys1 q1]$ du -sh
**11M**     q1
```

#### Examples of quota configuration

## These examples help you understand how to configure quotas and read quota reports.

For the following examples, assume that you have a storage system that includes an SVM, vs1, with one volume, vol1. To start setting up quotas, you create a new quota policy for the SVM with the following command:

```
cluster1::>volume quota policy create -vserver vs1 -policy-name
quota_policy_vs1_1
```

Since the quota policy is new, you assign it to the SVM:

```
cluster1::>vserver modify -vserver vs1 -quota-policy quota_policy_vs1_1
```

**Example 1: Default user quota**

You decide to impose a hard limit of 50 MB for each user in vol1:

```
cluster1::>volume quota policy rule create -vserver vs1 -policy-name
quota_policy_vs1_1 -volume vol1 -type user -target "" -disk-limit 50MB
-qtree ""
```

To activate the new rule, you initialize quotas on the volume:

```
cluster1::>volume quota on -vserver vs1 -volume vol1 -foreground
```

To view the quota report, you enter the following command:

```
cluster1::>volume quota report
```

The resulting quota report is similar to the following report:

```
Vserver: vs1
                                     ----Disk----  ----Files-----   Quota
Volume   Tree      Type    ID        Used  Limit    Used   Limit
Specifier
-------  --------  ------  -------  -----  -----  ------  ------
---------
vol1               user    *           0B   50MB       0       -   *
vol1               user    jsmith     49MB   50MB      37       -   *
vol1               user    root        0B      -       1       -
```

The first line shows the default user quota that you created, including the disk limit. Like all default quotas, this default user quota does not display information about disk or file usage. In addition to the quota that was created, two other quotas appear—one quota for each user that currently owns files on vol1. These additional quotas are user quotas that were derived automatically from the default user quota. The derived user quota for the user jsmith has the same 50-MB disk limit as the default user quota. The derived user quota for the root user is a tracking quota (without limits).

If any user on the system (other than the root user) tries to perform an action that would use more than 50 MB

in vol1 (for example, writing to a file from an editor), the action fails.

**Example 2: Explicit user quota overriding a default user quota**

If you need to provide more space in volume vol1 to the user jsmith, then you enter the following command:

```
cluster1::>volume quota policy rule create -vserver vs1 -policy-name
quota_policy_vs1_1 -volume vol1 -type user -target jsmith -disk-limit 80MB
-qtree ""
```

This is an explicit user quota, because the user is explicitly listed as the target of the quota rule.

This is a change to an existing quota limit, because it changes the disk limit of the derived user quota for the user jsmith on the volume. Therefore, you do not need to reinitialize quotas on the volume to activate the change.

To resize quotas:

```
cluster1::>volume quota resize -vserver vs1 -volume vol1 -foreground
```

Quotas remain in effect while you resize, and the resizing process is short.

The resulting quota report is similar to the following report:

```
cluster1::> volume quota report
Vserver: vs1
                                    ----Disk----  ----Files-----   Quota
Volume   Tree      Type    ID        Used  Limit    Used   Limit
Specifier
-------  --------  ------  -------  -----  -----  ------  ------
---------
vol1               user    *           0B   50MB       0       -   *
vol1               user    jsmith     50MB   80MB      37       -   jsmith
vol1               user    root        0B      -       1       -
3 entries were displayed.
```

The second line now shows a Disk Limit of 80 MB and a Quota Specifier of jsmith.

Therefore, jsmith can use up to 80 MB of space on vol1, even though all other users are still limited to 50 MB.

**Example 3: Thresholds**

Suppose you want to receive a notification when users reach within 5 MB of their disk limits. To create a threshold of 45 MB for all users, and a threshold of 75 MB for jsmith, you change the existing quota rules:

```
cluster1::>volume quota policy rule modify -vserver vs1 -policy
quota_policy_vs1_1 -volume vol1 -type user -target "" -qtree "" -threshold
45MB
cluster1::>volume quota policy rule modify -vserver vs1 -policy
quota_policy_vs1_1 -volume vol1 -type user -target jsmith -qtree ""
-threshold 75MB
```

Since the sizes of the existing rules are changed, you resize quotas on the volume in order to activate the changes. You wait until the resize process is finished.

To see the quota report with thresholds, you add the `-thresholds` parameter to the `volume quota report` command:

```
cluster1::>volume quota report -thresholds
Vserver: vs1
                                    ----Disk----  ----Files-----
Volume   Tree      Type    ID        Used  Limit   Used    Limit  Quota
                                          (Thold)
Specifier
-------  --------  ------  -------  -----  -----  ------  ------
---------
vol1              user    *           0B   50MB       0       -  *
                                          (45MB)
vol1              user    jsmith     59MB   80MB      55       -  jsmith
                                          (75MB)
vol1              user    root        0B      -       1       -
                                          ( -)
3 entries were displayed.
```

The thresholds appear in parentheses in the Disk Limit column.

**Example 4: Quotas on qtrees**

Suppose you need to partition some space for two projects. You can create two qtrees, named proj1 and proj2, to accommodate those projects within vol1.

Currently, users can use as much space in a qtree as they are allotted for the entire volume (provided they did not exceed the limit for the volume by using space in the root or another qtree). In addition, each of the qtrees can grow to consume the entire volume. If you want to ensure that neither qtree grows beyond 20 GB, you can create default tree quota on the volume:

```
cluster1:>>volume quota policy rule create -vserver vs1 -policy-name
quota_policy_vs1_1 -volume vol1 -type tree -target "" -disk-limit 20GB
```

Note that the correct type is *tree*, not qtree.

Because this is a new quota, you cannot activate it by resizing. You reinitialize quotas on the volume:

```
cluster1:>>volume quota off -vserver vs1 -volume vol1
cluster1:>>volume quota on -vserver vs1 -volume vol1 -foreground
```

> You must ensure that you wait for about five minutes before reactivating the quotas on each affected volume, as attempting to activate them almost immediately after running the `volume quota off` command might result in errors. Alternatively, you can run the commands to re-initialize the quotas for a volume from the node that contains the particular volume.

Quotas are not enforced during the reinitialization process, which takes longer than the resizing process.

When you display a quota report, it has several new lines: some lines are for tree quotas and some lines are for derived user quotas.

The following new lines are for the tree quotas:

```
                                    ----Disk----  ----Files-----   Quota
Volume   Tree      Type    ID        Used  Limit    Used   Limit
Specifier
-------  --------  ------  -------  -----  -----  ------  ------
---------
...
vol1              tree    *           0B   20GB       0       -   *
vol1     proj1    tree    1           0B   20GB       1       -   proj1
vol1     proj2    tree    2           0B   20GB       1       -   proj2
...
```

The default tree quota that you created appears in the first new line, which has an asterisk (*) in the ID column. In response to the default tree quota on a volume, ONTAP automatically creates derived tree quotas for each qtree in the volume. These are shown in the lines where proj1 and proj2 appear in the Tree column.

The following new lines are for derived user quotas:

```
                                    ----Disk----  ----Files-----   Quota
Volume   Tree      Type    ID        Used  Limit    Used   Limit
Specifier
-------  --------  ------  -------  -----  -----  ------  ------
---------
...
vol1     proj1    user    *           0B   50MB       0       -
vol1     proj1    user    root        0B      -       1       -
vol1     proj2    user    *           0B   50MB       0       -
vol1     proj2    user    root        0B      -       1       -
...
```

Default user quotas on a volume are automatically inherited for all qtrees contained by that volume, if quotas are enabled for qtrees. When you added the first qtree quota, you enabled quotas on qtrees. Therefore, derived default user quotas were created for each qtree. These are shown in the lines where ID is asterisk (*).

Because the root user is the owner of a file, when default user quotas were created for each of the qtrees, special tracking quotas were also created for the root user on each of the qtrees. These are shown in the lines where ID is root.

**Example 5: User quota on a qtree**

You decide to limit users to less space in the proj1 qtree than they get in the volume as a whole. You want to keep them from using any more than 10 MB in the proj1 qtree. Therefore, you create a default user quota for the qtree:

```
cluster1::>volume quota policy rule create -vserver vs1 -policy-name
quota_policy_vs1_1 -volume vol1 -type user -target "" -disk-limit 10MB
-qtree proj1
```

This is a change to an existing quota, because it changes the default user quota for the proj1 qtree that was derived from the default user quota on the volume. Therefore, you activate the change by resizing quotas. When the resize process is complete, you can view the quota report.

The following new line appears in the quota report showing the new explicit user quota for the qtree:

```
                                    ----Disk----  ----Files-----   Quota
Volume   Tree      Type    ID        Used  Limit    Used   Limit
Specifier
-------  --------  ------  -------  -----  -----  ------  ------
---------
vol1     proj1     user    *           0B   10MB       0       -   *
```

However, the user jsmith is being prevented from writing more data to the proj1 qtree because the quota you created to override the default user quota (to provide more space) was on the volume. As you have added a default user quota on the proj1 qtree, that quota is being applied and limiting all the users' space in that qtree, including jsmith. To provide more space to the user jsmith, you add an explicit user quota rule for the qtree with an 80 MB disk limit to override the default user quota rule for the qtree:

```
cluster1::>volume quota policy rule create -vserver vs1 -policy-name
quota_policy_vs1_1 -volume vol1 -type user -target jsmith -disk-limit 80MB
-qtree proj1
```

Since this is an explicit quota for which a default quota already existed, you activate the change by resizing quotas. When the resize process is complete, you display a quota report.

The following new line appears in the quota report:

```
                                   ----Disk----  ----Files-----   Quota
Volume   Tree      Type    ID        Used  Limit    Used   Limit
Specifier
-------  --------  ------  -------  -----  -----  ------  ------
---------
vol1     proj1     user    jsmith    61MB   80MB      57       -   jsmith
```

The final quota report is similar to the following report:

```
cluster1::>volume quota report
Vserver: vs1
                                   ----Disk----  ----Files-----   Quota
Volume   Tree      Type    ID        Used  Limit    Used   Limit
Specifier
-------  --------  ------  -------  -----  -----  ------  ------
---------
vol1               tree    *           0B   20GB       0       -   *
vol1               user    *           0B   50MB       0       -   *
vol1               user    jsmith    70MB   80MB      65       -   jsmith
vol1     proj1     tree    1           0B   20GB       1       -   proj1
vol1     proj1     user    *           0B   10MB       0       -   *
vol1     proj1     user    root        0B      -       1       -
vol1     proj2     tree    2           0B   20GB       1       -   proj2
vol1     proj2     user    *           0B   50MB       0       -
vol1     proj2     user    root        0B      -       1       -
vol1               user    root        0B      -       3       -
vol1     proj1     user    jsmith    61MB   80MB      57       -   jsmith
11 entries were displayed.
```

The user jsmith is required to meet the following quota limits to write to a file in proj1:

1. The tree quota for the proj1 qtree.
2. The user quota on the proj1 qtree.
3. The user quota on the volume.

#### Set up quotas on an SVM

To set up quotas on a new storage virtual machine (SVM, formerly known as Vserver), you must create a quota policy, add quota policy rules to the policy, assign the policy to the SVM, and initialize quotas on each FlexVol volume on the SVM.

#### Steps

1. Use the `vserver show` command with the `-instance` option to display the name of the default quota policy that was automatically created when the SVM was created.

If a name was not specified when the SVM was created, the name is "default". You can also use the `vserver quota policy rename` command to give the default policy a name.

> You can also create a new policy by using the `volume quota policy create` command.

2. Use the `volume quota policy rule create` command to create *any* of the following quota rules for each volume on the SVM:
   - Default quota rules for all users
   - Explicit quota rules for specific users
   - Default quota rules for all groups
   - Explicit quota rules for specific groups
   - Default quota rules for all qtrees
   - Explicit quota rules for specific qtrees
3. Use the `volume quota policy rule show` command to check that the quota rules are configured correctly.
4. If you are working on a new policy, use the `vserver modify` command to assign the new policy to the SVM.
5. Use the `volume quota on` command to initialize the quotas on each volume on the SVM.

   You can monitor the initialization process in the following ways:

   - When you use the `volume quota on` command, you can add the `-foreground` parameter to run the quota on job in the foreground. (By default, the job runs in the background.)

     When the job runs in the background, you can monitor its progress by using the `job show` command.
   - You can use the `volume quota show` command to monitor the status of the quota initialization.
6. Use the `volume quota show -instance` command to check for initialization errors, such as quota rules that failed to initialize.
7. Use the `volume quota report` command to display a quota report so that you can ensure the enforced quotas match your expectations.

#### Modify (or Resizing) quota limits

When you make changes to the size of existing quotas, you can resize the quotas on all affected volumes, which is faster than reinitializing quotas on those volumes.

##### About this task

You have a storage virtual machine (SVM, formerly known as Vserver) with enforced quotas and you want either to change the size limits of existing quotas or to add or delete quotas for targets that already have derived quotas.

##### Steps

1. Use the `vserver show` command with the `-instance` parameter to determine the name of the policy that is currently assigned to the SVM.

2. Modify quota rules by performing any of the following actions:
   - Use the `volume quota policy rule modify` command to modify the disk or file limits of existing quota rules.
   - Use the `volume quota policy rule create` command to create explicit quota rules for targets (users, groups, or qtrees) that currently have derived quotas.
   - Use the `volume quota policy rule delete` command to delete explicit quota rules for targets (users, groups, or qtrees) that also have default quotas.
3. Use the `volume quota policy rule show` command to check that the quota rules are configured correctly.
4. Use the `volume quota resize` command on each volume where you changed quotas, to activate the changes on each volume.

   You can monitor the resize process in either of the following ways:
   - When you use the `volume quota resize` command, you can add the `-foreground` parameter to run the resize job in the foreground. (By default, the job runs in the background.)

     When the job runs in the background, you can monitor its progress by using the `job show` command.
   - You can use the `volume quota show` command to monitor the resize status.
5. Use the `volume quota show -instance` command to check for resize errors such as, quota rules that failed to get resized.

   In particular, check for “new definition” errors, which occur when you resize quotas after adding an explicit quota for a target that does not already have a derived quota.
6. Use the `volume quota report` command to display a quota report so that you can ensure the enforced quotas match your requirements.

#### Reinitialize quotas after making extensive changes

## When you make extensive changes to existing quotas; for example, by adding or deleting quotas for targets that have no enforced quotas-- you must make the changes and re-initialize quotas on all affected volumes.

#### About this task

You have a storage virtual machine (SVM) with enforced quotas and you want to make changes that require a full reinitialization of quotas.

#### Steps

1. Use the `vserver show` command with the `-instance` parameter to determine the name of the policy that is currently assigned to the SVM.
2. Modify quota rules by performing any of the following actions:

| If you want to… | Then… |
| --- | --- |
| Create new quota rules | Use the `volume quota policy rule create` command |

| If you want to… | Then… |
| --- | --- |
| Modify the settings of existing quota rules | Use the `volume quota policy rule modify` command |
| Delete existing quota rules | Use the `volume quota policy rule delete` command |

3. Use the `volume quota policy rule show` command to check that the quota rules are configured correctly.
4. Re-initialize quotas on each volume where you changed quotas by turning quotas off and then turning quotas on for those volumes.
   a. Use the `volume quota off` command on each affected volume to deactivate quotas on that volume.
   b. Use the `volume quota on` command on each affected volume to activate quotas on that volume.

> You must ensure that you wait for about five minutes before reactivating the quotas on each affected volume, as attempting to activate them almost immediately after running the `volume quota off` command might result in errors.
>
> Alternatively, you can run the commands to re-initialize the quotas for a volume from the node that contains the particular volume.

   You can monitor the initialization process in either of the following ways:

   - When you use the `volume quota on` command, you can add the `-foreground` parameter to run the quota on job in the foreground. (By default, the job runs in the background.)

     When the job runs in the background, you can monitor its progress by using the `job show` command.

   - You can use the `volume quota show` command to monitor the status of the quota initialization.

5. Use the `volume quota show -instance` command to check for initialization errors, such as quota rules that failed to initialize.
6. Use the `volume quota report` command to display a quota report so that you can ensure the enforced quotas match your expectations.

#### Commands to manage quota rules and quota policies

You can use the `volume quota policy rule` commands to configure quota rules, and use the `volume quota policy` commands and some `vserver` commands to configure quota policies.

> You can run the following commands only on FlexVol volumes.

##### Commands for managing quota rules

| If you want to… | Use this command… |
| --- | --- |
| Create a new quota rule | `volume quota policy rule create` |
| Delete an existing quota rule | `volume quota policy rule delete` |
| Modify an existing quota rule | `volume quota policy rule modify` |
| Display information about configured quota rules | `volume quota policy rule show` |

#### Commands for managing quota policies

| If you want to… | Use this command… |
| --- | --- |
| Duplicate a quota policy and the quota rules it contains | `volume quota policy copy` |
| Create a new, blank quota policy | `volume quota policy create` |
| Delete an existing quota policy that is not currently assigned to a storage virtual machine (SVM) | `volume quota policy delete` |
| Rename a quota policy | `volume quota policy rename` |
| Display information about quota policies | `volume quota policy show` |
| Assign a quota policy to anSVM | `vserver modify` |
| Display the name of the quota policy assigned to anSVM | `vserver show` |

See the man page for each command for more information.

#### Commands to activate and modify quotas

You can use the `volume quota` commands to change the state of quotas and configure message logging of quotas.

| If you want to… | Use this command… |
| --- | --- |
| Turn quotas on (also called *initializing* them) | `volume quota on` |
| Resize existing quotas | `volume quota resize` |
| Turn quotas off | `volume quota off` |

| If you want to… | Use this command… |
| --- | --- |
| Change the message logging of quotas, turn quotas on, turn quotas off, or resize existing quotas | `volume quota modify` |

See the man page for each command for more information.

## Use deduplication, data compression, and data compaction to increase storage efficiency

### Use deduplication, data compression, and data compaction to increase storage efficiency overview

You can run deduplication, data compression, and data compaction together or independently to achieve optimal space savings on a FlexVol volume. Deduplication eliminates duplicate data blocks. Data compression compresses the data blocks to reduce the amount of physical storage that is required. Data compaction stores more data in less space to increase storage efficiency.

Beginning with ONTAP 9.2, all inline storage efficiency features, such as inline deduplication and inline compression, are enabled by default on AFF volumes.

### Enable deduplication on a volume

You can enable deduplication on a FlexVol volume to achieve storage efficiency. You can enable postprocess deduplication on all volumes and inline deduplication on volumes that reside on AFF or Flash Pool aggregates. You must contact technical support if you want to enable inline deduplication on other types of volumes.

#### What you'll need

For a FlexVol volume, you must have verified that enough free space exists for deduplication metadata in volumes and aggregates. The deduplication metadata requires a minimum amount of free space in the aggregate. This amount is equal to 3% of the total amount of physical data for all deduplicated FlexVol volumes or data constituents within the aggregate. Each FlexVol volume or data constituent should have 4% of the total amount of physical data's worth of free space, for a total of 7%.

Beginning with ONTAP 9.2, inline deduplication is enabled by default on AFF systems.

#### Choices

- Use the `volume efficiency on` command to enable postprocess deduplication.

  The following command enables postprocess deduplication on volume VolA:

  ```
  volume efficiency on -vserver vs1 -volume VolA
  ```

- Use the `volume efficiency on` command followed by the `volume efficiency modify` command with the `-inline-deduplication` option set to `true` to enable both postprocess deduplication and inline deduplication.

  The following commands enable both postprocess deduplication and inline deduplication on volume VolA:

```
volume efficiency on -vserver vs1 -volume VolA

volume efficiency modify -vserver vs1 -volume VolA -inline-dedupe true
```

- Use the `volume efficiency on` command followed by the `volume efficiency modify` command with the `-inline-deduplication` option set to `true` and the `-policy` option set to `inline-only` to enable only inline deduplication.

  The following commands enable only inline deduplication on volume VolA:

  ```
  volume efficiency on -vserver vs1 -volume VolA

  volume efficiency modify -vserver vs1 -volume VolA -policy inline-only -inline
  -dedupe true
  ```

#### After you finish

Verify that the setting has changed by viewing the volume efficiency settings:
`volume efficiency show -instance`

### Disable deduplication on a volume

You can disable postprocess deduplication and inline deduplication independently on a volume.

#### What you'll need

Stop any volume efficiency operation that is currently active on the volume: `volume efficiency stop`

#### About this task

If you have enabled data compression on the volume, running the `volume efficiency off` command disables data compression.

#### Choices

- Use the `volume efficiency off` command to disable both postprocess deduplication and inline deduplication.

  The following command disable both postprocess deduplication and inline deduplication on volume VolA:

  ```
  volume efficiency off -vserver vs1 -volume VolA
  ```

- Use the `volume efficiency modify` command with the `-policy` option set to `inline only` to disable postprocess deduplication, but inline deduplication remains enabled.

  The following command disables postprocess deduplication, but inline deduplication remains enabled on volume VolA:

  ```
  volume efficiency modify -vserver vs1 -volume VolA -policy inline-only
  ```

- Use the `volume efficiency modify` command with the `-inline-deduplication` option set to `false` to disable inline deduplication only.

  The following command disables only inline deduplication on volume VolA:

```
volume efficiency modify -vserver vs1 -volume VolA -inline-deduplication false
```

### Manage automatic volume-level background deduplication on AFF systems

Beginning with ONTAP 9.3, volume-level background deduplication can be managed to run automatically using a predefined `auto` AFF policy. No manual configuration of the schedules is required. The `auto` policy performs continuous deduplication in the background.

The `auto` policy is set for all newly created volumes and for all upgraded volumes that have not been manually configured for background deduplication. You can change the policy to `default` or any other policy to disable the feature.

If a volume moves from a non-AFF system to an AFF system, the `auto` policy is enabled on the destination node by default. If a volume moves from an AFF node to a non-AFF node, the `auto` policy on the destination node is replaced by the `inline-only` policy by default.

On AFF, the system monitors all the volumes having the `auto` policy and deprioritizes the volume that has less savings or has frequent overwrites. The deprioritized volumes no longer participate in automatic background deduplication. Change logging on deprioritized volumes is disabled and metadata on the volume is truncated.

Users can promote the deprioritized volume to re-participate in an automatic background deduplication using the `volume efficiency promote` command available at the advanced privilege level.

### Manage aggregate-level inline deduplication on AFF systems

Aggregate-level deduplication eliminates duplicate blocks across volumes belonging to the same aggregate. Beginning with ONTAP 9.2, you can perform aggregate-level deduplication inline on AFF systems. The feature is enabled by default for all newly created volumes and all upgraded volumes with volume inline deduplication turned on.

#### About this task

The deduplication operation eliminates duplicate blocks before data is written to disk. Only volumes with the `space guarantee` set to `none` can participate in aggregate-level inline deduplication. This is the default setting on AFF systems.

> Aggregate-level inline deduplication is sometimes referred to as cross-volume inline deduplication.

#### Step

1. Manage aggregate-level inline deduplication on AFF systems:

| If you want to… | Use this command |
|---|---|
| Enable aggregate-level inline deduplication | `volume efficiency modify -vserver vserver_name -volume vol_name -cross -volume-inline-dedupe true` |

| If you want to… | Use this command |
| --- | --- |
| Disable aggregate-level inline deduplication | `volume efficiency modify -vserver vserver_name -volume vol_name -cross -volume-inline-dedupe false` |
| Display aggregate-level inline deduplication status | `volume efficiency config -volume vol_name` |

**Examples**

The following command displays the aggregate-level inline deduplication status:

```
wfit-8020-03-04::> volume efficiency config -volume choke0_wfit_8020_03_0
Vserver:                                    vs0
Volume:                                     choke0_wfit_8020_03_0
Schedule:                                   -
Policy:                                     choke_VE_policy
Compression:                                true
Inline Compression:                         true
Inline Dedupe:                              true
Data Compaction:                            true
Cross Volume Inline Deduplication:          false
```

#### Manage aggregate-level background deduplication on AFF systems

Aggregate-level deduplication eliminates duplicate blocks across volumes belonging to the same aggregate. Beginning with ONTAP 9.3, you can perform aggregate-level deduplication in the background on AFF systems. The feature is enabled by default for all newly created volumes and all upgraded volumes with volume background deduplication turned on.

**About this task**

The operation is triggered automatically when a large enough percentage of the change log has been populated. No schedule or policy is associated with the operation.

Beginning with ONTAP 9.4, AFF users can also run the aggregate-level deduplication scanner to eliminate duplicates of existing data across volumes in the aggregate. You can use the `storage aggregate efficiency cross-volume-dedupe start` command with the `-scan-old-data=true` option to start the scanner:

```
cluster-1::> storage aggregate efficiency cross-volume-dedupe start
-aggregate aggr1 -scan-old-data true
```

Deduplication scanning can be time-consuming. You might want to run the operation in off-peak hours.

Aggregate-level background deduplication is sometimes referred to as cross-volume background deduplication.

**Step**

1. Manage aggregate-level background deduplication on AFF systems:

| If you want to… | Use this command |
|---|---|
| Enable aggregate-level background deduplication | `volume efficiency modify -vserver <vserver_name\> -volume <vol_name\> -cross-volume-background-dedupe true` |
| Disable aggregate-level background deduplication | `volume efficiency modify -vserver <vserver_name\> -volume <vol_name\> -cross-volume-background-dedupe false` |
| Display aggregate-level background deduplication status | `aggregate efficiency cross-volume-dedupe show` |

### Temperature-sensitive storage efficiency overview

Temperature-sensitive storage efficiency was introduced in ONTAP 9.8 and was enabled automatically on newly created thin-provisioned AFF volumes. Starting with ONTAP 9.10.1, you enable temperature-sensitive storage efficiency on newly created AFF volumes and on existing AFF volumes. Additionally, two modes are introduced: default, which is the performance-based mode, which is enabled by default, and efficient mode, which you must enable.

Accomplishing storage efficiency depends on a correct assessment of your data's "temperature;" meaning, how frequently the data is accessed. Temperature-sensitive storage efficiency is determined by the temperature of a volume's data. For cold data, larger data blocks are compressed, and for hot data, which is overwritten more often, smaller data blocks are compressed, making the process more efficient.

Both storage efficiency modes are supported on FabricPool-enabled aggregates and with all tiering policy types.

#### Upgrade considerations

When upgrading to Data ONTAP 9.10.1, existing volumes are assigned a storage efficiency mode based on the type of compression currently enabled on the volumes. During an upgrade, volumes with compression enabled are assigned the default mode, and volumes with temperature-sensitive storage efficiency enabled are assigned the efficient mode. If compression is not enabled, storage efficiency mode remains blank.

### Set storage efficiency mode during volume creation

Beginning with ONTAP 9.10.1, you can set the storage efficiency mode when creating a new AFF volume. Using the parameter `-storage-efficiency-mode`, you can specify whether the volume uses either the efficient mode or the default performance mode. The

`-storage-efficiency-mode` parameter is not supported on non-AFF volumes or on data protection volumes.

#### Create a new volume using efficient mode

To set the efficiency mode when enabling storage efficiency, you can use the `-storage-efficiency-mode` parameter with the value `efficient`.

**Step**

1. Create a new volume with efficiency mode enabled:

   **`volume create -vserver <vserver name> -volume <volume name> -aggregate <aggregate name> -size <volume size> -storage-efficiency-mode efficient`**

   ```
   volume create -vserver vs1 -volume aff_vol1 -aggregate aff_aggr1
   -storage-efficiency-mode efficient -size 10g
   ```

#### Create a new volume using performance modes

Performance mode is set by default when you create new AFF volumes with temperature-sensitive storage efficiency. Optionally, you can use the `default` value with the `-storage-efficiency-mode` parameter.

**Step**

1. Create a new volume with efficiency mode enabled:

   **`volume create -vserver <vserver name> -volume <volume name> -aggregate <aggregate name> -size <volume size> -storage-efficiency-mode default`**

   ```
   volume create -vserver vs1 -volume aff_vol1 -aggregate aff_aggr1
   -storage-efficiency-mode default -size 10g
   ```

#### System Manager procedure

Beginning with ONTAP 9.10.1, you can use System Manager to enable higher storage efficiency using the temperature-sensitive storage efficiency feature. Performance-based storage efficiency is enabled by default.

1. Click **Storage > Volumes**.
2. Locate the volume on which you want to enable or disable storage efficiency, and click ⋮.
3. Click **Edit**, and scroll to **Storage Efficiency**.
4. Select **Enable Higher Storage Efficiency**.

### Check volume efficiency mode

You can use the `volume-efficiency-show` command on an AFF volume to check whether efficiency is set and to view the current efficiency mode.

**Step**

1. Check the efficiency mode on a volume:

```
volume efficiency show -vserver <vserver name> -volume <volume name> -fields
storage-efficiency-mode
```

### Change volume efficiency mode

You can use the `volume efficiency modify` command to change the storage efficiency mode that's set on an AFF volume. You can change the mode from `default` to `efficient` or you can set an efficiency mode when volume efficiency is not already set.

#### Steps

1. Change the volume efficiency mode:

```
volume efficiency modify -vserver <vserver name> -volume <volume name>
-storage-efficiency-mode <default|efficient>
```

### Enable data compression on a volume

You can enable data compression on a volume to achieve space savings by using the `volume efficiency modify` command. You can enable data compression on a FlexVol volume to achieve space savings by using the `volume efficiency modify` command. You can also assign a compression type to your volume, if you do not want the default compression type.

#### What you'll need

You must have enabled deduplication on the volume.

- Deduplication only needs to be enabled and does not need to be running on the volume.
- The compression scanner must be used to compress the existing data on the volumes present in AFF platforms.

Enabling deduplication on a volume

#### About this task

- In HDD aggregates and Flash Pool aggregates, you can enable both inline and postprocess compression or only postprocess compression on a volume.

  If you are enabling both, then you must enable postprocess compression on the volume before enabling inline compression.

- In AFF platforms, only inline compression is supported.

  Before enabling inline compression, you must enable postprocess compression on the volume. However, because postprocess compression is not supported in AFF platforms, no postprocess compression takes place on those volumes and an EMS message is generated informing you that postprocess compression was skipped.

- Temperature sensitive storage efficiency is introduced in ONTAP 9.8. With this feature, storage efficiency is applied according to whether data is hot or cold. For cold data, larger data blocks are compressed, and for

hot data, which is overwritten more often, smaller data blocks are compressed, making the process more efficient. Temperature sensitive storage efficiency is enabled automatically on newly created thin-provisioned AFF volumes.

- The compression type is automatically assigned based on the aggregate's platform:

| Platform/aggregates | Compression type |
|---|---|
| AFF | Adaptive compression |
| Flash Pool aggregates | Adaptive compression |
| HDD aggregates | Secondary compression |

**Choices**

- Use the `volume efficiency modify` command to enable data compression with the default compression type.

  The following command enables postprocess compression on volume VolA of SVM vs1:

  ```
  volume efficiency modify -vserver vs1 -volume VolA -compression true
  ```

  The following command enables both postprocess and inline compression on volume VolA of SVM vs1:

  ```
  volume efficiency modify -vserver vs1 -volume VolA -compression true -inline
  -compression true
  ```

- Use the `volume efficiency modify` command at the advanced privilege level to enable data compression with a specific compression type.
  a. Use the `set -privilege advanced` command to change the privilege level to advanced.
  b. Use the `volume efficiency modify` command to assign a compression type to a volume.

     The following command enables postprocess compression and assigns the adaptive compression type to volume VolA of SVM vs1:

     ```
     volume efficiency modify -vserver vs1 -volume VolA -compression true
     -compression-type adaptive
     ```

     The following command enables both postprocess and inline compression and assigns the adaptive compression type to volume VolA of SVM vs1:

     ```
     volume efficiency modify -vserver vs1 -volume VolA -compression true
     -compression-type adaptive -inline-compression true
     ```

  c. Use the `set -privilege admin` command to change the privilege level to admin.

**Move between secondary compression and adaptive compression**

You can switch between secondary compression and adaptive compression depending on the amount of data reads. Adaptive compression is preferred when there are a high

volume of random reads on the system and higher performance is required. Secondary compression is preferred when data is written sequentially and higher compression savings are required.

**About this task**

The default compression type is selected based on your aggregates and platform.

**Steps**

1. Disable data compression on the volume:

   ```
   volume efficiency modify
   ```

   The following command disables data compression on volume vol1:

   ```
   volume efficiency modify -compression false -inline-compression false -volume
   vol1
   ```

2. Change to the advanced privilege level:

   ```
   set -privilege advanced
   ```

3. Decompress the compressed data:

   ```
   volume efficiency undo
   ```

   The following command decompresses the compressed data on volume vol1:

   ```
   volume efficiency undo -vserver vs1 -volume vol1 -compression true
   ```

   > You must verify that you have sufficient space in the volume to accommodate the decompressed data.

4. Verify that the status of the operation is idle:

   ```
   volume efficiency show
   ```

   The following command displays the status of an efficiency operation on volume vol1:

   ```
   volume efficiency show -vserver vs1 -volume vol1
   ```

5. Enable data compression, and then set the type of compression:

   ```
   volume efficiency modify
   ```

   The following command enables data compression and sets the compression type as secondary compression on volume vol1:

   ```
   volume efficiency modify -vserver vs1 -volume vol1 -compression true
   -compression-type secondary
   ```

This step only enables secondary compression on the volume; the data on the volume is not compressed.

- To compress existing data on AFF systems, you must run the background compression scanner.
- To compress existing data on Flash Pool aggregates or HDD aggregates, you must run the background compression.

6. Change to the admin privilege level:

   ```
   set -privilege admin
   ```

7. Optional: Enable inline compression:

   ```
   volume efficiency modify
   ```

   The following command enables inline compression on volume vol1:

   ```
   volume efficiency modify -vserver vs1 -volume vol1 -inline-compression true
   ```

### Disable data compression on a volume

You can disable data compression on a volume by using the `volume efficiency modify` command.

#### About this task

If you want to disable postprocess compression, you must first disable inline compression on the volume.

#### Steps

1. Stop any volume efficiency operation that is currently active on the volume:

   ```
   volume efficiency stop
   ```

2. Disable data compression:

   ```
   volume efficiency modify
   ```

   Existing compressed data will remain compressed on the volume. Only new writes coming into the volume are not compressed.

#### Examples

The following command disables inline compression on volume VolA:

```
volume efficiency modify -vserver vs1 -volume VolA -inline-compression false
```

The following command disables both postprocess compression and inline compression on volume VolA:

```
volume efficiency modify -vserver vs1 -volume VolA -compression false -inline
-compression false
```

### Manage inline data compaction for AFF systems

You can control inline data compaction on AFF systems at the volume level using the `volume efficiency modify` command. Data compaction is enabled by default for all volumes on AFF systems.

#### What you'll need

Data compaction requires that the volume space guarantee be set to `none`. This is the default for AFF systems.

> The default space guarantee on non-AFF data protection volumes is set to none.

#### Steps

1. To verify the space guarantee setting for the volume:

   ```
   volume show -vserver vserver_name -volume volume_name –fields space-guarantee
   ```

2. To enable data compaction:

   ```
   volume efficiency modify -vserver vserver_name -volume volume_name -data
   -compaction true
   ```

3. To disable data compaction:

   ```
   volume efficiency modify -vserver vserver_name -volume volume_name -data
   -compaction false
   ```

4. To display data compaction status:

   ```
   volume efficiency show -instance
   ```

#### Examples

```
cluster1::> volume efficiency modify -vserver vs1 -volume vol1 -data-compaction
true cluster1::> volume efficiency modify -vserver vs1 -volume vol1 -data
-compaction false
```

### Enable inline data compaction for FAS systems

You can control inline data compaction on FAS systems with Flash Pool (hybrid) aggregates or HDD aggregates at the volume or aggregate level by using the `volume efficiency` cluster shell command. Data compaction is disabled by default for FAS systems.

#### About this task

If you enable data compaction at the aggregate level, data compaction is enabled on any new volume that is created with a volume space guarantee of `none` in the aggregate. Enabling data compaction on a volume on an HDD aggregate uses additional CPU resources.

#### Steps

1. Change to the advanced privilege level:

```
set -privilege advanced
```

2. Check the data compaction state of the volumes and aggregates for the desired node:
`volume efficiency show -volume volume_name` +
3. Enable data compaction on volume:
`volume efficiency modify -volume volume_name -data-compaction true`

> If data compaction is set to `false` for either an aggregate or a volume, then compaction fails. Enabling compaction does not compact existing data; only new writes to the system are compacted. The `volume efficiency start` command contains more information about how to compact existing data (in ONTAP 9.1 and later).
> ONTAP 9 commands

4. View the compaction statistics:
`volume efficiency show -volume volume_name`

#### Inline storage efficiency enabled by default on AFF systems

Storage efficiency features are currently enabled by default on all newly created volumes on AFF systems. Beginning with ONTAP 9.2, all inline storage efficiency features are enabled by default on all existing and newly created volumes on all AFF systems.

Storage efficiency features include inline deduplication, inline cross-volume deduplication and inline compression, and are enabled by default on AFF systems as shown in the table.

> Data compaction behavior on AFF volumes is unchanged in ONTAP 9.2 as it is already enabled by default.

| Volume conditions | Storage efficiency features enabled by default in ONTAP 9.2 | | |
|---|---|---|---|
| | Inline deduplication | Inline cross-volume deduplication | Inline compression |
| Cluster upgrade to 9.2 | Yes | Yes | Yes |
| ONTAP 7-Mode transition to clustered ONTAP | Yes | Yes | Yes |
| Volume move | Yes | Yes | Yes |
| Thick-provisioned volumes | Yes | No | Yes |
| Encrypted volumes | Yes | No | Yes |

The following exceptions apply to one or more inline storage efficiency features:

- Only read-write volumes can support default inline storage efficiency enablement.
- Volumes with compression savings are omitted from enabling inline compression.

- Volumes that have postprocess deduplication turned on are omitted from enabling inline compression.
- On volumes where volume efficiency is turned off, the system overrides the existing volume efficiency policy settings and sets it to enable the inline-only policy.

**Enable storage efficiency visualization**

## Use the `storage aggregate show-efficiency` command to display information about the storage efficiency of all the aggregates in your system.

The `storage aggregate show-efficiency` command has three different views that can be invoked by passing command options.

#### Default view

The default view displays the overall ratio for each of the aggregates.

```
cluster1::> storage aggregate show-efficiency
```

#### Detailed view

Invoke the detailed view with the `-details` command option. This view displays the following:

- Overall efficiency ratio for each of the aggregates.
- Overall ratio without Snapshot copies.
- Ratio split for the following efficiency technologies: volume deduplication, volume compression, Snapshot copies, clones, data compaction, and aggregate inline deduplication.

```
cluster1::> storage aggregate show-efficiency -details
```

#### Advanced view

The advanced view is similar to the detailed view and displays the logical and physical used details. The view was enhanced to now display the efficiency technologies separately.

You must run this command at the advanced privilege level. Switch to advanced privilege by using the `set -privilege advanced` command.

The command prompt changes to `cluster::*>`.

```
cluster1::> set -privilege advanced
```

Invoke the advanced view with the `-advanced` command option.

```
cluster1::*> storage aggregate show-efficiency -advanced
```

To view ratios for a single aggregate individually invoke the `-aggregate <name>` command. This command can be run at the admin level, as well as the advanced privilege level.

```
cluster1::> storage aggregate show-efficiency -aggregate aggr1
```

## Create a volume efficiency policy to run efficiency operations

### Create a volume efficiency policy to run efficiency operations

You can create a volume efficiency policy to run deduplication or data compression followed by deduplication on a volume for a specific duration, and specify the job schedule using the `volume efficiency policy create` command.

#### What you'll need

You must have created a cron schedule using the `job schedule cron create` command. For more information about managing the cron schedules, see the System administration reference.

#### About this task

An SVM administrator with default predefined roles cannot manage the deduplication policies. However, the cluster administrator can modify the privileges assigned to an SVM administrator by using any customized roles. For more information about the SVM administrator capabilities, see Administrator authentication and RBAC.

> You can run deduplication or data compression operations at a scheduled time, or by creating a schedule with a specific duration, or by specifying a threshold percentage, which waits for the new data to exceed the specified percentage and then triggers the deduplication or data compression operation. This threshold value is the percentage of the total number of blocks used in the volume. You can obtain the total number of blocks used from the `df` command output.

#### Steps

1. Use the `volume efficiency policy create` command to create a volume efficiency policy.

#### Examples

The following command creates a volume efficiency policy named pol1 that triggers an efficiency operation daily:

```
volume efficiency policy create -vserver vs1 -policy pol1 -schedule daily
```

The following command creates a volume efficiency policy named pol2 that triggers an efficiency operation when the threshold percentage reaches 20%:

```
volume efficiency policy create -vserver vs1 -policy pol2 -type threshold -start
-threshold-percent 20%
```

### Assign a volume efficiency policy to a volume

You can assign an efficiency policy to a volume to run deduplication or data compression operation by using the `volume efficiency modify` command.

#### About this task

If an efficiency policy is assigned to a SnapVault secondary volume, only the volume efficiency priority attribute is considered when running volume efficiency operations. The job schedules are ignored and the deduplication operation is run when incremental updates are made to the SnapVault secondary volume.

#### Step

1. Use the `volume efficiency modify` command to assign a policy to a volume.

**Example**

The following command assigns the volume efficiency policy named new_policy with volume VolA:

```
volume efficiency modify -vserver vs1 -volume VolA -policy new_policy
```

#### Modify a volume efficiency policy

You can modify a volume efficiency policy to run deduplication and data compression for a different duration or change the job schedule using the `volume efficiency policy modify` command.

**Step**

1. Use the `volume efficiency policy modify` command to modify a volume efficiency policy.

**Examples**

The following command modifies the volume efficiency policy named policy1 to run every hour:

```
volume efficiency policy modify -vserver vs1 -policy policy1 -schedule hourly
```

The following command modifies a volume efficiency policy named pol2 to threshold 30%:

```
volume efficiency policy modify -vserver vs1 -policy pol1 -type threshold -start
-threshold-percent 30%
```

#### View a volume efficiency policy

You can view the volume efficiency policy name, schedule, duration, and description by using the `volume efficiency policy show` command.

**About this task**

When you run the `volume efficiency policy show` command from the cluster scope, the cluster-scoped policies are not displayed. However, you can view the cluster-scoped policies in the storage virtual machine (SVM) context.

**Step**

1. Use the `volume efficiency policy show` command to view information about a volume efficiency policy.

   The output depends on the parameters you specify. For more information about displaying detailed view and other parameters, see the man page for this command.

**Examples**

The following command displays information about the policies created for the SVM vs1: `volume efficiency policy show -vserver vs1`

The following command displays the policies for which the duration is set as 10 hours: `volume efficiency policy show -duration 10`

#### Disassociate a volume efficiency policy from a volume

You can disassociate a volume efficiency policy from a volume to stop running any further schedule-based deduplication and data compression operations on the volume. Once you disassociate a volume efficiency policy, you have it trigger it manually.

**Step**

1. Use the `volume efficiency modify` command to disassociate a volume efficiency policy from a volume.

**Example**

The following command disassociates the volume efficiency policy from volume VolA: `volume efficiency modify -vserver vs1 -volume VolA -policy -`

#### Delete a volume efficiency policy

You can delete a volume efficiency policy by using the `volume efficiency policy delete` command.

**What you'll need**

You must have ensured that the policy you want to delete is not associated with any volume.

You cannot delete the *inline-only* and the *default* predefined efficiency policy.

**Step**

1. Use the `volume efficiency policy delete` command to delete a volume efficiency policy.

**Example**

The following command deletes a volume efficiency policy named policy1: `volume efficiency policy delete -vserver vs1 -policy policy1`

### Manage volume efficiency operations manually

#### Manage volume efficiency operations manually overview

You can manage how the efficiency operations run on a volume by running efficiency operations manually.

You can also control how the efficiency operations run based on the following conditions:

- Use checkpoints or not
- Run efficiency operations on existing data or only new data
- Stop efficiency operations if required

You can use the `volume efficiency show` command with `schedule` as value for the `-fields` option to view the schedule assigned to the volumes.

#### Run efficiency operations manually

You can run efficiency operations manually on a volume by using the `volume`

`efficiency start` command.

**What you'll need**

Depending on the efficiency operation you want to run manually, you must have enabled deduplication or both data compression and deduplication on a volume.

**About this task**

If deduplication and data compression are enabled on a volume, data compression is run initially followed by deduplication.

Deduplication is a background process that consumes system resources while it is running. If the data does not change often in a volume, it is best to run deduplication less frequently. Multiple concurrent deduplication operations running on a storage system lead to a higher consumption of system resources.

You can run a maximum of eight concurrent deduplication or data compression operations per node. If any more efficiency operations are scheduled, the operations are queued.

**Step**

1. Use the `volume efficiency start` command to start the efficiency operation on a volume.

**Example**

The following command allows you to manually start only deduplication or data compression followed by deduplication on the volume VolA:

```
volume efficiency start -vserver vs1 -volume VolA
```

#### Use checkpoints to resume efficiency operation

The checkpoints are used internally to log the execution process of an efficiency operation. When an efficiency operation is stopped for any reason (such as system halt, system disruption, reboot, or because last efficiency operation failed or stopped) and checkpoint data exists, the efficiency operation can resume from the latest checkpoint file.

A checkpoint is created:

- in each stage or substage of the operation
- when you run the `sis stop` command
- when the duration expires

#### Resume a halted efficiency operation

If an efficiency operation is halted due to a system halt, system disruption, or reboot, you can resume the efficiency operation from the same point by using the `volume efficiency start` command with the checkpoint option. This helps in saving time and resources by not having to restart the efficiency operation from the beginning.

**About this task**

If you enabled only deduplication on the volume, deduplication runs on the data. If you enabled both deduplication and data compression on a volume, then data compression runs first, followed by deduplication.

You can view the details of the checkpoint for a volume by using the `volume efficiency show` command.

By default, the efficiency operations resume from checkpoints. However, if a checkpoint corresponding to a previous efficiency operation (the phase when the `volume efficiency start`-scan-old-data` command is run) is older than 24 hours, then the efficiency operation does not resume from the previous checkpoint automatically. In this case, the efficiency operation starts from the beginning. However, if you know that significant changes have not occurred in the volume since the last scan, you can force continuation from the previous checkpoint by using the `-use-checkpoint` option.

**Step**

1. Use the `volume efficiency start` command with the `-use-checkpoint` option to resume an efficiency operation.

   The following command enables you to resume an efficiency operation on new data on volume VolA:

   ```
   volume efficiency start -vserver vs1 -volume VolA -use-checkpoint true
   ```

   The following command enables you to resume an efficiency operation on existing data on volume VolA:

   ```
   volume efficiency start -vserver vs1 -volume VolA -scan-old-data true -use
   -checkpoint true
   ```

#### Run efficiency operations manually on existing data

## You can run the efficiency operations manually on the data that exists in volumes prior to enabling deduplication, data compression, or data compaction. You can run these operations by using the `volume efficiency start -scan-old-data` command.

**About this task**

If you enable only deduplication on a volume, then deduplication runs on the data. If you enable deduplication, data compression, and data compaction on a volume, then data compression runs first, followed by deduplication and data compaction.

When you run data compression on existing data, by default the data compression operation skips the data blocks that are shared by deduplication and the data blocks that are locked by Snapshot copies. If you choose to run data compression on shared blocks, then optimization is turned off and the fingerprint information is captured and used for sharing again. You can change the default behavior of data compression when compressing existing data.

You can run a maximum of eight deduplication, data compression, or data compaction operations concurrently per node. The remaining operations are queued.

Postprocess compression does not run on AFF platforms. An EMS message is generated to inform you that this operation was skipped.

**Step**

1. Use the `volume efficiency start -scan-old-data` command to run deduplication, data compression, or data compaction manually on the existing data.

   The following command enables you to run these operations manually on the existing data in volume VolA:

   ```
   volume efficiency start -vserver vs1 -volume VolA -scan-old-data true [-
   ```

```
compression | -dedupe | -compaction ] true
```

## Manage volume efficiency operations using schedules

### Run efficiency operations depending on the amount of new data written

You can modify the efficiency operation schedule to run deduplication or data compression when the number of new blocks written to the volume after the previous efficiency operation (performed manually or scheduled) exceeds a specified threshold percentage.

#### About this task

If the `schedule` option is set to `auto`, the scheduled efficiency operation runs when the amount of new data exceeds the specified percentage. The default threshold value is 20 percent. This threshold value is the percentage of the total number of blocks already processed by the efficiency operation.

#### Step

1. Use the `volume efficiency modify` command with the `auto@num` option to modify the threshold percentage value.

   `num` is a two-digit number to specify the percentage.

#### Example

The following command modifies the threshold percentage value to 30 percent for the volume VolA:

```
volume efficiency modify -vserver vs1 -volume -VolA -schedule auto@30
```

### Run efficiency operations using scheduling

You can modify the scheduling of deduplication or data compression operation on a volume by using the `volume efficiency modify` command. The configuration options of a schedule and volume efficiency policy are mutually exclusive.

#### Step

1. Use the `volume efficiency modify` command to modify the scheduling of deduplication or data compression operations on a volume.

#### Examples

The following command modifies the scheduling of efficiency operations for VolA to run at 11 p.m., Monday through Friday:

```
volume efficiency modify -vserver vs1 -volume VolA -schedule mon-fri@23
```

## Monitor volume efficiency operations

### View the status of efficiency operations

You can view whether deduplication or data compression is enabled on a volume. You can also view the status, state, type of compression, and progress of the efficiency operations on a volume by using the `volume efficiency show` command.

**Step**

1. Use the `volume efficiency show` command to view the status of an efficiency operation on a volume.

   The following command displays the status of an efficiency operation on volume VolA that is assigned the adaptive compression type:

   ```
   volume efficiency show -instance -vserver vs1 -volume VolA
   ```

   If the efficiency operation is enabled on volume VolA and the operation is idle, then you can see the following in the system output:

   ```
   cluster1::> volume efficiency show -vserver vs1 -volume VolA

     Vserver Name: vs1
      Volume Name: VolA
      Volume Path: /vol/VolA
            State: Enabled
           Status: Idle
         Progress: Idle for 00:03:20
   ```

#### View efficiency space savings

## You can view the amount of space savings achieved through deduplication and data compression on a volume by using the `volume show` command.

**About this task**

The space savings in Snapshot copies are not included when calculating the space savings achieved on a volume. Using deduplication does not affect volume quotas. Quotas are reported at the logical level, and remain unchanged.

**Step**

1. Use the `volume show` command to view space savings achieved on a volume using deduplication and data compression.

**Example**

The following command enables you to view the space savings achieved by using deduplication and data compression on volume VolA: `volume show -vserver vs1 -volume VolA`

```
cluster1::> volume show -vserver vs1 -volume VolA

                                  Vserver Name: vs1
                                   Volume Name: VolA

...
            Space Saved by Storage Efficiency: 115812B
       Percentage Saved by Storage Efficiency: 97%
                 Space Saved by Deduplication: 13728B
            Percentage Saved by Deduplication: 81%
                Space Shared by Deduplication: 1028B
                   Space Saved by Compression: 102084B
        Percentage Space Saved by Compression: 97%

...
```

#### View efficiency statistics of a FlexVol volume

You can view the details of the efficiency operations run on a FlexVol volume by using the `volume efficiency stat` command.

**Step**

1. Use the `volume efficiency stat` command to view the statistics of efficiency operations on a FlexVol volume.

**Example**

The following command enables you to view the statistics of the efficiency operations on the volume VolA: `volume efficiency stat -vserver vs1 -volume VolA`

```
cluster1::> volume efficiency stat -vserver vs1 -volume VolA

               Vserver Name: vs1
                Volume Name: VolA
                Volume Path: /vol/VolA
Inline Compression Attempts: 0
```

#### Stop volume efficiency operations

You can stop a deduplication or postprocess compression operation by using the `volume efficiency stop` command. This command automatically generates a checkpoint.

**Step**

1. Use the `volume efficiency stop` command to stop an active deduplication or postprocess compression operation.

If you specify the `-all` option, active and queued efficiency operations are aborted.

#### Examples

The following command stops the deduplication or postprocess compression operation that is currently active on volume VolA:

```
volume efficiency stop -vserver vs1 -volume VolA
```

The following command aborts both active and queued deduplication or postprocess compression operations on volume VolA:

```
volume efficiency stop -vserver vs1 -volume VolA -all true
```

#### Information about removing space savings from a volume

You can choose to remove the space savings achieved by running efficiency operations on a volume. You must ensure that you contact technical support before removing or undoing the space savings on a volume.

## Rehost a volume from one SVM to another SVM

#### Rehost a volume from one SVM to another SVM overview

Volume rehost enables you to reassign NAS or SAN volumes from one storage virtual machine (SVM, formerly known as Vserver) to another SVM without requiring a SnapMirror copy. The volume rehost procedures depend upon the protocol type and the volume type. Volume rehost is a disruptive operation for data access and volume management.

#### What you'll need

Several conditions must be met before you can rehost a volume from one SVM to another:

- The volume must be online.
- Protocols: SAN or NAS

  For the NAS protocol, the volume must be unmounted.

- If the volume is in a SnapMirror relationship, then the relationship must be either deleted or broken prior to volume rehost.

  You can resynchronize the SnapMirror relationship after the volume rehost operation.

#### Rehost CIFS volumes

You can rehost volumes that serve data over SMB protocol. After rehosting the CIFS volume, to continue accessing data over SMB protocol, you must manually configure policies and the associated rules.

#### What you'll need

- Volume must be online.
- Volume management operations, such as volume move or LUN move, must not be running.
- Data access to the volume that is being rehosted must be stopped.
- The ns-switch and name services configuration of the target SVM must be configured to support data access of the rehosting volume.
- The source SVM and destination SVM must have the same Active Directory and realmDNS domain.
- The user ID and group ID of the volume must be either available in the target SVM or changed on the hosting volume.

> If local users and groups are configured, and if there are files and directories on that volume with permissions set for those users or groups, these permissions are no longer effective.

**About this task**

- Rehosting is a disruptive operation.
- If the rehosting operation fails, you might need to reconfigure the volume policies and the associated rules on the source volume.
- If the source SVM and destination SVM Active Directory domains differ, you might lose access to the objects on the volume.
- When the source SVM has local users and groups, the permissions for the files and directories (ACLs) that are set are no longer effective after volume rehost operation.

  The same is true for audit ACLs (SACLs)

- After the rehost operation, the following volume policies, policy rules, and configurations are lost from the source volume, and must be manually reconfigured on the rehosted volume:
  - Volume and qtree export policies
  - Antivirus policies
  - Volume efficiency policy
  - Quality of service (QoS) policies
  - Snapshot policies
  - Quota rules
  - ns-switch and name services configuration export policy and rules
  - User and group IDs

**Steps**

1. Record information about the CIFS shares to avoid losing information on CIFS shares in case volume rehost operation fails.
2. Unmount the volume from the parent volume:

   ```
   volume unmount
   ```

3. Switch to the advanced privilege level:

   ```
   set -privilege advanced
   ```

4. Rehost the volume on the destination SVM:

   ```
   volume rehost -vserver source_svm -volume vol_name -destination-vserver
   destination_svm
   ```

5. Mount the volume under the appropriate junction path in the destination SVM:

   ```
   volume mount
   ```

6. Create CIFS shares for the rehosted volume:

   ```
   vserver cifs share create
   ```

7. If the DNS domains differ between the source SVM and destination SVM, create new users and groups.
8. Update the CIFS client with the new destination SVM LIFs and junction path to the rehosted volume.

**After you finish**

You must manually reconfigure the policies and the associated rules on the rehosted volume.

SMB configuration

SMB and NFS multiprotocol configuration

### Rehost NFS volumes

You can rehost volumes that serve data over NFS protocol. After rehosting the NFS volumes, to continue accessing data over NFS protocol, you must associate the volume with the export policy of the hosting SVM and manually configure policies and associated rules.

**What you'll need**

- The volume must be online.
- Volume management operations, such as volume moves or LUN moves, must not be running.
- Data access to the volume that is being rehosted must be stopped.
- The ns-switch and name services configuration of the target SVM must be configured to support data access of the rehosting volume.
- The user ID and group ID of the volume must be either available in the target SVM or changed on the hosting volume.

**About this task**

- Rehosting is a disruptive operation.
- If the rehosting operation fails, you might need to reconfigure the volume policies and the associated rules on the source volume.
- After the rehost operation, the following volume policies, policy rules, and configurations are lost from the source volume, and must be manually reconfigured on the rehosted volume:
  - Volume and qtree export policies
  - Antivirus policies
  - Volume efficiency policy

- Quality of service (QoS) policies
- Snapshot policies
- Quota rules
- ns-switch and name services configuration export policy and rules
- User and group IDs

**Steps**

1. Record information about the NFS export policies to avoid losing information on NFS policies in case volume rehost operation fails.
2. Unmount the volume from the parent volume:

   ```
   volume unmount
   ```

3. Switch to the advanced privilege level:

   ```
   set -privilege advanced
   ```

4. Rehost the volume on the destination SVM:

   ```
   volume rehost -vserver source_svm -volume vol_name -destination-vserver
   destination_svm
   ```

   The default export policy of the destination SVM is applied to the rehosted volume.

5. Create the export policy:

   ```
   vserver export-policy create
   ```

6. Update the export policy of the rehosted volume to a user-defined export policy:

   ```
   volume modify
   ```

7. Mount the volume under the appropriate junction path in the destination SVM:

   ```
   volume mount
   ```

8. Verify that the NFS service is running on the destination SVM.
9. Resume NFS access to the rehosted volume.
10. Update the NFS client credentials and LIF configurations to reflect the destination SVM LIFs.

    This is because the volume access path (LIFs and junction path) has undergone changes.

**After you finish**

You must manually reconfigure the policies and the associated rules on the rehosted volume.

NFS configuration

### Rehost SAN volumes

You can rehost volumes that have mapped LUNs. After re-creating the initiator group

(igroup) in the destination SVM, volume rehost can automatically remap the volume on the same SVM.

**What you'll need**

- The volume must be online.
- Volume management operations, such as volume moves or LUN moves, must not be running.
- There must be no active I/O on the volumes or LUNs.
- You must have verified that the destination SVM does not have igroup of the same name but different initiators.

  If the igroup has the same name, then you must have renamed the igroup in either one of the SVMs (source or destination).

- You must have enabled the `force-unmap-luns` option.
  - The default value of the `force-unmap-luns` option is `false`.
  - No warning or confirmation message is displayed when you set the `force-unmap-luns` option to `true`.

**About this task**

- Rehosting is a disruptive operation.
- If the rehosting operation fails, you might need to reconfigure the volume policies and the associated rules on the source volume.
- After the rehost operation, the following volume policies, policy rules, and configurations are lost from the source volume and must be manually reconfigured on the rehosted volume:
  - Antivirus policies
  - Volume efficiency policy
  - Quality of service (QoS) policies
  - Snapshot policies
  - ns-switch and name services configuration export policy and rules
  - User and group IDs

**Steps**

1. Record LUN mapping information on target volume:

   ```
   lun mapping show-volume volume to be rehosted-vserver source vserver
   ```

   This is a precautionary step to avoid losing information about LUN mapping in case the volume rehost fails.

2. Delete igroups associated with the target volume.
3. Rehost the target volume to the destination SVM:

   ```
   volume rehost -vserver source_svm -volume vol_name -destination-vserver
   destination_svm
   ```

4. Map LUNs on the target volume to appropriate igroups.
   - Volume rehost preserves LUNs on the target volume; however, LUNs remain unmapped.

- Use the destination SVM port set while mapping LUNs.
- If the `auto-remap-luns` option is set to `true`, the LUNs are mapped automatically after rehost.

### Rehost volumes in a SnapMirror relationship

You can rehost volumes in a SnapMirror relationship.

#### What you'll need

- The volume must be online.
- Volume management operations, such as volume moves or LUN moves, must not be running.
- Data access to the volume that is being rehosted must be stopped.
- The ns-switch and name services configuration of the target SVM must be configured to support data access of the rehosting volume.
- The user ID and group ID of the volume must be either available in the target SVM or changed on the hosting volume.

#### About this task

- Rehosting is a disruptive operation.
- If the rehosting operation fails, you might need to reconfigure the volume policies and the associated rules on the source volume.
- After the rehost operation, the following volume policies, policy rules, and configurations are lost from the source volume and must be manually reconfigured on the rehosted volume:
  - Volume and qtree export policies
  - Antivirus policies
  - Volume efficiency policy
  - Quality of service (QoS) policies
  - Snapshot policies
  - Quota rules
  - ns-switch and name services configuration export policy and rules
  - User and group IDs

#### Steps

1. Record the SnapMirror relationship type:

   ```
   snapmirror show
   ```

   This is a precautionary step to avoid losing information about the SnapMirror relationship type in case the volume rehost fails.

2. From the destination cluster, delete the SnapMirror relationship:

   ```
   snapmirror delete
   ```

   You must not break the SnapMirror relationship; otherwise, the data protection capability of the destination volume is lost and the relationship cannot be reestablished after the rehosting operation.

3. From the source cluster, remove the SnapMirror relationship information:

   ```
   snapmirror release relationship-info-only true
   ```

   Setting the `relationship-info-only` parameter to `true` removes the source relationship information without deleting the Snapshot copies.

4. Switch to the advanced privilege level:

   ```
   set -privilege advanced
   ```

5. Rehost the volume on the destination SVM:

   ```
   volume rehost -vserver source_svm -volume vol_name -destination-vserver
   destination_svm
   ```

6. If the SVM peering relation is not present, create the SVM peer relationship between the source SVM and destination SVM:

   ```
   vserver peer create
   ```

7. Create the SnapMirror relationship between the source volume and destination volume:

   ```
   snapmirror create
   ```

   You must run the `snapmirror create` command from the SVM that is hosting the DP volume. The rehosted volume can be the source or destination of the SnapMirror relationship.

8. Resynchronize the SnapMirror relationship.

#### Features that do not support volume rehost

There are certain features that do not support volume rehost.

The following features do not support volume rehost:

- VDR setup
- MetroCluster configurations
- SnapLock volumes
- NetApp Volume Encryption (NVE) volumes

  Volume encryption keys depend on SVM keys. If a volume is moved to another SVM and if multitenant key configuration is enabled on either the source or destination SVM, the volume and the SVM keys will not match.

- FlexGroup volumes
- Clone volumes

## Storage limits

There are limits for storage objects that you should consider when planning and managing your storage architecture.

Limits are listed in the following sections:

- Volume limits
- FlexClone file and FlexClone LUN limits

Storage limits for Cloud Volumes ONTAP are documented in the *Cloud Volumes ONTAP Release Notes*.

### Volume limits

| Storage object | Limit | Native storage | Storage arrays | Data ONTAP Edge |
|---|---|---|---|---|
| **Array LUNs** | Minimum size for root volume[1] | N/A | Model-dependent | N/A |
| **Files** | Maximum size | 16 TB | 16 TB | 16 TB |
| | Maximum per volume[3] | Volume size dependent, up to 2 billion | Volume size dependent, up to 2 billion | Volume size dependent, up to 2 billion |
| **FlexClone volumes** | Hierarchical clone depth[4] | 499 | 499 | 499 |
| **FlexVol volumes** | Maximum per node[1] | Model-dependent | Model-dependent | 200 |
| | Maximum per node per SVM[5] | Model-dependent | Model-dependent | 200 |
| | Minimum size | 20 MB | 20 MB | 20 MB |
| | Maximum size[1] | Model-dependent | Model-dependent | Model-dependent |
| **FlexVol volumes for primary workloads** | Maximum per node[2] | Model-dependent | Model-dependent | Model-dependent |
| **FlexVol root volumes** | Minimum size[1] | Model-dependent | Model-dependent | Model-dependent |
| **LUNs** | Maximum per node[5] | Model-dependent | Model-dependent | 1,024 |
| | Maximum per cluster[5] | Model-dependent | Model-dependent | 1,024 |
| | Maximum per volume[5] | Model-dependent | Model-dependent | 512 |
| | Maximum size | 16 TB | 16 TB | 16 TB |

| Storage object | Limit | Native storage | Storage arrays | Data ONTAP Edge |
|---|---|---|---|---|
| **Qtrees** | Maximum per FlexVol volume | 4,995 | 4,995 | 4,995 |
| **Snapshot copies** | Maximum per volume[6] | 255/1023 | 255/1023 | 255/1023 |
| **Volumes** | Maximum per cluster for NAS | 12,000 | 12,000 | 200 |
| | Maximum per cluster with SAN protocols configured | Model-dependent | Model-dependent | 200 |

**Notes:**

1. In ONTAP 9.3 and earlier, a volume can contain up to 255 Snapshot copies. In ONTAP 9.4 and later, a volume can contain up to 1023 Snapshot copies.
2. Beginning with ONTAP 9.7, the maximum supported number of FlexVol volumes on AFF platforms with at least 128 GB of memory has increased to 2,500 FlexVol volumes per node; however, only 1,000 volumes per node can be active (primary workloads) at one time.

   For platform-specific information and for the latest support details, see Hardware Universe.
3. 2 billion = 2 × 10 to the 9th power.
4. The maximum depth of a nested hierarchy of FlexClone volumes that can be created from a single FlexVol volume.
5. This limit applies only in SAN environments.

   SAN Configuration
6. You can use a SnapMirror cascade deployment to increase this limit.

**FlexClone file and FlexClone LUN limits**

| Limit | Native storage | Storage arrays | Data ONTAP Edge |
|---|---|---|---|
| **Maximum per file or LUN**[1] | 32,767 | 32,767 | 32,767 |
| **Maximum total shared data per FlexVol volume** | 640 TB | 640 TB | 100 TB |

**Note:**

1. If you try to create more than 32,767 clones, ONTAP automatically creates a new physical copy of the parent file or LUN.

   This limit might be lower for FlexVol volumes that use deduplication.

**Related information**

Find the Release Notes for your version of Cloud Volumes ONTAP

## Recommended volume and file or LUN configuration combinations

### Recommended volume and file or LUN configuration combinations overview

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.

### Determine 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.

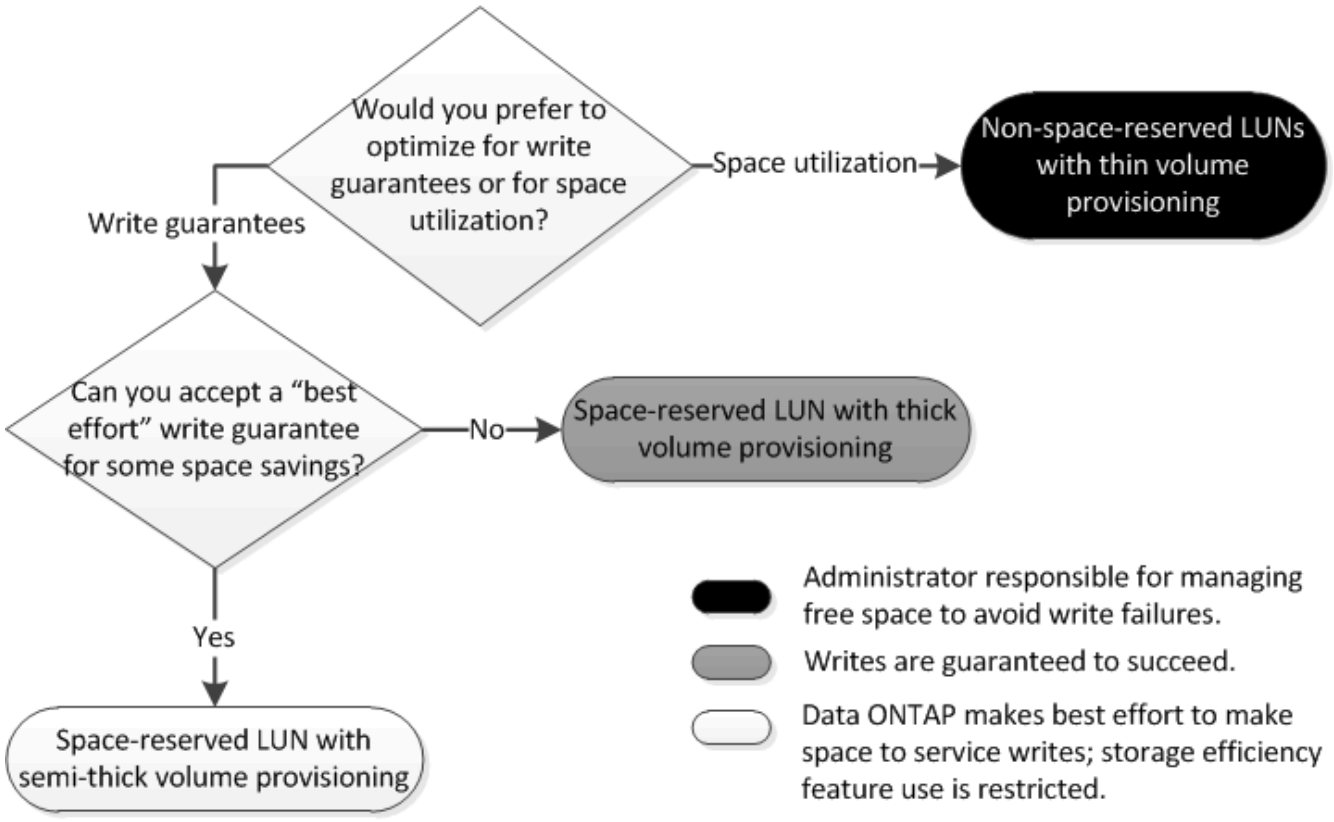
#### About this task

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.

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:



#### 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.

## Cautions and considerations for changing file or directory capacity

### Considerations for changing the maximum number of files allowed on a FlexVol volume

FlexVol volumes have a maximum number of files that they can contain. You can change the maximum number of files for a volume, but before doing so you should understand how this change affects the volume.

If your data requires a large number of files or very large directories, you can expand ONTAP file or directory capacity. However, you should understand the limitations and caveats for doing so before proceeding.

The number of files a volume can contain is determined by how many inodes it has. An *inode* is a data structure that contains information about files. Volumes have both private and public inodes. Public inodes are used for files that are visible to the user; private inodes are used for files that are used internally by ONTAP. You can change only the maximum number of public inodes for a volume. You cannot affect the number of private inodes.

ONTAP automatically sets the maximum number of public inodes for a newly created volume based on the size of the volume: 1 inode per 32 KB of volume size. When the size of a volume is increased, either directly by an administrator or automatically by ONTAP through the autosize feature, ONTAP also increases (if necessary) the maximum number of public inodes so there is at least 1 inode per 32 KB of volume size, until the volume reaches approximately 680 GB in size. Growing the volume greater than 680 GB in size does not automatically result in more inodes, because ONTAP does not automatically create more than 22,369,621 inodes. If you need more files than the default number for any size volume, you can use the volume modify command to increase the maximum number of inodes for the volume.

You can also decrease the maximum number of public inodes. This does not change the amount of space currently allocated to inodes, but it does lower the maximum amount of space the public inode file can consume. However, after space has been allocated for inodes, it is never returned to the volume. Therefore, lowering the maximum number of inodes below the number of inodes currently allocated does not return the space used by the allocated but unused inodes to the volume.

### Cautions for increasing the maximum directory size for FlexVol volumes

The default maximum directory size for FlexVol volumes is model-dependent, and optimized for the size of system memory. Before increasing the maximum directory size,

involve technical support.

You can increase the default maximum directory size for a specific FlexVol volume by using the `-maxdir-size` option of the `volume modify` command, but doing so could impact system performance.

### Rules governing node root volumes and root aggregates

## A node's root volume contains special directories and files for that node. The root aggregate contains the root volume. A few rules govern a node's root volume and root aggregate.

A node's root volume is a FlexVol volume that is installed at the factory or by setup software. It is reserved for system files, log files, and core files. The directory name is `/mroot`, which is accessible only through the systemshell by technical support. The minimum size for a node's root volume depends on the platform model.

- The following rules govern the node's root volume:
  - Unless technical support instructs you to do so, do not modify the configuration or content of the root volume.
  - Do not store user data in the root volume.

    Storing user data in the root volume increases the storage giveback time between nodes in an HA pair.
  - You can move the root volume to another aggregate.

    Relocating root volumes to new aggregates
- The root aggregate is dedicated to the node's root volume only.

  ONTAP prevents you from creating other volumes in the root aggregate.

NetApp Hardware Universe

### Relocate root volumes to new aggregates

## The root replacement procedure migrates the current root aggregate to another set of disks without disruption.

#### About this task

You can change the location of the root volume to a new aggregate in the following scenarios:

- When the root aggregates are not on the disk you prefer
- When you want to rearrange the disks connected to the node
- When you are performing a shelf replacement of the EOS disk shelves

#### Steps

1. Relocate the root aggregate:

   ```
   system node migrate-root -node node_name -disklist disk_list -raid-type
   raid_type
   ```

   - **-node**

Specifies the node that owns the root aggregate that you want to migrate.

- **-disklist**

  Specifies the list of disks on which the new root aggregate will be created. All disks must be spares and owned by the same node. The minimum number of disks required is dependent on the RAID type.

- **-raid-type**

  Specifies the RAID type of the root aggregate. The default value is `raid-dp`. This is the only type supported in advanced mode.

2. Monitor the progress of the job:

```
job show -id jobid -instance
```

**Results**

If all of the pre-checks are successful, the command starts a root volume replacement job and exits.

## Features supported with FlexClone files and FlexClone LUNs

### Features supported with FlexClone files and FlexClone LUNs

FlexClone files and FlexClone LUNs work with different ONTAP features, such as deduplication, Snapshot copies, quotas, and volume SnapMirror.

The following features are supported with FlexClone files and FlexClone LUNs:

- Deduplication
- Snapshot copies
- Access control lists
- Quotas
- FlexClone volumes
- NDMP
- Volume SnapMirror
- The `volume move` command
- Space reservation
- HA configuration

### How deduplication works with FlexClone files and FlexClone LUNs

You can efficiently use the physical storage space of the data blocks by creating a FlexClone file or FlexClone LUN of the parent file and parent LUN in a deduplication-enabled volume.

The block-sharing mechanism used by FlexClone files and LUNs is also used by deduplication. You can maximize the space savings in a FlexVol volume by enabling deduplication on the volume and then cloning the deduplication-enabled volume.

While executing the `sis undo` command on a deduplication-enabled volume, you cannot create FlexClone files and FlexClone LUNs of the parent files and parent LUNs residing in that volume.

#### How Snapshot copies work with FlexClone files and FlexClone LUNs

You can create FlexClone files and FlexClone LUNs from an existing Snapshot copy of the parent files and parent LUNs contained in a FlexVol volume.

However, you cannot manually delete a Snapshot copy from which FlexClone files or FlexClone LUNs are being created until the block-sharing process between the parent and clone entities is complete. The Snapshot copy remains locked until the completion of the block-sharing process, which occurs in the background. Therefore, when you try to delete a locked Snapshot copy, the system displays a message asking you to retry the operation after some time. In such a situation, if you want to manually delete the particular Snapshot copy, you must keep retrying the deletion operation so that the Snapshot copy is deleted after the block sharing is complete.

#### How access control lists work with FlexClone files and FlexClone LUNs

FlexClone files and FlexClone LUNs inherit the access control lists of their parent files and LUNs.

If the parent files contain Windows NT streams, the FlexClone files also inherit the stream information. However, parent files containing more than six streams cannot be cloned.

#### How quotas work with FlexClone files and FlexClone LUNs

Quota limits are applied on the total logical size of the FlexClone files or FlexClone LUNs. Cloning operations do not fail block sharing even if it causes quotas to exceed.

When you create a FlexClone file or FlexClone LUN, quotas do not recognize any space savings. For example, if you create a FlexClone file of a parent file of 10 GB, you are only using 10 GB of physical space, but the quota utilization is recorded as 20 GB (10 GB for the parent and 10 GB for the FlexClone file).

If the creation of a FlexClone file or LUN results in the group or user quota's being exceeded, the clone operation succeeds provided the FlexVol volume has enough space to hold the metadata for the clone. However, the quota for that user or group is oversubscribed.

#### How FlexClone volumes work with FlexClone files and FlexClone LUNs

You can create a FlexClone volume of a FlexVol volume that has both a FlexClone file and FlexClone LUN and its parent file or LUN in it.

FlexClone files or FlexClone LUNs and their parent files or LUNs that are present in the FlexClone volume continue to share blocks the same way they do in the parent FlexVol volume. In fact, all the FlexClone entities and their parents share the same underlying physical data blocks, minimizing physical disk space usage.

If the FlexClone volume is split from its parent volume, then the FlexClone files or FlexClone LUNs and their parent files or LUNs stop sharing the blocks in the clone of the FlexClone volume. Thereafter they exist as independent files or LUNs. This means that the clone of the volume uses more space than before the splitting operation.

### How NDMP works with FlexClone files and FlexClone LUNs

NDMP works at the logical level with FlexClone files and FlexClone LUNs. All FlexClone files or LUNs are backed up as separate files or LUNs.

When you use NDMP services to back up a qtree or a FlexVol volume that contains FlexClone files or FlexClone LUNs, block sharing between parent and clone entities is not preserved, and clone entities are backed up to tape as separate files or LUNs. The space saving is lost. Therefore, the tape onto which you are backing up should have sufficient space to store the expanded amount of data. When you restore, all the FlexClone files and FlexClone LUNs are restored as separate physical files and LUNs. You can enable deduplication on the volume to restore the block-sharing benefits.

When FlexClone files and FlexClone LUNs are being created from an existing Snapshot copy of a FlexVol volume, you cannot back up the volume to tape until the block-sharing process, which happens in the background, is complete. If you use NDMP on the volume when the block-sharing process is in progress, the system displays a message asking you to retry the operation after some time. In such a situation, you must keep retrying the tape backup operation so that it succeeds after the block sharing is complete.

### How volume SnapMirror works with FlexClone files and FlexClone LUNs

Volume SnapMirror used with FlexClone files and FlexClone LUNs helps in maintaining space savings because the cloned entities are replicated only once.

If a FlexVol volume is a volume SnapMirror source and contains FlexClone files or FlexClone LUNs, volume SnapMirror transfers only the shared physical block and a small amount of metadata to the volume SnapMirror destination. The destination stores only one copy of the physical block, and this block is shared between the parent and cloned entities. Therefore, the destination volume is an exact copy of the source volume and all the clone files or LUNs on the destination volume share the same physical block.

### How volume move affects FlexClone files and FlexClone LUNs

During the cutover phase of a volume move operation, you cannot create FlexClone files or FlexClone LUNs of a FlexVol volume.

### How space reservation works with FlexClone files and FlexClone LUNs

FlexClone files and FlexClone LUNs inherit the space reservation attribute from the parent file and parent LUN by default. However, you can create FlexClone files and FlexClone LUNs with space reservation disabled from a parent file and parent LUN with space reservation enabled if the FlexVol volume lacks space.

If the FlexVol volume does not contain enough space to create a FlexClone file or FlexClone LUN with the same space reservation as that of the parent, then the cloning operation fails.

### How an HA configuration works with FlexClone files and FlexClone LUNs

FlexClone file and FlexClone LUN operations are supported in an HA configuration.

In an HA pair, you cannot create FlexClone files or FlexClone LUNs on the partner while the takeover or giveback operation is in progress. All the pending block sharing operations on the partner are resumed after the takeover or giveback operation is complete.

# Provision NAS storage for large file systems using FlexGroup volumes

A FlexGroup volume is a scalable NAS container that provides high performance along with automatic load distribution. FlexGroup volumes provide massive capacity (in petabytes), which considerably exceeds the FlexVol volume limits, without adding any management overhead.

The topics in this section show you how to manage FlexGroup volumes with System Manager in ONTAP 9.7 and later releases. If you are using the classic System Manager (available only in ONTAP 9.7 and earlier), see this topic:

- Create FlexGroup volumes

Beginning with ONTAP 9.9.1, SnapMirror fanout relationships of two or more FlexGroup volumes are supported, with a maximum of eight fanout legs. System Manager does not support SnapMirror cascading FlexGroup volume relationships.

ONTAP automatically selects the local tiers required for creating the FlexGroup volume.

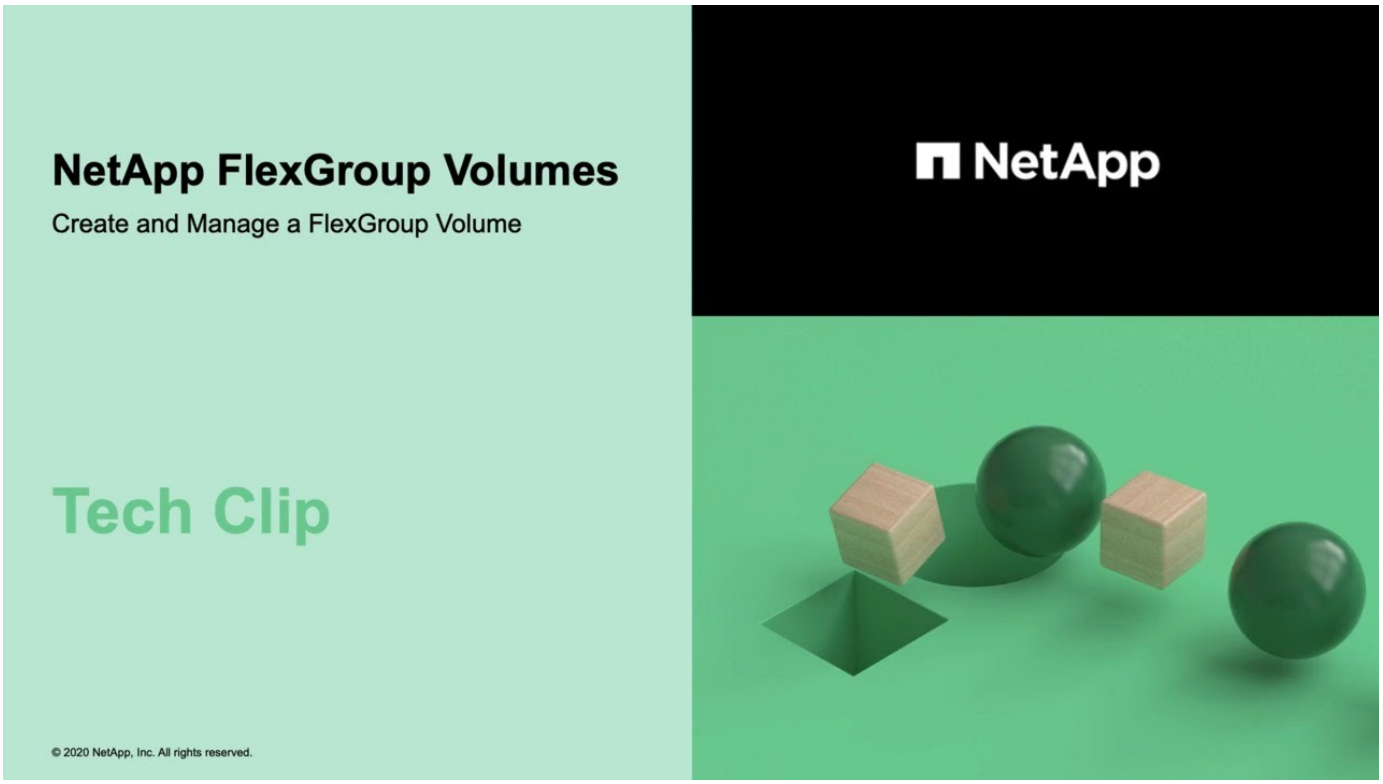
Beginning with ONTAP 9.8, when you provision storage, QoS is enabled by default. You can disable QoS or choose a custom QoS policy during the provisioning process or at a later time.

**Steps**

1. Click **Storage > Volumes**.
2. Click **Add**.
3. Click **More Options** and then select **Distribute volume data across the cluster**.
    a. If you are running ONTAP 9.8 or later and you want to disable QoS or choose a custom QoS policy, click **More Options** and then, under **Storage and Optimization** select **Performance Service Level**.

## Videos

**Create and manage a Flexgroup volume**




FlexGrop volumes - Do more with less

# FlexGroup volumes management with the CLI

## FlexGroup volumes management overview with the CLI

You can set up, manage, and protect FlexGroup volumes for scalability and performance. A FlexGroup volume is a scale-out volume that provides high performance along with automatic load distribution.

You can configure FlexGroup volumes if the following are true:

- You are running ONTAP 9.1 or later.
- You want to use NFSv4.x, NFSv3, SMB 2.0, or SMB 2.1.
- You want to use the ONTAP command-line interface (CLI), not System Manager or an automated scripting tool.

  Details about command syntax are available from the CLI help and the ONTAP man pages.

  An important subset of FlexGroup functionality is available in System Manager.
- You want to use best practices, not explore every available option.
- You have cluster administrator privileges, not SVM administrator privileges.

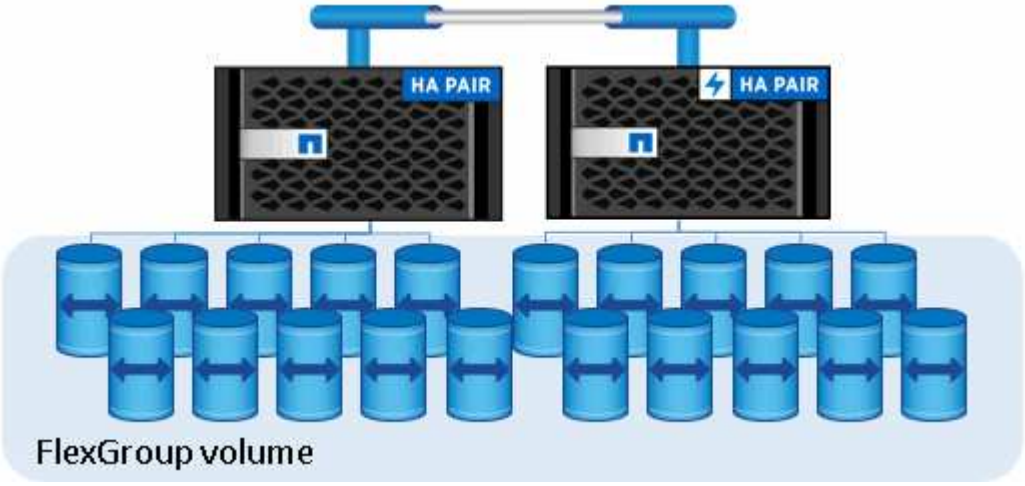
FlexGroups replace Infinite Volumes, which are not supported in newer versions of ONTAP.

**Related information**

Conceptual information about FlexVol volumes is applicable to FlexGroup volumes. Information about FlexVol volumes and ONTAP technology is available in the ONTAP Reference Library and in Technical Reports (TRs).

## What a FlexGroup volume is

A FlexGroup volume is a scale-out NAS container that provides high performance along with automatic load distribution and scalability. A FlexGroup volume contains several constituents that automatically and transparently share the traffic.




FlexGroup volumes provide the following benefits:

- High scalability

The maximum size for a FlexGroup volume in ONTAP 9.1 and later is 20 PB, with 400 billion files on a 10-node cluster.

- High performance

  FlexGroup volumes can utilize the resources of the cluster to serve workloads that have high throughput and low latency.

- Simplified management

  A FlexGroup volume is a single namespace container that can be managed in a similar way as FlexVol volumes.

## Supported and unsupported configurations for FlexGroup volumes

You should be aware of the ONTAP features that are supported and not supported with FlexGroup volumes in ONTAP 9.

#### Features supported beginning with ONTAP 9.10.1

- Convert FlexVol volumes to FlexGroup volumes in an SVM-DR source

  Convert a FlexVol volume to a FlexGroup volume within an SVM-DR relationship

- SVM-DR FlexClone support for FlexGroup volumes

  Learn more about creating FlexClone volumes.

#### Features supported beginning with ONTAP 9.9.1

- SVM disaster recovery

  Cloning a FlexGroup volume that is part of an SVM-DR relationship is not supported.

- SnapMirror fanout relationships of 2 or more (A to B, A to C), with a maximum of 8 fanout legs.

  Considerations for creating SnapMirror cascade and fanout relationships for FlexGroups

- SnapMirror cascading relationships up to two levels (A to B to C)

  Considerations for creating SnapMirror cascade and fanout relationships for FlexGroups

#### Features supported beginning with ONTAP 9.8

- Restoring a single file from a FlexGroup SnapMirror vault or from a UDP destination
  - Restore can be from a FlexGroup volume of any geometry to FlexGroup volume of any geometry
  - Only one file per restore operation is supported
- Converting volumes transitioned from 7-mode systems to FlexGroup volumes

  Converting transitioned volumes to FlexGroup volumes requires diag mode and should be performed only under NetApp Support supervision. It is highly recommended that you contact NetApp Support before you proceed with the conversion process.

- NFSv4.2
- Asynchronous delete of files and directories
- Files System Analytics (FSA)
- FlexGroup as a VMware vSphere datastore
- Restoring "pre-conversion" Snapshot copies to a FlexGroup volume

  Pre-conversion Snapshot copies are Snapshot copies made on a FlexVol volume before it was converted to a FlexGroup volume.

- Additional support for tape backup and restore using NDMP, including the following features:
  - NDMP restartable backup extension (RBE) and Snapshot Management Extension (SSME)
  - Environment variables EXCLUDE and MULTI_SUBTREE_NAMES support FlexGroup backups
  - Introduction of IGNORE_CTIME_MTIME environment variable for FlexGroup backups
  - Individual file recovery in a FlexGroup using the NDMP_SNAP_RECOVER message, which is part of extension 0x2050
    Dump and restore sessions are aborted during an upgrade or revert.

**Features supported beginning with ONTAP 9.7**

- FlexClone volume
- NFSv4 and NFSv4.1
- pNFS
- Tape backup and restore by using NDMP

  You must be aware of the following points for NDMP support on FlexGroup volumes:

  - The NDMP_SNAP_RECOVER message in the extension class 0x2050 can be used only for recovering an entire FlexGroup volume.

    Individual files in a FlexGroup volume cannot be recovered.

  - NDMP restartable backup extension (RBE) is not supported for FlexGroup volumes.
  - Environment variables EXCLUDE and MULTI_SUBTREE_NAMES are not supported for FlexGroup volumes.
  - The `ndmpcopy` command is supported for data transfer between FlexVol and FlexGroup volumes.

    If you revert from Data ONTAP 9.7 to an earlier version, the incremental transfer information of the previous transfers is not retained and therefore, you must perform a baseline copy after reverting.

- VMware vStorage APIs for Array Integration (VAAI)
- Conversion of a FlexVol volume to a FlexGroup volume
- FlexGroup volumes as FlexCache origin volumes

**Features supported beginning with ONTAP 9.6**

- Continuously available SMB shares
- MetroCluster configurations

- Renaming a FlexGroup volume (`volume rename` command)
- Shrinking or reducing the size of a FlexGroup volume (`volume size` command)
- Elastic sizing
- NetApp aggregate encryption (NAE)
- Cloud Volumes ONTAP

**Features supported beginning with ONTAP 9.5**

- ODX copy offload
- Storage-Level Access Guard
- Enhancements to change notifications for SMB shares

  Change notifications are sent for changes to the parent directory on which the `changenotify` property is set and for changes to all of the subdirectories in that parent directory.

- FabricPool
- Quota enforcement
- Qtree statistics
- Adaptive QoS for files in FlexGroup volumes
- FlexCache (cache only; FlexGroup as origin supported in ONTAP 9.7)

**Features supported beginning with ONTAP 9.4**

- FPolicy
- File auditing
- Throughput floor (QoS Min) and adaptive QoS for FlexGroup volumes
- Throughput ceiling (QoS Max) and throughput floor (QoS Min) for files in FlexGroup volumes

  You use the `volume file modify` command to manage the QoS policy group that is associated with a file.

- Relaxed SnapMirror limits
- SMB 3.x multichannel

**Features supported beginning with ONTAP 9.3**

- Antivirus configuration
- Change notifications for SMB shares

  Notifications are sent only for changes to the parent directory on which the `changenotify` property is set. Change notifications are not sent for changes to subdirectories in the parent directory.

- Qtrees
- Throughput ceiling (QoS Max)
- Expand the source FlexGroup volume and destination FlexGroup volume in a SnapMirror relationship
- SnapVault backup and restore

- Unified data protection relationships
- Autogrow option and autoshrink option
- Inode count factored to ingest

**Feature supported beginning with ONTAP 9.2**

- Volume encryption
- Aggregate inline deduplication (cross-volume deduplication)
- NetApp volume encryption (NVE)

**Features supported beginning with ONTAP 9.1**

FlexGroup volumes were introduced in ONTAP 9.1, with support for several ONTAP features.

- SnapMirror technology
- Snapshot copies
- Active IQ
- Inline adaptive compression
- Inline deduplication
- Inline data compaction
- AFF
- Quota reporting
- NetApp Snapshot technology
- SnapRestore software (FlexGroup level)
- Hybrid aggregates
- Constituent or member volume move
- Postprocess deduplication
- NetApp RAID-TEC technology
- Per-aggregate consistency point
- Sharing FlexGroup with FlexVol volume in the same SVM

**Unsupported configurations in ONTAP 9**

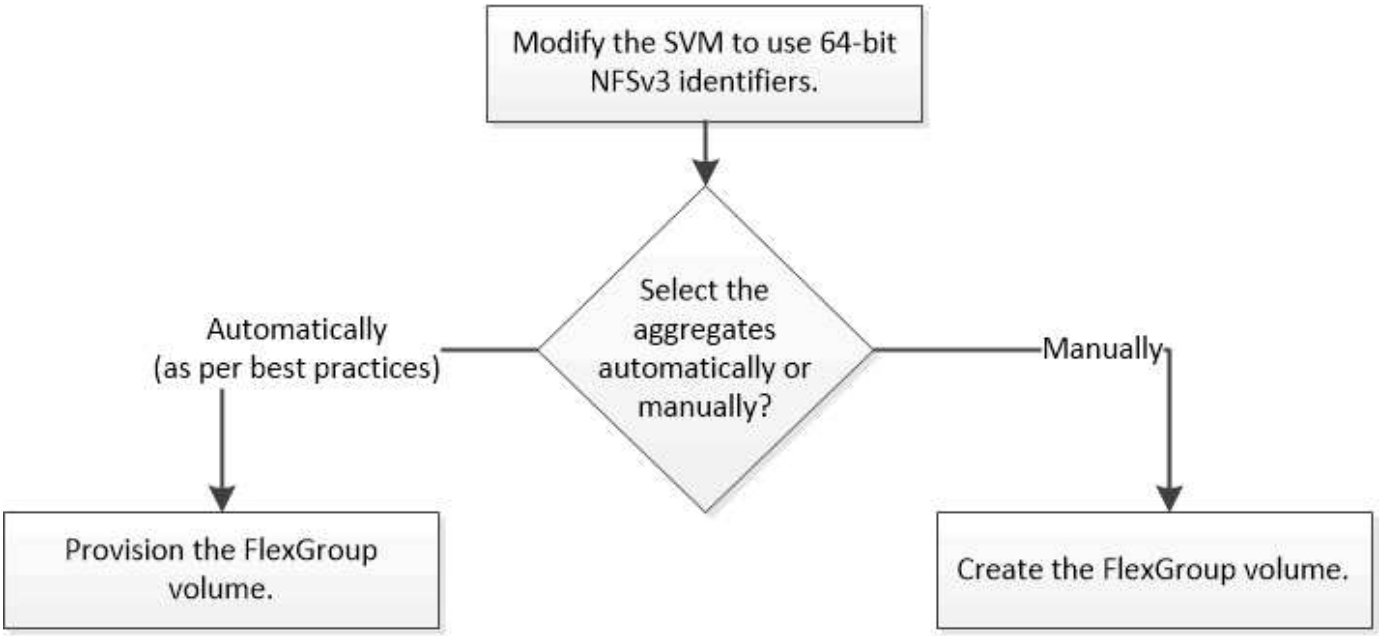
| Unsupported protocols | Unsupported data protection features | Other unsupported ONTAP features |
|---|---|---|
| • pNFS (ONTAP 9.0 to 9.6)<br>• SMB 1.0<br>• SMB transparent failover (ONTAP 9.0 to 9.5)<br>• SAN | • SnapLock volumes<br>• SMTape | Remote Volume Shadow Copy Service (VSS) |

**Related information**

# FlexGroup volume setup

### FlexGroup volume setup workflow

You can either provision a FlexGroup volume where ONTAP automatically selects the aggregates based on the best practices for optimum performance, or create a FlexGroup volume by manually selecting the aggregates and configuring it for data access.




#### What you'll need

You must have created the SVM with NFS and SMB added to the list of allowed protocols for the SVM.

#### About this task

You can automatically provision a FlexGroup volume only on clusters with four nodes or less. On clusters with more than four nodes, you must create a FlexGroup volume manually.

### Enable 64-bit NFSv3 identifiers on an SVM

To support the high file count of FlexGroup volumes and to avoid file ID collisions, you should enable 64-bit file identifiers on the SVM on which the FlexGroup volume must be created.

#### Steps

1. Log in to the advanced privilege level: `set -privilege advanced`
2. Modify the SVM to use 64-bit NFSv3 FSIDs and file IDs: `vserver nfs modify -vserver svm_name -v3-64bit-identifiers enabled`

```
cluster1::*> vserver nfs modify -vserver vs0 -v3-64bit-identifiers
enabled

Warning: You are attempting to increase the number of bits used for
NFSv3
         FSIDs and File IDs from 32 to 64 on Vserver "vs0". This could
         result in older client software no longer working with the
volumes
         owned by Vserver "vs0".
Do you want to continue? {y|n}: y

Warning: Based on the changes you are making to the NFS server on
Vserver
         "vs0", it is highly recommended that you remount all NFSv3
clients
         connected to it after the command completes.
Do you want to continue? {y|n}: y
```

**After you finish**

All of the clients must be remounted. This is required because the file system IDs change, and the clients might receive stale file handle messages when attempting NFS operations.

### Provision a FlexGroup volume automatically

You can automatically provision a FlexGroup volume. ONTAP creates and configures a FlexGroup volume by automatically selecting the aggregates. Aggregates are selected based on the best practices for optimum performance.

**What you'll need**

Each node in the cluster must have at least one aggregate.

> For creating a FlexGroup volume for FabricPool in ONTAP 9.5, each node must have at least one aggregate that is FabricPool.

**About this task**

ONTAP selects two aggregates with the largest amount of usable space on each node to create the FlexGroup volume. If two aggregates are not available, ONTAP selects one aggregate per node to create the FlexGroup volume.

**Steps**

1. Provision the FlexGroup volume:

| If you are using… | Use this command… |
|---|---|

| | |
|---|---|
| ONTAP 9.2 or later | `volume create -vserver svm_name -volume fg_vol_name -auto-provision-as flexgroup -size fg_size [-encrypt true] [-qos-policy-group qos_policy_group_name] [-support-tiering true]` Beginning with ONTAP 9.5, you can create FlexGroup volumes for FabricPool. To automatically provision a FlexGroup volume on FabricPool, you must set the `-support-tiering` parameter to `true`. The volume guarantee must be always set to `none` for FabricPool. You can also specify the tiering policy and tiering minimum cooling period for the FlexGroup volume.<br><br>Disk and aggregate management<br><br>Beginning with ONTAP 9.3, you can specify a throughput ceiling (QoS Max) for FlexGroup volumes, which limits the performance resources that the FlexGroup volume can consume. Beginning with ONTAP 9.4, you can specify throughput floors (QoS Min) and adaptive QoS for FlexGroup volumes.<br><br>Performance management<br><br>Beginning with ONTAP 9.2, you can set the `-encrypt` parameter to `true` if you want to enable encryption on the FlexGroup volume. For creating an encrypted volume, you must have installed the volume encryption license and the key manager.<br><br>You must enable encryption on FlexGroup volumes at the time of creation. You cannot enable encryption on existing FlexGroup volumes.<br><br>Encryption of data at rest |
| ONTAP 9.1 | `volume flexgroup deploy -vserver svm_name -size fg_size` |

The `size` parameter specifies the size of the FlexGroup volume in KB, MB, GB, TB, or PB.

The following example shows how to provision a FlexGroup volume of size 400 TB in ONTAP 9.2:

```
cluster-1::> volume create -vserver vs0 -volume fg –auto-provision-as
flexgroup -size 400TB
Warning: The FlexGroup "fg" will be created with the following number of
constituents of size 25TB: 16.
The constituents will be created on the following aggregates:
aggr1,aggr2
Do you want to continue? {y|n}: y
[Job 34] Job succeeded: Successful
```

The following example shows how to create a QoS policy group for throughput ceiling and how to apply it to a FlexGroup volume:

```
cluster1::> qos policy-group create -policy group pg-vs1 -vserver vs1
-max-throughput 5000iops
```

```
cluster-1::> volume create -vserver vs0 -volume fg –auto-provision-as
flexgroup -size 400TB -qos-policy-group pg-vs1
Warning: The FlexGroup "fg" will be created with the following number of
constituents of size 25TB: 16.
The constituents will be created on the following aggregates:
aggr1,aggr2
Do you want to continue? {y|n}: y
[Job 34] Job succeeded: Successful
```

The following example shows how to provision a FlexGroup volume of size 400 TB on aggregates in FabricPool in ONTAP 9.5:

```
cluster-1::> volume create -vserver vs0 -volume fg –auto-provision-as
flexgroup -size 400TB -support-tiering true -tiering-policy auto
Warning: The FlexGroup "fg" will be created with the following number of
constituents of size 25TB: 16.
The constituents will be created on the following aggregates:
aggr1,aggr2
Do you want to continue? {y|n}: y
[Job 34] Job succeeded: Successful
```

The FlexGroup volume is created with eight constituents on each node in the cluster. The constituents are distributed equally between the two largest aggregates on each node.

The FlexGroup volume is created with the `volume` space guarantee except on AFF systems. For AFF systems, the FlexGroup volume is created with the `none` space guarantee.

2. Mount the FlexGroup volume with a junction path: `volume mount -vserver vserver_name`

`-volume vol_name -junction-path junction_path`

```
cluster1::> volume mount -vserver vs0 -volume fg2 -junction-path /fg2
```

**After you finish**

You should mount the FlexGroup volume from the client.

If you are running ONTAP 9.6 or earlier and if the storage virtual machine (SVM) has both NFSv3 and NFSv4 configured, mounting the FlexGroup volume from the client might fail. In such cases, you must explicitly specify the NFS version when mounting the FlexGroup volume from the client.

```
# mount -t nfs -o vers=3 192.53.19.64:/fg2 /mnt/fg2
# ls /mnt/fg2
file1  file2
```

### Create a FlexGroup volume

You can create a FlexGroup volume by manually selecting the aggregates on which the FlexGroup volume must be created, and then specifying the number of constituents on each aggregate.

**About this task**

You must be aware of the space required in the aggregates for creating a FlexGroup volume.

Guidelines for aggregate space when provisioning a FlexGroup volume

You should also be aware of the considerations and requirements when selecting the aggregates for provisioning a FlexGroup volume.

You must consider the following guidelines when creating a FlexGroup volume for obtaining the best performance results with a FlexGroup volume:

- A FlexGroup volume should span only aggregates that are on identical hardware systems.

  The use of identical hardware systems helps in providing predictable performance across the FlexGroup volume.

- A FlexGroup volume should span aggregates with the same disk type and RAID group configurations.

  For consistent performance, you must ensure that all of the aggregates are made of all SSDs, all HDDs, or all hybrid aggregates. Additionally, the aggregates should have the same number of drives and RAID groups across the FlexGroup volume.

- A FlexGroup volume can span parts of a cluster.

  A FlexGroup volume does not have to be configured to span the entire cluster, but doing so can take greater advantage of the hardware resources that are available.

- When creating a FlexGroup volume, it is best if the aggregates on which the FlexGroup volume is deployed have the following characteristics:

- Approximately the same amount of free space should be available across multiple aggregates, especially when using thin provisioning.
- Approximately 3 percent of the free space should be reserved for aggregate metadata after creation of the FlexGroup volume.

- For FAS systems, it is best to have two aggregates per node and for AFF systems, you must have one aggregate per node for the FlexGroup volume.
- For each FlexGroup volume, you should create at least eight constituents that are distributed over two or more aggregates on FAS systems, and over one or more aggregates on AFF systems.

**Steps**

1. Create the FlexGroup volume: `volume create -vserver svm_name -volume flexgroup_name -aggr-list aggr1,aggr2,.. -aggr-list-multiplier constituents_per_aggr -size fg_size [-encrypt true] [-qos-policy-group qos_policy_group_name]`

   - The `-aggr-list` parameter specifies the list of aggregates to be used for FlexGroup volume constituents.

     Each entry in the list creates a constituent on the specified aggregate. You can specify an aggregate multiple times to have multiple constituents created on the aggregate.

     For consistent performance across the FlexGroup volume, all of the aggregates must use the same disk type and RAID group configurations.

   - The `-aggr-list-multiplier` parameter specifies the number of times to iterate over the aggregates that are listed with the `-aggr-list` parameter when creating a FlexGroup volume.

     The default value of the `-aggr-list-multiplier` parameter is 4.

   - The `size` parameter specifies the size of the FlexGroup volume in KB, MB, GB, TB, or PB.
   - Beginning with ONTAP 9.5, you can create FlexGroup volumes for FabricPool, which use only all SSD aggregates.

     To create a FlexGroup volume for FabricPool, all the aggregates specified with the `-aggr-list` parameter must be FabricPool. The volume guarantee must be always set to `none` for FabricPool. You can also specify the tiering policy and tiering minimum cooling period for the FlexGroup volume.

     Disk and aggregate management

   - Beginning with ONTAP 9.4, you can specify throughput floors (QoS Min) and adaptive QoS for FlexGroup volumes.

     Performance management

   - Beginning with ONTAP 9.3, you can specify a throughput ceiling (QoS Max) for FlexGroup volumes, which limits the performance resources that the FlexGroup volume can consume.
   - Beginning with ONTAP 9.2, you can set the `-encrypt` parameter to `true` if you want to enable encryption on the FlexGroup volume.

     For creating an encrypted volume, you must have installed the volume encryption license and the key manager.

You must enable encryption on FlexGroup volumes at the time of creation. You cannot enable encryption on existing FlexGroup volumes.

Encryption of data at rest

```
cluster-1::> volume create -vserver vs0 -volume fg2 -aggr-list
aggr1,aggr2,aggr3,aggr1 -aggr-list-multiplier 2 -size 500TB

Warning: A FlexGroup "fg2" will be created with the following number of
constituents of size 62.50TB: 8.
Do you want to continue? {y|n}: y

[Job 43] Job succeeded: Successful
```

In the previous example, if you want to create the FlexGroup volume for FabricPool, all aggregates (aggr1, aggr2, and aggr3) must be aggregates in FabricPool.
. Mount the FlexGroup volume with a junction path: `volume mount -vserver vserver_name -volume vol_name -junction-path junction_path`

```
cluster1::> volume mount -vserver vs0 -volume fg2 -junction-path /fg
```

**After you finish**

You should mount the FlexGroup volume from the client.

If you are running ONTAP 9.6 or earlier and if the storage virtual machine (SVM) has both NFSv3 and NFSv4 configured, mounting the FlexGroup volume from the client might fail. In such cases, you must explicitly specify the NFS version when you are mounting the FlexGroup volume from the client.

```
# mount -t nfs -o vers=3 192.53.19.64:/fg /mnt/fg2
# ls /mnt/fg2
file1  file2
```

**Related information**

NetApp Technical Report 4571: NetApp FlexGroup Best Practices and Implementation Guide

## Manage FlexGroup volumes

### Monitor the space usage of a FlexGroup volume

You can view a FlexGroup volume and its constituents, and monitor the space used by the FlexGroup volume.

**About this task**

Beginning with ONTAP 9.6, elastic sizing is supported. ONTAP automatically grows a constituent of a FlexGroup volume if it is running out of space by shrinking any other constituent in the FlexGroup volume that

has free space by an equivalent amount. Elastic sizing avoids any out-of-space errors that are generated because of one or more FlexGroup constituent volumes running out of space.

> Beginning with ONTAP 9.9.1, logical space reporting and enforcement is also available for FlexGroup volumes. For more information, see Logical space reporting and enforcement for volumes.

**Step**

1. View the space used by the FlexGroup volume and its constituents: `volume show -vserver vserver_name -volume-style-extended [flexgroup | flexgroup-constituent]`

```
cluster-2::> volume show -vserver vs1 -volume-style-extended flexgroup
Vserver   Volume       Aggregate    State      Type       Size
Available Used%
--------- ------------ ------------ ---------- ---- ----------
---------- -----
vs1       fg1          -            online     RW        500GB
207.5GB   56%
```

```
ccluster-2::> volume show -vserver vs1 -volume-style-extended flexgroup-
constituent
Vserver   Volume       Aggregate    State      Type       Size
Available Used%
--------- ------------ ------------ ---------- ---- ----------
---------- -----
vs1       fg1__0001    aggr3        online     RW      31.25GB
12.97GB   56%
vs1       fg1__0002    aggr1        online     RW      31.25GB
12.98GB   56%
vs1       fg1__0003    aggr1        online     RW      31.25GB
13.00GB   56%
vs1       fg1__0004    aggr3        online     RW      31.25GB
12.88GB   56%
vs1       fg1__0005    aggr1        online     RW      31.25GB
13.00GB   56%
vs1       fg1__0006    aggr3        online     RW      31.25GB
12.97GB   56%
vs1       fg1__0007    aggr1        online     RW      31.25GB
13.01GB   56%
vs1       fg1__0008    aggr1        online     RW      31.25GB
13.01GB   56%
vs1       fg1__0009    aggr3        online     RW      31.25GB
12.88GB   56%
vs1       fg1__0010    aggr1        online     RW      31.25GB
13.01GB   56%
vs1       fg1__0011    aggr3        online     RW      31.25GB
12.97GB   56%
vs1       fg1__0012    aggr1        online     RW      31.25GB
13.01GB   56%
vs1       fg1__0013    aggr3        online     RW      31.25GB
12.95GB   56%
vs1       fg1__0014    aggr3        online     RW      31.25GB
12.97GB   56%
vs1       fg1__0015    aggr3        online     RW      31.25GB
12.88GB   56%
vs1       fg1__0016    aggr1        online     RW      31.25GB
13.01GB   56%
16 entries were displayed.
```

You can use the available space and percentage space used to monitor the space usage of the FlexGroup volume.

### Increase the size of a FlexGroup volume

You can increase the size of a FlexGroup volume either by adding more capacity to the existing constituents of the FlexGroup volume or by expanding the FlexGroup volume with new constituents.

#### What you'll need

Sufficient space must be available in the aggregates.

#### About this task

If you want to add more space, you can increase the collective size of the FlexGroup volume. Increasing the size of a FlexGroup volume resizes the existing constituents of the FlexGroup volume.

If you want to improve performance, you can expand the FlexGroup volume. You might want to expand a FlexGroup volume and add new constituents in the following situations:

- New nodes have been added to the cluster.
- New aggregates have been created on the existing nodes.
- The existing constituents of the FlexGroup volume have reached the maximum FlexVol size for the hardware, and therefore the FlexGroup volume cannot be resized.

In releases earlier than ONTAP 9.3, you must not expand FlexGroup volumes after a SnapMirror relationship is established. If you expand the source FlexGroup volume after breaking the SnapMirror relationship in releases earlier than ONTAP 9.3, you must perform a baseline transfer to the destination FlexGroup volume once again. Beginning with ONTAP 9.3, you can expand FlexGroup volumes that are in a SnapMirror relationship.

#### Step

1. Increase the size of the FlexGroup volume by increasing the capacity or performance of the FlexGroup volume, as required:

| If you want to increase the… | Then do this… |
|---|---|
| Capacity of the FlexGroup volume | Resize the constituents of the FlexGroup volume:<br><br>`volume modify -vserver vserver_name -volume fg_name -size new_size` |
| Performance to the FlexGroup volume | Expand the FlexGroup volume by adding new constituents:<br><br>`volume expand -vserver vserver_name -volume fg_name -aggr-list aggregate name,... [-aggr-list-multiplier constituents_per_aggr]`<br><br>The default value of the `-aggr-list -multiplier` parameter is 1.<br><br>To expand a FlexGroup volume for FabricPool in ONTAP 9.5, any new aggregates used must be FabricPool. |

Whenever possible, you should increase the capacity of a FlexGroup volume. If you must expand a FlexGroup volume, you should add constituents in the same multiples as the constituents of the existing FlexGroup volume to ensure consistent performance. For example, if the existing FlexGroup volume has 16 constituents with eight constituents per node, you can expand the existing FlexGroup volume by 8 or 16 constituents.

**Examples**

**Example of increasing the capacity of the existing constituents**

The following example shows how to add 20 TB space to a FlexGroup volume volX:

```
cluster1::> volume modify -vserver svm1 -volume volX -size +20TB
```

If the FlexGroup volume has 16 constituents, the space of each constituent is increased by 1.25 TB.

**Example of improving performance by adding new constituents**

The following example shows how to add two more constituents to the FlexGroup volume volX:

```
cluster1::> volume expand -vserver vs1 -volume volX -aggr-list aggr1,aggr2
```

The size of the new constituents is the same as that of the existing constituents.

### Reduce the size of a FlexGroup volume

Beginning with ONTAP 9.6, you can resize a FlexGroup volume to a value lower than its current size to free up the unused space from the volume. When you reduce the size of a FlexGroup volume, ONTAP automatically resizes all of the FlexGroup constituents.

**Step**

1. Reduce the size of the FlexGroup volume: `volume size -vserver vserver_name -volume fg_name -size new_size`

   `new_size` is the size of the FlexGroup volume. You can either specify a lower value than the current size or a negative value by which the current size of the FlexGroup volume is reduced.

   > If automatic shrinking is enabled for the volume (`volume autosize` command), the minimum autosize is set to the new size of the volume.

   ```
   cluster1::> volume size -vserver svm1 -volume volX -size 10TB
   ```

   ```
   cluster1::> volume size -vserver svm1 -volume volX -size -5TB
   ```

### Configure FlexGroup volumes to automatically grow and shrink their size

Beginning with ONTAP 9.3, you can configure FlexGroup volumes to automatically grow

and shrink according to how much space they currently require.

**What you'll need**

The FlexGroup volume must be online.

**About this task**

You can autosize FlexGroup volumes in two modes:

- Increase the size of the volume automatically (`grow` mode)

  Automatic growing helps prevent a FlexGroup volume from running out of space, if the aggregate can supply more space. You can configure the 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.

  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.

- Shrink the size of the volume automatically (`grow_shrink` mode)

  Automatic shrinking prevents a volume from being larger than needed, freeing space in the aggregate for use by other volumes.

  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.

**Step**

1. Configure the volume to grow and shrink its size automatically: `volume autosize -vserver vserver_name -volume vol_name -mode [grow | grow_shrink]`

   You can also specify the maximum size, minimum size, and thresholds for growing or shrinking the volume.

   The following command enables automatic size changes for a volume called fg1. The volume is configured to grow to a maximum size of 5 TB when it is 70% full.

   ```
   cluster1::> volume autosize -volume fg1 -mode grow -maximum-size 5TB
   -grow-threshold-percent 70
   vol autosize: volume "vs_src:fg1" autosize settings UPDATED.
   ```

**Perform a fast directory delete by deleting files and directories asynchronously**

You should use the REST API to delete your directory. Beginning with ONTAP 9.8, you can also use the `volume file async-delete` command to delete files and directories

from Linux and Windows client shares in the background. You can perform asynchronous delete on both FlexVol and FlexGroup volumes.

**About this task**

You must be a cluster administrator or a SVM administrator using the advanced privilege mode.

Beginning with ONTAP 9.9.1, you can also use System Manager to perform a fast directory delete. For more information, see Take corrective action based on analytics.

**Steps**

1. Enter advanced privilege mode: `-privilege advance`
2. Delete files or directories on a FlexVol or FlexGroup volume: `volume file async-delete start -vserver vserver_name -volume volume_name -path file_path -throttle throttle`

   The minimum throttle value is 10, the maximum is 100,000, and the default is 5000.

   The following example deletes the directory named d2, which is located in the directory named d1.

   ```
   cluster::*>volume file async-delete start -vserver vs1 -volume vol1
   -path d1/d2
   ```

3. Verify that the directory was deleted: `event log show`

   The following example shows output for the event log when the directory is successfully deleted.

   ```
   cluster-cli::*> event log show
   Time                 Node              Severity      Event
   -------------------  ----------------- ------------- --------------------
   MM/DD/YYYY 00:11:11  cluster-vsim      INFORMATIONAL
   asyncDelete.message.success: Async delete job on path d1/d2 of volume
   (MSID: 2162149232) was completed.
   ```

### Create qtrees with FlexGroup volumes

Beginning with ONTAP 9.3, you can create qtrees with FlexGroup volumes. Qtrees enable you to partition your FlexGroup volumes into smaller segments that you can manage individually.

**About this task**

- If you want to revert to ONTAP 9.2 or earlier and if you have created one or more qtrees in the FlexGroup volume or modified the attributes (security style and SMB oplocks) of the default qtree, you must delete all of the non-default qtrees and then disable the qtree functionality on each FlexGroup volume before reverting to ONTAP 9.2 or earlier.

  Disable qtree functionality in FlexGroup volumes before reverting

- If the source FlexGroup volume has qtrees in a SnapMirror relationship, the destination cluster must be

running ONTAP 9.3 or later (a version of ONTAP software that supports qtrees).

- Beginning with ONTAP 9.5, qtree statistics are supported for FlexGroup volumes.

**Steps**

1. Create a qtree in the FlexGroup volume: `volume qtree create -vserver vserver_name -volume volume_name -qtree qtree name`

   You can optionally specify the security style, SMB oplocks, UNIX permissions, and export policy for the qtree.

   ```
   cluster1::> volume qtree create -vserver vs0 -volume fg1 -qtree qtree1
   -security-style mixed
   ```

**Related information**

Logical storage management

### Use quotas for FlexGroup volumes

In ONTAP 9.4 and earlier, you can apply quotas rules to FlexGroup volumes only for reporting purposes, but not for enforcing quota limits. Beginning with ONTAP 9.5, you can enforce limits on quota rules that are applied to FlexGroup volumes.

**About this task**

- Beginning with ONTAP 9.5, you can specify hard, soft, and threshold limit quotas for FlexGroup volumes.

  You can specify these limits to constrain the amount of space, the number of files that a specific user, group, or qtree can create, or both. Quota limits generate warning messages in the following scenarios:

  - When usage exceeds a configured soft limit, ONTAP issues a warning message, but further traffic is still allowed.

    If usage later drops below the configured soft limit again, an all-clear message is issued.

  - When usage exceeds a configured threshold limit, ONTAP issues a second warning message.

    No all-clear administrative message is issued when usage later drops below a configured threshold limit.

  - If usage reaches a configured hard limit, ONTAP prevents further resource consumption by rejecting traffic.

- In ONTAP 9.5, quota rules cannot be created or activated on the destination FlexGroup volume of a SnapMirror relationship.

#### Quota targets and types

Quotas have a type: they can be either user, group, or tree. Quota targets specify the user, group, or qtree for which the quota limits are applied.

The following table lists the kinds of quota targets, what types of quotas each quota target is associated with, and how each quota target is represented:

| Quota target | Quota type | How target is represented | Notes |
|---|---|---|---|
| user | user quota | UNIX user name UNIX UID<br><br>Windows user name in pre-Windows 2000 format<br><br>Windows SID | User quotas can be applied for a specific volume or qtree. |
| group | group quota | UNIX group name UNIX GID | Group quotas can be applied for a specific volume or qtree.<br><br>ONTAP does not apply group quotas based on Windows IDs. |
| qtree | tree quota | qtree name | Tree quotas are applied to a particular volume and do not affect qtrees in other volumes. |
| | user quotagroup quota<br><br>tree quota | Double quotation marks ("") | A quota target of "" denotes a *default quota*. For default quotas, the quota type is determined by the value of the type field. |

#### Behavior of FlexGroup volumes when quota limits are exceeded

Beginning with ONTAP 9.5, quota limits are supported on FlexGroup volumes. There are some differences in the way quota limits are enforced on a FlexGroup volume when compared to a FlexVol volume.

FlexGroup volumes might show the following behaviors when the quota limits are exceeded:

- The space and file usage in a FlexGroup volume might reach up to 5 percent higher than the configured hard limit before the quota limit is enforced by rejecting further traffic.

  To provide the best performance, ONTAP might allow the space consumption to exceed the configured hard limit by a small margin before the quota enforcement begins. This additional space consumption does not exceed 5 percent of the configured hard limits, 1 GB, or 65536 files, whichever is lower.

- After the quota limit is reached, if a user or administrator deletes some files or directories such that the quota usage is now below the limit, the subsequent quota-consuming file operation might resume with a delay (might take up to 5 seconds to resume).

- When the total space and file usage of a FlexGroup volume exceed the configured quota limits, there might be a slight delay in logging an event log message.
- You might get “no space” errors if some constituents of the FlexGroup volume get full, but the quota limits are not reached.
- Operations, such as renaming a file or directory or moving files between qtrees, on quota targets, for which quota hard limits are configured, might take longer when compared to similar operations on FlexVol volumes.

#### Examples of quota enforcement for FlexGroup volumes

You can use the examples to understand how to configure quotas with limits in ONTAP 9.5 and later.

#### Example 1: Enforcing a quota rule with disk limits

1. You should create a quota policy rule of type `user` with both an achievable soft disk limit and hard disk limit.

```
cluster1::> volume quota policy rule create -vserver vs0 -policy-name
default -volume FG -type user -target "" -qtree "" -disk-limit 1T -soft
-disk-limit 800G
```

2. You can view the quota policy rule:

```
cluster1::> volume quota policy rule show -vserver vs0 -policy-name
default -volume FG

Vserver: vs0               Policy: default           Volume: FG

                                                Soft             Soft
                         User          Disk     Disk   Files    Files
Type   Target    Qtree   Mapping      Limit    Limit   Limit    Limit
Threshold
-----  --------  ------- -------  --------  -------  ------  -------
---------
user   ""        ""      off           1TB    800GB       -        -
-
```

3. To activate the new quota rule, you initialize quotas on the volume:

```
cluster1::> volume quota on -vserver vs0 -volume FG -foreground true
[Job 49] Job succeeded: Successful
```

4. You can view the disk usage and file usage information of the FlexGroup volume by using the quota report.

```
cluster1::> volume quota report -vserver vs0 -volume FG
Vserver: vs0

                                    ----Disk----  ----Files-----   Quota
Volume   Tree      Type    ID        Used  Limit    Used   Limit
Specifier
-------  --------  ------  -------  -----  -----  ------  ------
---------
FG                 user    root      50GB      -       1       -
FG                 user    *         800GB    1TB      0       -   *
2 entries were displayed.
```

After the hard disk limit is reached, the quota policy rule target (user, in this case) is blocked from writing more data to the files.

**Example 2: Enforcing a quota rule for multiple users**

1. You should create a quota policy rule of type `user`, where multiple users are specified in the quota target (UNIX users, SMB users, or a combination of both) and where the rule has both an achievable soft disk limit and hard disk limit.

```
cluster1::> quota policy rule create -vserver vs0 -policy-name default
-volume FG -type user -target "rdavis,ABCCORP\RobertDavis" -qtree ""
-disk-limit 1TB -soft-disk-limit  800GB
```

2. You can view the quota policy rule:

```
cluster1::> quota policy rule show -vserver vs0 -policy-name default
-volume FG

Vserver: vs0               Policy: default           Volume: FG

                                                Soft             Soft
                         User          Disk     Disk   Files    Files
Type   Target    Qtree   Mapping      Limit    Limit   Limit    Limit
Threshold
-----  --------  ------- -------  --------  -------  ------  -------
---------
user   "rdavis,ABCCORP\RobertDavis"  "" off  1TB  800GB  -  -
```

3. To activate the new quota rule, you initialize quotas on the volume:

```
cluster1::> volume quota on -vserver vs0 -volume FG -foreground true
[Job 49] Job succeeded: Successful
```

4. You can verify that the quota state is active:

```
cluster1::> volume quota show -vserver vs0 -volume FG
              Vserver Name: vs0
               Volume Name: FG
               Quota State: on
               Scan Status: -
          Logging Messages: on
          Logging Interval: 1h
          Sub Quota Status: none
  Last Quota Error Message: -
Collection of Quota Errors: -
```

5. You can view the disk usage and file usage information of the FlexGroup volume by using the quota report.

```
cluster1::> quota report -vserver vs0 -volume FG
Vserver: vs0

                                      ----Disk----  ----Files-----   Quota
Volume   Tree      Type    ID        Used  Limit    Used   Limit
Specifier
-------  --------  ------  -------  -----  -----  ------  ------
---------
FG                 user    rdavis,ABCCORP\RobertDavis  0B  1TB  0  -
rdavis,ABCCORP\RobertDavis
```

The quota limit is shared among all users listed in the quota target.

After the hard disk limit is reached, users listed in the quota target are blocked from writing more data to the files.

**Example 3: Enforcing quota with user mapping enabled**

1. You should create a quota policy rule of type `user`, specify a UNIX user or a Windows user as the quota target with `user-mapping` set to `on`, and create the rule with both an achievable soft disk limit and hard disk limit.

   The mapping between UNIX and Windows users must be configured earlier by using the `vserver name-mapping create` command.

```
cluster1::> quota policy rule create -vserver vs0 -policy-name default
-volume FG -type user -target rdavis -qtree "" -disk-limit 1TB -soft
-disk-limit  800GB -user-mapping on
```

2. You can view the quota policy rule:

```
cluster1::> quota policy rule show -vserver vs0 -policy-name default
-volume FG

Vserver: vs0              Policy: default          Volume: FG

                                                Soft             Soft
                         User         Disk     Disk   Files    Files
Type   Target    Qtree   Mapping     Limit    Limit   Limit    Limit
Threshold
-----  --------  ------- -------  --------  -------  ------  -------
---------
user   rdavis    ""      on           1TB    800GB       -        -
-
```

3. To activate the new quota rule, you initialize quotas on the volume:

```
cluster1::> volume quota on -vserver vs0 -volume FG -foreground true
[Job 49] Job succeeded: Successful
```

4. You can verify that the quota state is active:

```
cluster1::> volume quota show -vserver vs0 -volume FG
              Vserver Name: vs0
               Volume Name: FG
               Quota State: on
               Scan Status: -
          Logging Messages: on
          Logging Interval: 1h
          Sub Quota Status: none
  Last Quota Error Message: -
Collection of Quota Errors: -
```

5. You can view the disk usage and file usage information of the FlexGroup volume by using the quota report.

```
cluster1::> quota report -vserver vs0 -volume FG
Vserver: vs0

                                     ----Disk----  ----Files-----   Quota
Volume   Tree      Type    ID        Used  Limit    Used   Limit
Specifier
-------  --------  ------  -------  -----  -----  ------  ------
---------
FG                 user    rdavis,ABCCORP\RobertDavis  0B  1TB  0  -
rdavis
```

The quota limit is shared between the user listed in the quota target and its corresponding Windows or UNIX user.

After the hard disk limit is reached, both the user listed in the quota target and its corresponding Windows or UNIX user is blocked from writing more data to the files.

**Example 4: Verifying the qtree size when quota is enabled**

1. You should create a quota policy rule of type `tree` and where the rule has both an achievable soft disk limit and hard disk limit.

```
cluster1::> quota policy rule create -vserver vs0 -policy-name default
-volume FG -type tree -target tree_4118314302 -qtree "" -disk-limit 48GB
-soft-disk-limit 30GB
```

2. You can view the quota policy rule:

```
cluster1::> quota policy rule show -vserver vs0

Vserver: vs0               Policy: default           Volume: FG

                                                Soft             Soft
                         User         Disk     Disk   Files    Files
Type   Target    Qtree   Mapping     Limit    Limit   Limit    Limit
Threshold
-----  --------  ------- -------  --------  -------  ------  -------
---------
tree   tree_4118314302  "" -          48GB        -      20        -
```

3. To activate the new quota rule, you initialize quotas on the volume:

```
cluster1::> volume quota on -vserver vs0 -volume FG -foreground true
[Job 49] Job succeeded: Successful
```

a. You can view the disk usage and file usage information of the FlexGroup volume by using the quota report.

```
cluster1::> quota report -vserver vs0
Vserver: vs0
----Disk---- ----Files----- Quota
Volume Tree Type ID Used Limit Used Limit Specifier
------- -------- ------ ------- ----- ----- ------ ------ ---------
FG tree_4118314302 tree 1 30.35GB 48GB 14 20 tree_4118314302
```

The quota limit is shared between the user listed in the quota target and its corresponding Windows or UNIX user.

4. From an NFS client, use the `df` command to view the total space usage, available space, and the used space.

```
scsps0472342001# df -m /t/10.53.2.189/FG-3/tree_4118314302
Filesystem 1M-blocks Used Available Use% Mounted on
10.53.2.189/FG-3 49152 31078 18074 63% /t/10.53.2.189/FG-3
```

With hard limit, the space usage is calculated from an NFS client as follows:

- Total space usage = hard limit for tree
- Free space = Hard limit minus qtree space usage
  Without hard limit, the space usage is calculated from an NFS client as follows:
- Space usage = quota usage
- Total space = Sum of quota usage and physical free space in the volume

5. From the SMB share, use Windows Explorer to view the total space usage, available space, and the used space.

From an SMB share, you should be aware of the following considerations for calculating the space usage:

- The user quota hard limit for the user and group is taken into consideration for calculating the total available space.
- The minimum value among the free space of the tree quota rule, the user quota rule, and the group quota rule is considered as the free space for the SMB share.
- The total space usage is variable for SMB and depends on the hard limit that corresponds to the minimum free space among the tree, user, and group.

#### Apply rules and limits on the FlexGroups volume

**Steps**

1. Create quota rules for targets : `volume quota policy rule create -vserver vs0 -policy -name quota_policy_of_the_rule -volume flexgroup_vol -type {tree|user|group} -target target_for_rule -qtree qtree_name [-disk-limit hard_disk_limit_size] [-file-limit hard_limit_number_of_files] [-threshold`

`threshold_disk_limit_size] [-soft-disk-limit soft_disk_limit_size] [-soft-file-limit soft_limit_number_of_files]`

- In ONTAP 9.2 and ONTAP 9.1, the quota target type can be only `user` or `group` for FlexGroup volumes.

  Tree quota type is not supported for FlexGroup volumes in ONTAP 9.2 and ONTAP 9.1.

- In ONTAP 9.3 and later, the quota target type can be `user`, `group`, or `tree` for FlexGroup volumes.
- A path is not supported as the target when creating quota rules for FlexGroup volumes.
- Beginning with ONTAP 9.5, you can specify hard disk limit, hard file limit, soft disk limit, soft file limit, and threshold limit quotas for FlexGroup volumes.

  In ONTAP 9.4 and earlier, you cannot specify the disk limit, file limit, threshold for disk limit, soft disk limit, or soft file limit when you create quota rules for FlexGroup volumes.

The following example shows a default quota rule being created for the user target type:

```
cluster1::> volume quota policy rule create -vserver vs0 -policy-name
quota_policy_vs0_1 -volume fg1 -type user -target "" -qtree ""
```

The following example shows a tree quota rule being created for the qtree named qtree1:

```
cluster1::> volume quota policy rule create -policy-name default -vserver
vs0 -volume fg1 -type tree -target "qtree1"
```

1. Activate the quotas for the specified FlexGroup volume: `volume quota on -vserver svm_name -volume flexgroup_vol -foreground true`

```
cluster1::> volume quota on -vserver vs0 -volume fg1 -foreground true
```

1. Monitor the state of quota initialization: `volume quota show -vserver svm_name`

FlexGroup volumes might show the `mixed` state, which indicates that all of the constituent volumes are not in the same state yet.

```
cluster1::> volume quota show -vserver vs0
                                        Scan
Vserver    Volume        State          Status
---------  ------------  -------------  ------
vs0        fg1           initializing       95%
vs0        vol1          off                 -
2 entries were displayed.
```

1. View the quota report for the FlexGroup volume with active quotas: `volume quota report -vserver svm_name -volume flexgroup_vol`

   You cannot specify a path with the `volume quota report` command for FlexGroup volumes.

   The following example shows the user quota for the FlexGroup volume fg1:

```
cluster1::> volume quota report -vserver vs0 -volume fg1
  Vserver: vs0
                                       ----Disk----  ----Files-----
Quota
  Volume   Tree      Type    ID        Used  Limit    Used   Limit
Specifier
  -------  --------  ------  -------  -----  -----  ------  ------
---------
  fg1                user    *           0B      -       0       -   *
  fg1                user    root       1GB      -       1       -   *
  2 entries were displayed.
```

   The following example shows the tree quota for the FlexGroup volume fg1:

```
cluster1::> volume quota report -vserver vs0 -volume fg1
Vserver: vs0

                                     ----Disk----  ----Files-----   Quota
Volume   Tree      Type    ID        Used  Limit    Used   Limit
Specifier
-------  --------  ------  -------  -----  -----  ------  ------
---------
fg1      qtree1  tree      1         68KB      -      18       -
qtree1
fg1              tree      *           0B      -       0       -   *
2 entries were displayed.
```

**Results**

The quota rules and limits are applied on the FlexGroups volume.

The usage might reach up to 5 percent higher than a configured hard limit before ONTAP enforces the quota by rejecting further traffic.

**Related information**

ONTAP 9 commands

**Enable storage efficiency on a FlexGroup volume**

You can run deduplication and data compression together or independently on a

FlexGroup volume to achieve optimal space savings.

**What you'll need**

The FlexGroup volume must be online.

**Steps**

1. Enable storage efficiency on the FlexGroup volume: `volume efficiency on -vserver svm_name -volume volume_name`

   Storage efficiency operations are enabled on all the constituents of the FlexGroup volume.

   If a FlexGroup volume is expanded after storage efficiency is enabled on the volume, storage efficiency is automatically enabled on the new constituents.

2. Enable the required storage efficiency operation on the FlexGroup volume by using the `volume efficiency modify` command.

   You can enable inline deduplication, postprocess deduplication, inline compression, and postprocess compression on FlexGroup volumes. You can also set the type of compression (secondary or adaptive) and specify a schedule or efficiency policy for the FlexGroup volume.

3. If you are not using schedules or efficiency policies for running the storage efficiency operations, start the efficiency operation: `volume efficiency start -vserver svm_name -volume volume_name`

   If deduplication and data compression are enabled on a volume, data compression is run initially followed by deduplication. This command fails if any efficiency operation is already active on the FlexGroup volume.

4. Verify the efficiency operations that are enabled on the FlexGroup volume: `volume efficiency show -vserver svm_name -volume volume_name`

```
cluster1::> volume efficiency show -vserver vs1 -volume fg1
             Vserver Name: vs1
              Volume Name: fg1
              Volume Path: /vol/fg1
                    State: Enabled
                   Status: Idle
                 Progress: Idle for 17:07:25
                     Type: Regular
                 Schedule: sun-sat@0

...

             Compression: true
      Inline Compression: true
Incompressible Data Detection: false
      Constituent Volume: false
Compression Quick Check File Size: 524288000
           Inline Dedupe: true
         Data Compaction: false
```

### Protect FlexGroup volumes using Snapshot copies

You can create Snapshot policies that automatically manage the creation of Snapshot copies or you can manually create Snapshot copies for FlexGroup volumes. A valid Snapshot copy is created for a FlexGroup volume only after ONTAP can successfully create a Snapshot copy for each constituent of the FlexGroup volume.

#### About this task

- If you have multiple FlexGroup volumes associated with a Snapshot policy, you should ensure that the FlexGroup volumes schedules do not overlap.
- Beginning with ONTAP 9.8, the maximum number of Snapshot copies supported on a FlexGroup volume is 1023.

> Beginning with ONTAP 9.8, the `volume snapshot show` command for FlexGroup volumes reports Snapshot copy size using logical blocks, rather than calculating the youngest owned blocks. This new size calculation method might make the Snapshot copy size appear larger than calculations in earlier versions of ONTAP.

#### Steps

1. Create a Snapshot policy or manually create a Snapshot copy:

| If you want to create a… | Enter this command… |
|---|---|
| Snapshot policy | `volume snapshot policy create`<br><br>The schedules that are associated with the Snapshot policy of a FlexGroup volume must have an interval greater than 30 minutes.<br><br>When you create a FlexGroup volume, the `default` Snapshot policy is applied to the FlexGroup volume. |
| Snapshot copy manually | `volume snapshot create`<br><br>After you create a Snapshot copy for a FlexGroup volume, you cannot modify the attributes of the Snapshot copy. If you want to modify the attributes, you must delete and then re-create the Snapshot copy. |

   Client access to the FlexGroup volume is briefly quiesced when a Snapshot copy is created.

2. Verify that a valid Snapshot copy is created for the FlexGroup volume: `volume snapshot show -volume volume_name -fields state`

```
cluster1::> volume snapshot show -volume fg -fields state
vserver volume snapshot               state
------- ------ ---------------------- -----
fg_vs   fg     hourly.2016-08-23_0505 valid
```

3. View the Snapshot copies for the constituents of the FlexGroup volume: `volume snapshot show -is-constituent true`

```
cluster1::> volume snapshot show -is-constituent true

---Blocks---
Vserver  Volume   Snapshot                                  Size Total%
Used%
-------- -------- ------------------------------------ -------- ------
-----
fg_vs    fg__0001
                  hourly.2016-08-23_0505                    72MB     0%
27%
         fg__0002
                  hourly.2016-08-23_0505                    72MB     0%
27%
         fg__0003
                  hourly.2016-08-23_0505                    72MB     0%
27%
...
         fg__0016
                  hourly.2016-08-23_0505                    72MB     0%
27%
```

#### Move the constituents of a FlexGroup volume

You can move the constituents of a FlexGroup volume from one aggregate to another for balancing the load when certain constituents experience more traffic. Moving constituents also helps in freeing up space on an aggregate for resizing the existing constituents.

##### What you'll need

To move a FlexGroup volume constituent that is in a SnapMirror relationship, you must have initialized the SnapMirror relationship.

##### About this task

You cannot perform a volume move operation while the constituents of the FlexGroup volume are being expanded.

##### Steps

1. Identify the FlexGroup volume constituent that you want to move: `volume show -vserver svm_name`

`-is-constituent *`

```
cluster1::> volume show -vserver vs2 -is-constituent *
Vserver   Volume       Aggregate    State      Type       Size
Available Used%
--------- ------------ ------------ ---------- ---- ----------
---------- -----
vs2       fg1          -            online     RW        400TB
15.12TB   62%
vs2       fg1__0001    aggr1        online     RW         25TB
8.12MB   59%
vs2       fg1__0002    aggr2        online     RW         25TB
2.50TB   90%
...
```

2. Identify an aggregate to which you can move the FlexGroup volume constituent: `volume move target-aggr show -vserver svm_name -volume vol_constituent_name`

   The available space in the aggregate that you select must be greater than the size of the FlexGroup volume constituent that you are moving.

```
cluster1::> volume move target-aggr show -vserver vs2 -volume fg1_0002
Aggregate Name   Available Size   Storage Type
--------------   --------------   ------------
aggr2            467.9TB          hdd
node12a_aggr3    100.34TB         hdd
node12a_aggr2    100.36TB         hdd
node12a_aggr1    100.36TB         hdd
node12a_aggr4    100.36TB         hdd
5 entries were displayed.
```

3. Verify that the FlexGroup volume constituent can be moved to the intended aggregate: `volume move start -vserver svm_name -volume vol_constituent_name -perform-validation-only true`

```
cluster1::> volume move start -vserver vs2 -volume fg1_0002 -destination
-aggregate node12a_aggr3 -perform-validation-only true
Validation succeeded.
```

4. Move the FlexGroup volume constituent: `volume move start -vserver svm_name -volume vol_constituent_name -destination-aggregate aggr_name [-allow-mixed-aggr-types {true|false}]`

   The volume move operation runs as a background process.

Beginning with ONTAP 9.5, you can move FlexGroup volume constituents from a Fabric Pool to a non-Fabric Pool, or vice versa by setting the `-allow-mixed-aggr-types` parameter to `true`. By default, the `-allow-mixed-aggr-types` option is set to `false`.

> You cannot use the `volume move` command for enabling encryption on FlexGroup volumes.

```
cluster1::> volume move start -vserver vs2 -volume fg1_002 -destination
-aggregate node12a_aggr3
```

> If the volume move operation fails due to an active SnapMirror operation, you should abort the SnapMirror operation by using the `snapmirror abort -h` command. In some cases, the SnapMirror abort operation might also fail. In such situations, you should abort the volume move operation and retry later.

5. Verify the state of the volume move operation: `volume move show -volume vol_constituent_name`

   The following example shows the state of a FlexGroup constituent volume that completed the replication phase and is in the cutover phase of the volume move operation:

```
cluster1::> volume move show -volume fg1_002
Vserver   Volume     State    Move Phase  Percent-Complete Time-To-
Complete
--------- ---------- -------- ----------  ----------------
----------------
vs2       fg1_002    healthy  cutover     -                -
```

#### Use aggregates in FabricPool for existing FlexGroup volumes

Beginning with ONTAP 9.5, FabricPool is supported for FlexGroup volumes. If you want to use aggregates in FabricPool for your existing FlexGroup volumes, you can either convert the aggregates on which the FlexGroup volume resides to aggregates in FabricPool or migrate the FlexGroup volume constituents to aggregates in FabricPool.

##### What you'll need

- The FlexGroup volume must have space-guarantee set to `none`.
- If you want to convert the aggregates on which the FlexGroup volume resides to aggregates in FabricPool, the aggregates must be using all SSD disks.

##### About this task

If an existing FlexGroup volume resides on non-SSD aggregates, you must migrate the FlexGroup volume constituents to aggregates in FabricPool.

##### Choices

- To convert the aggregates on which the FlexGroup volume resides to aggregates in FabricPool, perform

the following steps:

a. Set the tiering policy on the existing FlexGroup volume: `volume modify -volume flexgroup_name -tiering-policy [auto|snapshot|none|backup]`

```
cluster-2::> volume modify -volume fg1 -tiering-policy auto
```

b. Identify the aggregates on which the FlexGroup volume resides: `volume show -volume flexgroup_name -fields aggr-list`

```
cluster-2::> volume show -volume fg1 -fields aggr-list
vserver volume aggr-list
------- ------ -----------
vs1     fg1    aggr1,aggr3
```

c. Attach an object store to each aggregate listed in the aggregate list: `storage aggregate object-store attach -aggregate aggregate name -name object-store-name -allow -flexgroup true`

You must attach all of the aggregates to an object store.

```
cluster-2::> storage aggregate object-store attach -aggregate aggr1
-object-store-name Amazon01B1
```

- To migrate the FlexGroup volume constituents to aggregates in FabricPool, perform the following steps:

a. Set the tiering policy on the existing FlexGroup volume: `volume modify -volume flexgroup_name -tiering-policy [auto|snapshot|none|backup]`

```
cluster-2::> volume modify -volume fg1 -tiering-policy auto
```

b. Move each constituent of the FlexGroup volume to an aggregate in FabricPool in the same cluster: `volume move start -volume constituent-volume -destination-aggregate FabricPool_aggregate -allow-mixed-aggr-types true`

You must move all FlexGroup volume constituents to aggregates in FabricPool (in case the FlexGroup volume constituents are on mixed aggregate types) and ensure that all the constituents are balanced across the nodes in the cluster.

```
cluster-2::> volume move start -volume fg1_001 -destination-aggregate
FP_aggr1 -allow-mixed-aggr-types true
```

**Related information**

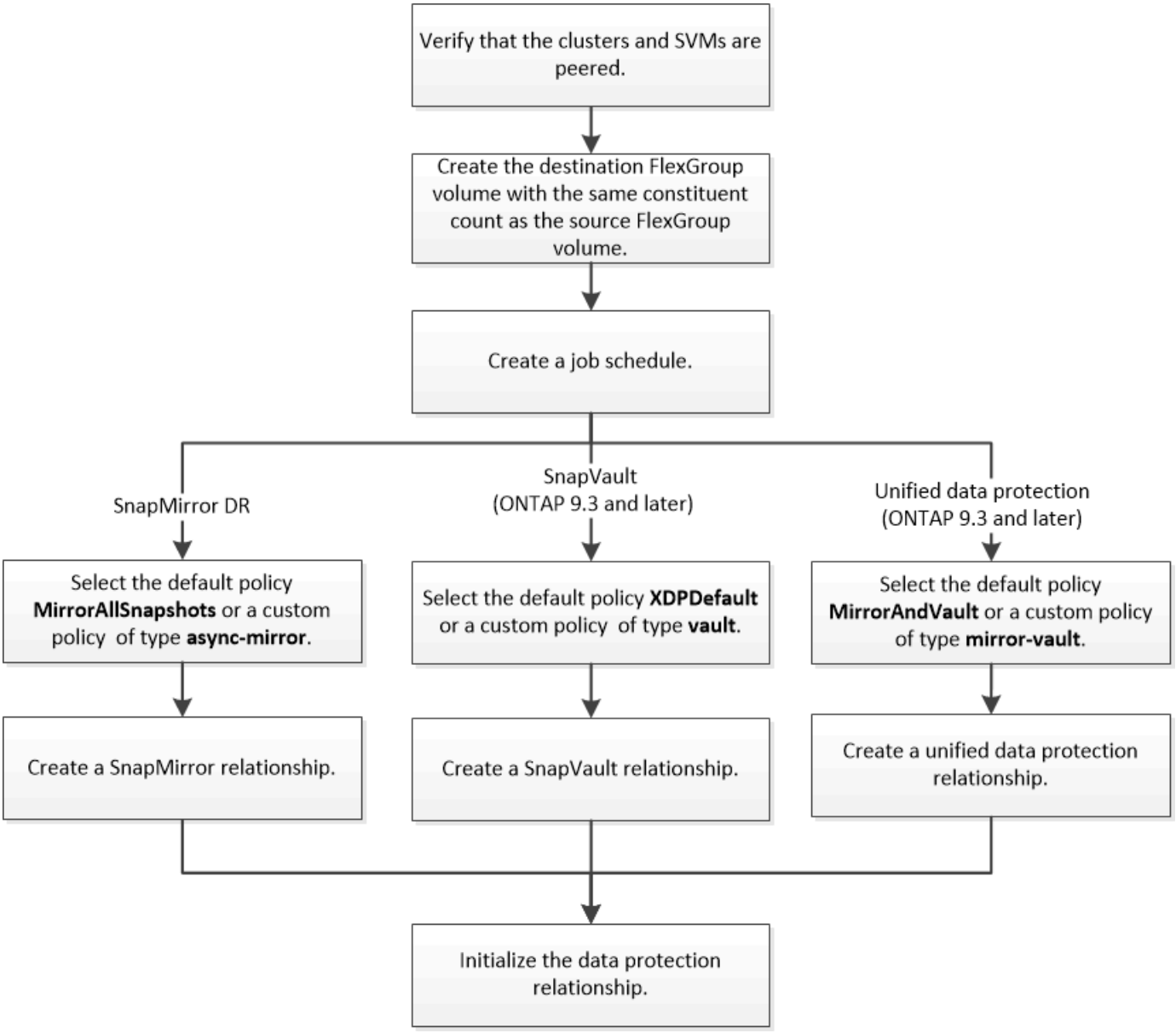
Disk and aggregate management

# Data protection for FlexGroup volumes

## Data protection workflow for FlexGroup volumes

You can create SnapMirror disaster recovery (DR) relationships for FlexGroup volumes. Beginning with ONTAP 9.3, you can also backup and restore FlexGroup volumes by using SnapVault technology, and you can create a unified data protection relationship that uses the same destination for backup and DR.

The data protection workflow consists of verifying the cluster and SVM peer relationships, creating a destination volume, creating a job schedule, specifying a policy, creating a data protection relationship, and initializing the relationship.




### About this task

The SnapMirror relationship type is always `XDP` for FlexGroup volumes. The type of data protection that is provided by a SnapMirror relationship is determined by the replication policy that you use. You can use either the default policy or a custom policy of the required type for the replication relationship that you want to create.

The following table shows the default policy types and supported custom policy types for different types of data protection relationships.

| Relationship type | Default Policy | Custom policy type |
|---|---|---|
| SnapMirror DR | MirrorAllSnapshots | async-mirror |
| SnapVault backup | XDPDefault | vault |
| Unified data protection | MirrorAndVault | mirror-vault |

The MirrorLatest policy is not supported with FlexGroup volumes.

### Create a SnapMirror relationship for FlexGroup volumes

You can create a SnapMirror relationship between the source FlexGroup volume and the destination FlexGroup volume on a peered SVM for replicating data for disaster recovery. You can use the mirror copies of the FlexGroup volume to recover data when a disaster occurs.

#### What you'll need

You must have created the cluster peering relationship and SVM peering relationship.

Cluster and SVM peering

#### About this task

- You can create both intercluster SnapMirror relationships and intracluster SnapMirror relationships for FlexGroup volumes.
- Beginning with ONTAP 9.3, you can expand FlexGroup volumes that are in a SnapMirror relationship.

  If you are using a version of ONTAP earlier than ONTAP 9.3, you must not expand FlexGroup volumes after a SnapMirror relationship is established; however, you can increase the capacity of FlexGroup volumes after establishing a SnapMirror relationship. If you expand the source FlexGroup volume after breaking the SnapMirror relationship in releases earlier than ONTAP 9.3, you must perform a baseline transfer to the destination FlexGroup volume.

#### Steps

1. Create a destination FlexGroup volume of type `DP` that has the same number of constituents as that of the source FlexGroup volume:
   a. From the source cluster, determine the number of constituents in the source FlexGroup volume:
      `volume show -volume volume_name* -is-constituent true`

```
cluster1::> volume show  -volume srcFG* -is-constituent true
Vserver   Volume       Aggregate    State      Type       Size
Available Used%
--------- ------------ ------------ ---------- ---- ----------
---------- -----
vss       srcFG          -            online     RW         400TB
172.86GB  56%
vss       srcFG__0001    Aggr_cmode   online     RW         25GB
10.86TB   56%
vss       srcFG__0002    aggr1        online     RW         25TB
10.86TB   56%
vss       srcFG__0003    Aggr_cmode   online     RW         25TB
10.72TB   57%
vss       srcFG__0004    aggr1        online     RW         25TB
10.73TB   57%
vss       srcFG__0005    Aggr_cmode   online     RW         25TB
10.67TB   57%
vss       srcFG__0006    aggr1        online     RW         25TB
10.64TB   57%
vss       srcFG__0007    Aggr_cmode   online     RW         25TB
10.63TB   57%
...
```

b. From the destination cluster, create a destination FlexGroup volume of type `DP` with the same number of constituents as that of the source FlexGroup volume.

```
cluster2::> volume create -vserver vsd -aggr-list aggr1,aggr2 -aggr
-list-multiplier 8 -size 400TB -type DP dstFG

Warning: The FlexGroup volume "dstFG" will be created with the
following number of constituents of size 25TB: 16.
Do you want to continue? {y|n}: y
[Job 766] Job succeeded: Successful
```

c. From the destination cluster, verify the number of constituents in the destination FlexGroup volume: `volume show -volume volume_name* -is-constituent true`

```
cluster2::> volume show  -volume dstFG* -is-constituent true
Vserver   Volume        Aggregate    State      Type       Size
Available  Used%
--------- ------------  ------------ ---------- ---- ----------
---------- -----
vsd       dstFG          -            online     DP         400TB
172.86GB  56%
vsd       dstFG__0001    Aggr_cmode   online     DP         25GB
10.86TB   56%
vsd       dstFG__0002    aggr1        online     DP         25TB
10.86TB   56%
vsd       dstFG__0003    Aggr_cmode   online     DP         25TB
10.72TB   57%
vsd       dstFG__0004    aggr1        online     DP         25TB
10.73TB   57%
vsd       dstFG__0005    Aggr_cmode   online     DP         25TB
10.67TB   57%
vsd       dstFG__0006    aggr1        online     DP         25TB
10.64TB   57%
vsd       dstFG__0007    Aggr_cmode   online     DP         25TB
10.63TB   57%
...
```

2. Create a job schedule: `job schedule cron create -name job_name -month month -dayofweek day_of_week -day day_of_month -hour hour -minute minute`

   For the `-month`, `-dayofweek`, and `-hour` options, you can specify `all` to run the job every month, every day of the week, and every hour, respectively.

   The following example creates a job schedule named `my_weekly` that runs on Saturdays at 3:00 a.m.:

   ```
   cluster1::> job schedule cron create -name my_weekly -dayofweek
   "Saturday" -hour 3 -minute 0
   ```

3. Create a custom policy of type `async-mirror` for the SnapMirror relationship: `snapmirror policy create -vserver SVM -policy snapmirror_policy -type async-mirror`

   If you do not create a custom policy, you should specify the `MirrorAllSnapshots` policy for SnapMirror relationships.

4. From the destination cluster, create a SnapMirror relationship between the source FlexGroup volume and the destination FlexGroup volume: `snapmirror create -source-path src_svm:src_flexgroup -destination-path dest_svm:dest_flexgroup -type XDP -policy snapmirror_policy -schedule sched_name`

   SnapMirror relationships for FlexGroup volumes must be of type `XDP`.

If you specify a throttle value for the SnapMirror relationship for the FlexGroup volume, each constituent uses the same throttle value. The throttle value is not divided among the constituents.

> You cannot use SnapMirror labels of Snapshot copies for FlexGroup volumes.

In ONTAP 9.4 and earlier, if the policy is not specified with the `snapmirror create` command, the `MirrorAllSnapshots` policy is used by default. In ONTAP 9.5, if the policy is not specified with the `snapmirror create` command, the `MirrorAndVault` policy is used by default.

```
cluster2::> snapmirror create -source-path vss:srcFG -destination-path
vsd:dstFG -type XDP -policy MirrorAllSnapshots -schedule hourly
Operation succeeded: snapmirror create for the relationship with
destination "vsd:dstFG".
```

5. From the destination cluster, initialize the SnapMirror relationship by performing a baseline transfer: `snapmirror initialize -destination-path dest_svm:dest_flexgroup`

   After the baseline transfer is completed, the destination FlexGroup volume is updated periodically based on the schedule of the SnapMirror relationship.

```
cluster2::> snapmirror initialize -destination-path vsd:dstFG
Operation is queued: snapmirror initialize of destination "vsd:dstFG".
```

> If you have created any SnapMirror relationship between FlexGroup volumes with the source cluster running ONTAP 9.3 and the destination cluster running ONTAP 9.2 or earlier, and if you create any qtrees in the source FlexGroup volume, the SnapMirror updates fail. To recover from this situation, you must delete all of the non-default qtrees in the FlexGroup volume, disable the qtree functionality on the FlexGroup volume, and then delete all of the Snapshot copies that are enabled with the qtree functionality. You must also perform these steps before reverting from ONTAP 9.3 to an earlier version of ONTAP, if you have the qtree functionality enabled on the FlexGroup volumes. Disable qtree functionality in FlexGroup volumes before reverting

**After you finish**

You should set up the destination SVM for data access by setting up required configurations such as LIFs and export policies.

### Create a SnapVault relationship for FlexGroup volumes

You can configure a SnapVault relationship and assign a SnapVault policy to the relationship to create a SnapVault backup.

**What you'll need**

You must be aware of the considerations for creating a SnapVault relationship for FlexGroup volumes.

**Steps**

1. Create a destination FlexGroup volume of type `DP` that has the same number of constituents as that of the

source FlexGroup volume:

a. From the source cluster, determine the number of constituents in the source FlexGroup volume:
`volume show -volume volume_name* -is-constituent true`

```
cluster1::> volume show  -volume src* -is-constituent true
Vserver   Volume       Aggregate    State      Type       Size
Available Used%
--------- ------------ ------------ ---------- ---- ----------
---------- -----
vss       src          -            online     RW         400TB
172.86GB  56%
vss       src__0001    Aggr_cmode   online     RW         25GB
10.86TB   56%
vss       src__0002    aggr1        online     RW         25TB
10.86TB   56%
vss       src__0003    Aggr_cmode   online     RW         25TB
10.72TB   57%
vss       src__0004    aggr1        online     RW         25TB
10.73TB   57%
vss       src__0005    Aggr_cmode   online     RW         25TB
10.67TB   57%
vss       src__0006    aggr1        online     RW         25TB
10.64TB   57%
vss       src__0007    Aggr_cmode   online     RW         25TB
10.63TB   57%
...
```

b. From the destination cluster, create a destination FlexGroup volume of type `DP` with the same number of constituents as that of the source FlexGroup volume.

```
cluster2::> volume create -vserver vsd -aggr-list aggr1,aggr2 -aggr
-list-multiplier 8 -size 400TB -type DP dst

Warning: The FlexGroup volume "dst" will be created with the
following number of constituents of size 25TB: 16.
Do you want to continue? {y|n}: y
[Job 766] Job succeeded: Successful
```

c. From the destination cluster, verify the number of constituents in the destination FlexGroup volume:
`volume show -volume volume_name* -is-constituent true`

```
cluster2::> volume show  -volume dst* -is-constituent true
Vserver   Volume       Aggregate    State      Type       Size
Available Used%
--------- ------------ ------------ ---------- ---- ----------
---------- -----
vsd       dst          -            online     RW         400TB
172.86GB  56%
vsd       dst__0001    Aggr_cmode   online     RW         25GB
10.86TB   56%
vsd       dst__0002    aggr1        online     RW         25TB
10.86TB   56%
vsd       dst__0003    Aggr_cmode   online     RW         25TB
10.72TB   57%
vsd       dst__0004    aggr1        online     RW         25TB
10.73TB   57%
vsd       dst__0005    Aggr_cmode   online     RW         25TB
10.67TB   57%
vsd       dst__0006    aggr1        online     RW         25TB
10.64TB   57%
vsd       dst__0007    Aggr_cmode   online     RW         25TB
10.63TB   57%
...
```

2. Create a job schedule: `job schedule cron create -name job_name -month month -dayofweek day_of_week -day day_of_month -hour hour -minute minute`

   For `-month`, `-dayofweek`, and `-hour`, you can specify `all` to run the job every month, day of the week, and hour, respectively.

   The following example creates a job schedule named `my_weekly` that runs on Saturdays at 3:00 a.m.:

   ```
   cluster1::> job schedule cron create -name my_weekly -dayofweek
   "Saturday" -hour 3 -minute 0
   ```

3. Create a SnapVault policy, and then define a rule for the SnapVault policy:

   a. Create a custom policy of type `vault` for the SnapVault relationship: `snapmirror policy create -vserver svm_name -policy policy_name -type vault`

   b. Define a rule for the SnapVault policy that determines which Snapshot copies are transferred during initialization and update operations: `snapmirror policy add-rule -vserver svm_name -policy policy_for_rule - snapmirror-label snapmirror-label -keep retention_count -schedule schedule`

   If you do not create a custom policy, you should specify the `XDPDefault` policy for SnapVault relationships.

4. Create a SnapVault relationship: `snapmirror create -source-path src_svm:src_flexgroup -destination-path dest_svm:dest_flexgroup -type XDP -schedule schedule_name -policy XDPDefault`

   In ONTAP 9.4 and earlier, if the policy is not specified with the `snapmirror create` command, the `MirrorAllSnapshots` policy is used by default. In ONTAP 9.5, if the policy is not specified with the `snapmirror create` command, the `MirrorAndVault` policy is used by default.

```
cluster2::> snapmirror create -source-path vss:srcFG -destination-path
vsd:dstFG -type XDP -schedule Daily -policy XDPDefault
```

5. From the destination cluster, initialize the SnapVault relationship by performing a baseline transfer: `snapmirror initialize -destination-path dest_svm:dest_flexgroup`

```
cluster2::> snapmirror initialize -destination-path vsd:dst
Operation is queued: snapmirror initialize of destination "vsd:dst".
```

#### Create a unified data protection relationship for FlexGroup volumes

Beginning with ONTAP 9.3, you can create and configure SnapMirror unified data protection relationships to configure disaster recovery and archiving on the same destination volume.

##### What you'll need

You must be aware of the considerations for creating unified data protection relationships for FlexGroup volumes.

Considerations for creating a SnapVault backup relationship and a unified data protection relationship for FlexGroup volumes

##### Steps

1. Create a destination FlexGroup volume of type `DP` that has the same number of constituents as that of the source FlexGroup volume:
   a. From the source cluster, determine the number of constituents in the source FlexGroup volume: `volume show -volume volume_name* -is-constituent true`

```
cluster1::> volume show  -volume srcFG* -is-constituent true
Vserver   Volume         Aggregate    State      Type       Size
Available  Used%
--------- ------------   ------------ ---------- ---- ----------
---------- -----
vss       srcFG          -            online     RW         400TB
172.86GB  56%
vss       srcFG__0001    Aggr_cmode   online     RW         25GB
10.86TB   56%
vss       srcFG__0002    aggr1        online     RW         25TB
10.86TB   56%
vss       srcFG__0003    Aggr_cmode   online     RW         25TB
10.72TB   57%
vss       srcFG__0004    aggr1        online     RW         25TB
10.73TB   57%
vss       srcFG__0005    Aggr_cmode   online     RW         25TB
10.67TB   57%
vss       srcFG__0006    aggr1        online     RW         25TB
10.64TB   57%
vss       srcFG__0007    Aggr_cmode   online     RW         25TB
10.63TB   57%
...
```

b. From the destination cluster, create a destination FlexGroup volume of type `DP` with the same number of constituents as that of the source FlexGroup volume.

```
cluster2::> volume create -vserver vsd -aggr-list aggr1,aggr2 -aggr
-list-multiplier 8 -size 400TB -type DP dstFG

Warning: The FlexGroup volume "dstFG" will be created with the
following number of constituents of size 25TB: 16.
Do you want to continue? {y|n}: y
[Job 766] Job succeeded: Successful
```

c. From the destination cluster, verify the number of constituents in the destination FlexGroup volume: `volume show -volume volume_name* -is-constituent true`

```
cluster2::> volume show  -volume dstFG* -is-constituent true
Vserver   Volume       Aggregate    State      Type       Size
Available Used%
--------- ------------ ------------ ---------- ---- ----------
---------- -----
vsd       dstFG          -            online     RW         400TB
172.86GB  56%
vsd       dstFG__0001    Aggr_cmode   online     RW         25GB
10.86TB   56%
vsd       dstFG__0002    aggr1        online     RW         25TB
10.86TB   56%
vsd       dstFG__0003    Aggr_cmode   online     RW         25TB
10.72TB   57%
vsd       dstFG__0004    aggr1        online     RW         25TB
10.73TB   57%
vsd       dstFG__0005    Aggr_cmode   online     RW         25TB
10.67TB   57%
vsd       dstFG__0006    aggr1        online     RW         25TB
10.64TB   57%
vsd       dstFG__0007    Aggr_cmode   online     RW         25TB
10.63TB   57%
...
```

2. Create a job schedule: `job schedule cron create -name job_name -month month -dayofweek day_of_week -day day_of_month -hour hour -minute minute`

   For the `-month`, `-dayofweek`, and `-hour` options, you can specify `all` to run the job every month, every day of the week, and every hour, respectively.

   The following example creates a job schedule named `my_weekly` that runs on Saturdays at 3:00 a.m.:

   ```
   cluster1::> job schedule cron create -name my_weekly -dayofweek
   "Saturday" -hour 3 -minute 0
   ```

3. Create a custom policy of type `mirror-vault`, and then define a rule for the mirror and vault policy:

   a. Create a custom policy of type `mirror-vault` for the unified data protection relationship: `snapmirror policy create -vserver svm_name -policy policy_name -type mirror-vault`

   b. Define a rule for the mirror and vault policy that determines which Snapshot copies are transferred during initialization and update operations: `snapmirror policy add-rule -vserver svm_name -policy policy_for_rule - snapmirror-label snapmirror-label -keep retention_count -schedule schedule`

   If you do not specify a custom policy, the `MirrorAndVault` policy is used for unified data protection relationships.

4. Create a unified data protection relationship: `snapmirror create -source-path src_svm:src_flexgroup -destination-path dest_svm:dest_flexgroup -type XDP -schedule schedule_name -policy MirrorAndVault`

   In ONTAP 9.4 and earlier, if the policy is not specified with the `snapmirror create` command, the `MirrorAllSnapshots` policy is used by default. In ONTAP 9.5, if the policy is not specified with the `snapmirror create` command, the `MirrorAndVault` policy is used by default.

```
cluster2::> snapmirror create -source-path vss:srcFG -destination-path
vsd:dstFG -type XDP -schedule Daily -policy MirrorAndVault
```

5. From the destination cluster, initialize the unified data protection relationship by performing a baseline transfer: `snapmirror initialize -destination-path dest_svm:dest_flexgroup`

```
cluster2::> snapmirror initialize -destination-path vsd:dstFG
Operation is queued: snapmirror initialize of destination "vsd:dstFG".
```

#### Create an SVM disaster recovery relationship for FlexGroup volumes

Beginning with ONTAP 9.9.1, you can create SVM disaster recovery (SVM DR) relationships using FlexGroup volumes. An SVM DR relationship provides redundancy and the ability to recover FlexGroups in the event of a disaster by synchronizing and replicating the SVM configuration and its data. A SnapMirror license is required for SVM DR.

##### Before you begin

You should be aware of the conditions when you cannot create a FlexGroup SVM DR relationship.

- A FlexClone FlexGroup configuration exists
- A FlexGroup volume contains a FabricPool configuration
- The FlexGroup volume is part of a fanout or cascading relationship

##### About this task

- All nodes in both clusters must be running the same ONTAP version as the node on which SVM DR support was added (ONTAP 9.9.1 or later).
- The SVM DR relationship between the primary and secondary sites should be healthy and should have enough space on both the primary and secondary SVMs to support the FlexGroup volumes.

For information about creating an SVM DR relationship, see Manage SnapMirror SVM replication.

##### Steps

1. Create an SVM DR relationship, or use an existing relationship.

   Replicate an entire SVM configuration

2. Create a FlexGroup volume on the primary site with the required number of constituents.

Creating a FlexGroup volume.

Wait until FlexGroup and all of its constituents are created before proceeding.

3. To replicate the FlexGroup volume, update the SVM at the secondary site: `snapmirror update -destination-path destination_svm_name: -source-path source_svm_name:`
+ You can also check if a scheduled SnapMirror update already exists by entering `snapmirror show -fields schedule`

4. From the secondary site, verify that the SnapMirror relationship is healthy: `snapmirror show`

```
cluster2::> snapmirror show

Progress
Source            Destination Mirror  Relationship   Total
Last
Path        Type  Path        State   Status         Progress  Healthy
Updated
----------- ---- ------------ ------- -------------- --------- -------
--------
vs1:        XDP  vs1_dst:     Snapmirrored
                                    Idle           -         true    -
```

5. From the secondary site, verify that the new FlexGroup volume and its constituents exist: `snapmirror show -expand`

```
cluster2::> snapmirror show -expand

Progress
Source            Destination Mirror  Relationship   Total
Last
Path        Type  Path        State   Status         Progress  Healthy
Updated
----------- ---- ------------ ------- -------------- --------- -------
--------
vs1:        XDP  vs1_dst:     Snapmirrored
                                 Idle           -         true    -
vs1:fg_src  XDP  vs1_dst:fg_src
                             Snapmirrored
                                 Idle           -         true    -
vs1:fg_src__0001
            XDP  vs1_dst:fg_src__0001
                             Snapmirrored
                                 Idle           -         true    -
vs1:fg_src__0002
            XDP  vs1_dst:fg_src__0002
                             Snapmirrored
                                 Idle           -         true    -
vs1:fg_src__0003
            XDP  vs1_dst:fg_src__0003
                             Snapmirrored
                                 Idle           -         true    -
vs1:fg_src__0004
            XDP  vs1_dst:fg_src__0004
                             Snapmirrored
                                 Idle           -         true    -
6 entries were displayed.
```

#### Transition an existing FlexGroup SnapMirror relationship to SVM DR

You can create a FlexGroup SVM DR relationship by transitioning an existing FlexGroup volume SnapMirror relationship.

**What you'll need**

- The FlexGroup volume SnapMirror relationship is in a healthy state.
- The source and destination FlexGroup volumes have the same name.

**Steps**

1. From the SnapMirror destination, resynchronize the FlexGroup level SnapMirror relationship: `snapmirror resync`

2. Create the FlexGroup SVM DR SnapMirror relationship: `snapmirror create -policy DPDefault -identity-preserve true -destination-path dest_svm:dest_flexgroup -source-path src_svm:src_flexgroup`
3. Verify the relationship is broken off: `snapmirror show -destination-path dest_svm:dest_flexgroup -source-path src_svm:src_flexgroup`

```
snapmirror show -destination-path fg_vs_renamed: -source-path fg_vs:


Progress
Source            Destination Mirror  Relationship   Total
Last
Path        Type  Path        State   Status         Progress  Healthy
Updated
----------- ---- ------------ ------- -------------- --------- -------
--------
fg_vs:        XDP  fg_vs1_renamed:     Broken-off
                                      Idle           -         true    -
```

4. Stop the destination SVM: `vserver stop -vserver vs_name`

```
vserver stop -vserver fg_vs_renamed
[Job 245] Job is queued: Vserver Stop fg_vs_renamed.
[Job 245] Done
```

5. Resynchronize the SVM SnapMirror relationship: `snapmirror resync -destination-path dest_svm:dest_flexgroup -source-path src_svm:src_flexgroup`

```
snapmirror resync -destination-path fg_vs_renamed: -source-path fg_vs:
Warning: This Vserver has volumes which are the destination of FlexVol
or FlexGroup SnapMirror relationships. A resync on the Vserver
SnapMirror relationship will cause disruptions in data access
```

6. Verify that the SVM DR level SnapMirror relationship reaches a healthy idle state: `snapmirror show -expand`
7. Verify that the FlexGroup SnapMirror relationship is in a healthy state: `snapmirror show`

#### Convert a FlexVol volume to a FlexGroup volume within an SVM-DR relationship

Beginning with ONTAP 9.10.1, you can convert a FlexVol volume to a FlexGroup volume on an SVM-DR source.

**What you'll need**

- The FlexVol volume that is being converted must be online.
- The operations and configurations on the FlexVol volume must be compatible with the conversion process.

  An error message is generated if the FlexVol volume has any incompatibility, and the volume conversion is cancelled. You can take corrective actions and retry the conversion.
  For more details, see Considerations for converting FlexVol volumes to FlexGroup volumes

**Steps**

1. From the destination, update the SVM-DR relationship:

   **snapmirror update -destination-path destination_svm_name: -source-path source_svm_name:**

2. Ensure that the SVM-DR relationship is in a SnapMirrored state and is not broken-off:

   **snapmirror show**

3. From the destination SVM, verify that the FlexVol volume is ready for conversion:

   **volume conversion start -vserver svm_name -volume vol_name -check-only true**

4. From the destination, disable transfers on the SVM-DR relationship:

   **snapmirror quiesce -destination-path dest_svm:**

5. Start the conversion:

   **volume conversion start -vserver svm_name -volume vol_name**

6. Verify that the conversion is successful:

   **volume show vol_name -fields -volume-style-extended,state**

   ```
   cluster-1::*> volume show my_volume -fields volume-style-extended,state

   vserver   volume     state    volume-style-extended
   -------       ---------     ------    ---------------------
   vs0     my_volume  online  flexgroup
   ```

7. From the destination cluster, resume transfers for the relationship:

   **snapmirror resume -destination-path dest_svm:**

8. From the destination cluster, perform an update to propagate the conversion to the destination:

   **snapmirror update -destination-path dest_svm:**

9. Ensure that the SVM-DR relationship is in a SnapMirrored state and is not broken off:

   **snapmirror show**

10. Ensure the conversion occurred on the destination:

**`volume show vol_name -fields -volume-style-extended,state`**

```
cluster-2::*> volume show my_volume -fields volume-style-extended,state

vserver    volume       state     volume-style-extended
-------       -------           ------     ---------------------
vs0_dst   my_volume  online  flexgroup
```

#### Considerations for creating SnapMirror cascade and fanout relationships for FlexGroups

There are support considerations and limitations you should keep in mind when creating SnapMirror cascade and fanout relationships for FlexGroup volumes.

##### Considerations for creating cascading relationships

- Each relationship can be either an inter cluster or intra cluster relationship.
- All asynchronous policy types, including async-mirror, mirror-vault, and vault, are supported for both relationships.
- Only "MirrorAllSnapshots," not "MirrorLatest" async-mirror policies are supported.
- Concurrent updates of cascaded XDP relationships is supported.
- Supports removing A to B and B to C and resync A to C or resync C to A
- A and B FlexGroup volumes also support fanout when all nodes are running ONTAP 9.9.1 or later.
- Restore operations from B or C FlexGroup volumes are supported.
- Transfers on FlexGroup relationships are not support while the destination is the source of a restore relationship.
- The destination of a FlexGroup restore cannot be the destination of any other FlexGroup relationship.
- FlexGroup file restore operations have the same restrictions as regular FlexGroup restore operations.
- All nodes in the cluster where the B and C FlexGroup volumes reside must be running ONTAP 9.9.1 or later.
- All expand and auto expand functionality is supported.
- In a cascade configuration such as A to B to C, if A to B and B to C have different numbers of constituent SnapMirror relationships, then an abort operation from the source is not supported for the B to C SnapMirror relationship.
- System Manager does not support cascading relationships in ONTAP 9.9.1.
- When converting an A to B to C set of FlexVol relationship to a FlexGroup relationship, you must convert the B to C hop first.
- All FlexGroup cascade configurations for relationships with policy types supported by REST are also supported by REST APIs in cascading FlexGroup configurations.
- As with FlexVol relationships, FlexGroup cascading is not supported by the `snapmirror protect` command.

#### Considerations for creating fanout relationships

- Two or more FlexGroup fanout relationships are supported; for example, A to B, A to C, with a maximum of 8 fanout legs.
- Each relationship can be either intercluster or intracluster.
- Concurrent updates are supported for the two relationships.
- All expand and auto expand functionality is supported.
- If the fanout legs of the relationship have different numbers of constituent SnapMirror relationships, then an abort operation from the source is not supported for the A to B and A to C relationships.
- All nodes in the cluster where the source and destination FlexGroups reside must be running ONTAP 9.9.1 or later.
- All asynchronous policy types currently supported for FlexGroup SnapMirror are supported in fanout relationships.
- You can perform restore operations from B to C FlexGroups.
- All fanout configurations with policy types supported by rest are also supported for REST APIs in FlexGroup fanout configurations.

### Considerations for creating a SnapVault backup relationship and a unified data protection relationship for FlexGroup volumes

You must be aware of the considerations for creating a SnapVault backup relationship and unified data protection relationship for FlexGroup volumes.

- You can resynchronize a SnapVault backup relationship and a unified data protection relationship by using the `-preserve` option that enables you to preserve Snapshot copies on the destination volume that are newer than the latest common Snapshot copy.
- Long-term retention is not supported with FlexGroup volumes.

  Long-term retention enables creating Snapshot copies directly on the destination volume without requiring to store the Snapshot copies on the source volume.

- Storage efficiency cannot be configured on the destination FlexGroup volume of a SnapVault backup relationship and unified data protection relationship.
- You cannot rename Snapshot copies of a SnapVault backup relationship and unified data protection relationship for FlexGroup volumes.
- A FlexGroup volume can be the source volume of only one backup relationship or restore relationship.

  A FlexGroup volume cannot be the source of two SnapVault relationships, two restore relationships, or a SnapVault backup relationship and a restore relationship.

- If you delete a Snapshot copy on the source FlexGroup volume and re-create a Snapshot copy with the same name, the next update transfer to the destination FlexGroup volume fails if the destination volume has a Snapshot copy of the same name.

  This is because Snapshot copies cannot be renamed for FlexGroup volumes.

### Monitor SnapMirror data transfers for FlexGroup volumes

You should periodically monitor the status of the FlexGroup volume SnapMirror

relationships to verify that the destination FlexGroup volume is updated periodically as per the specified schedule.

**About this task**

You must perform this task from the destination cluster.

**Steps**

1. View the SnapMirror relationship status of all FlexGroup volume relationships: `snapmirror show -relationship-group-type flexgroup`

```
cluster2::> snapmirror show -relationship-group-type flexgroup

Progress
Source            Destination Mirror  Relationship   Total
Last
Path        Type  Path        State   Status         Progress  Healthy
Updated
----------- ---- ------------ ------- -------------- --------- -------
--------
vss:s       XDP  vsd:d        Snapmirrored
                                    Idle           -         true    -
vss:s2      XDP  vsd:d2       Uninitialized
                                    Idle           -         true    -
2 entries were displayed.
```

2. View the SnapMirror relationship status for each constituent in the FlexGroup volume: `snapmirror show -expand`

```
cluster2::> snapmirror show -expand

Progress
Source            Destination Mirror  Relationship   Total
Last
Path        Type  Path        State   Status         Progress  Healthy
Updated
----------- ---- ------------ ------- -------------- --------- -------
--------
vss:s       XDP  vsd:d        Snapmirrored
                                     Idle           -         true    -
vss:s__0001 XDP  vsd:d__0001  Snapmirrored
                                     Idle           -         true    -
vss:s__0002 XDP  vsd:d__0002  Snapmirrored
                                     Idle           -         true    -
vss:s__0003 XDP  vsd:d__0003  Snapmirrored
                                     Idle           -         true    -
vss:s__0004 XDP  vsd:d__0004  Snapmirrored
                                     Idle           -         true    -
vss:s__0005 XDP  vsd:d__0005  Snapmirrored
                                     Idle           -         true    -
vss:s__0006 XDP  vsd:d__0006  Snapmirrored
                                     Idle           -         true    -
vss:s__0007 XDP  vsd:d__0007  Snapmirrored
                                     Idle           -         true    -
vss:s__0008 XDP  vsd:d__0008  Snapmirrored
                                     Idle           -         true    -
...
```

3. If the SnapMirror transfer fails, identify the FlexGroup volume constituent for which the transfer failed and the reason for the error: `snapmirror show -fields last-transfer-error -expand`

```
cluster2::> snapmirror show -fields last-transfer-error -expand
source-path destination-path last-transfer-error
----------- ----------------
-------------------------------------------
vss:s       vsd:d            Group Update failed (Failed to complete
update operation on one or more item relationships.)
vss:s__0001 vsd:d__0001      -
vss:s__0002 vsd:d__0002      -
vss:s__0003 vsd:d__0003      Failed to get information for source volume
"vss:s__0003" for setup of transfer. (Failed to get volume attributes
for e2de028c-8049-11e6-96ea-005056851ca2:s__0003. (Volume is offline))
vss:s__0004 vsd:d__0004      -
vss:s__0005 vsd:d__0005      -
vss:s__0006 vsd:d__0006      -
vss:s__0007 vsd:d__0007      -
vss:s__0008 vsd:d__0008      -
9 entries were displayed.
```

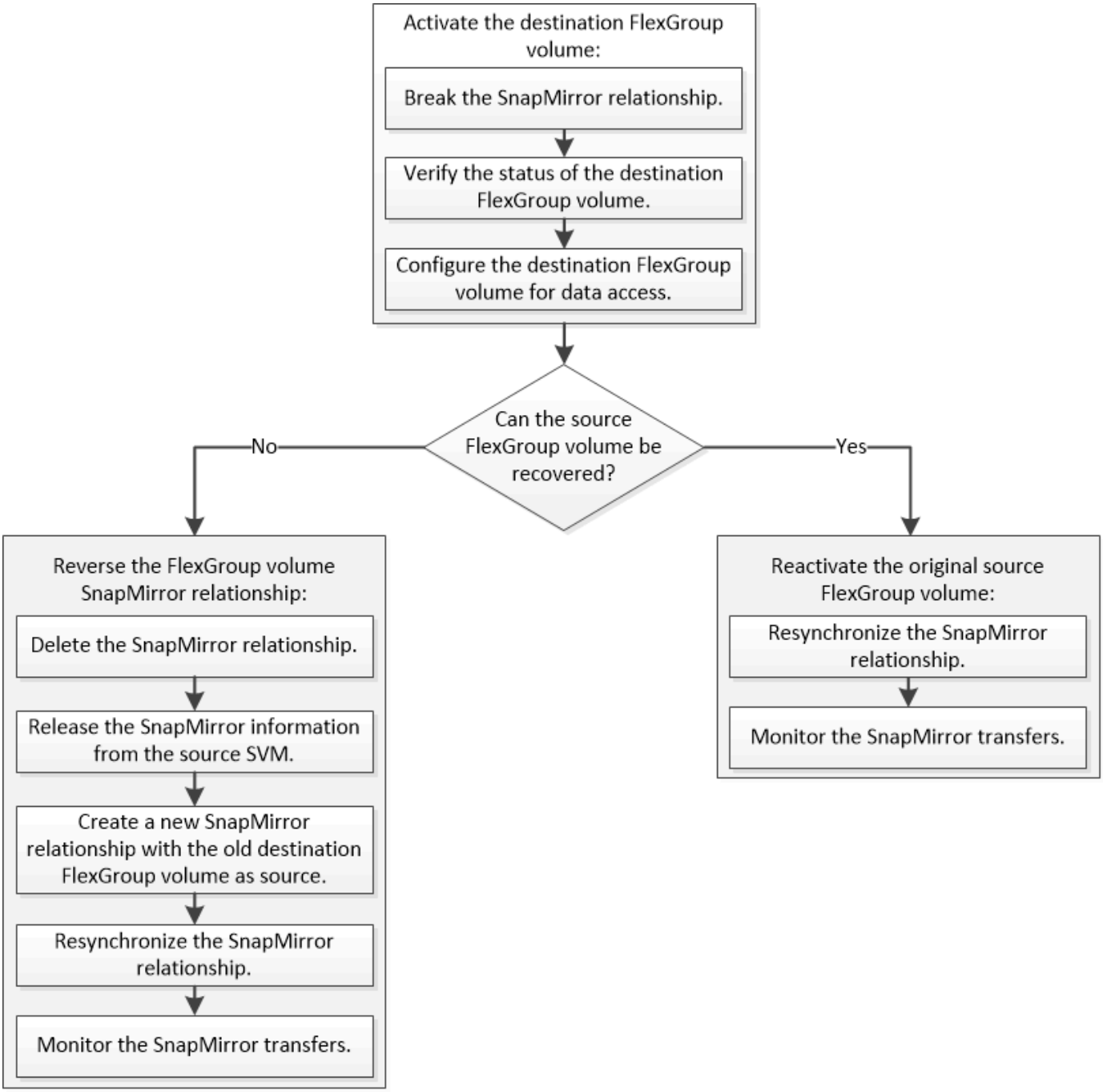
After rectifying the issue, you must rerun the SnapMirror operation.

## Manage data protection operations for FlexGroup volumes

### Disaster recovery for FlexGroup volumes

#### Disaster recovery workflow for FlexGroup volumes

When a disaster strikes on the source FlexGroup volume, you should activate the destination FlexGroup volume and redirect client access. Depending on whether the source FlexGroup volume can be recovered, you should either reactivate the source FlexGroup volume or reverse the SnapMirror relationship.




**About this task**

Client access to the destination FlexGroup volume is blocked for a brief period when some SnapMirror operations, such as SnapMirror break and resynchronization, are running. If the SnapMirror operation fails, it is possible that some of the constituents remain in this state and access to the FlexGroup volume is denied. In such cases, you must retry the SnapMirror operation.

#### Activate the destination FlexGroup volume

When the source FlexGroup volume is unable to serve data due to events such as data corruption, accidental deletion or an offline state, you must activate the destination FlexGroup volume to provide data access until you recover the data on the source FlexGroup volume. Activation involves stopping future SnapMirror data transfers and breaking the SnapMirror relationship.

**About this task**

You must perform this task from the destination cluster.

**Steps**

1. Disable future transfers for the FlexGroup volume SnapMirror relationship: `snapmirror quiesce dest_svm:dest_flexgroup`

```
cluster2::> snapmirror quiesce -destination-path vsd:dst
```

2. Break the FlexGroup volume SnapMirror relationship: `snapmirror break dest_svm:dest_flexgroup`

```
cluster2::> snapmirror break -destination-path vsd:dst
```

3. View the status of the SnapMirror relationship: `snapmirror show -expand`

```
cluster2::> snapmirror show -expand

Progress
Source            Destination Mirror  Relationship   Total
Last
Path        Type  Path        State   Status         Progress  Healthy
Updated
----------- ---- ------------ ------- -------------- --------- -------
--------
vss:s       XDP  vsd:dst        Broken-off
                                    Idle           -         true    -
vss:s__0001 XDP  vsd:dst__0001  Broken-off
                                    Idle           -         true    -
vss:s__0002 XDP  vsd:dst__0002  Broken-off
                                    Idle           -         true    -
vss:s__0003 XDP  vsd:dst__0003  Broken-off
                                    Idle           -         true    -
vss:s__0004 XDP  vsd:dst__0004  Broken-off
                                    Idle           -         true    -
vss:s__0005 XDP  vsd:dst__0005  Broken-off
                                    Idle           -         true    -
vss:s__0006 XDP  vsd:dst__0006  Broken-off
                                    Idle           -         true    -
vss:s__0007 XDP  vsd:dst__0007  Broken-off
                                    Idle           -         true    -
vss:s__0008 XDP  vsd:dst__0008  Broken-off
                                    Idle           -         true    -
...
```

The SnapMirror relationship status of each constituent is `Broken-off`.

4. Verify that the destination FlexGroup volume is read/write: `volume show -vserver svm_name`

```
cluster2::> volume show -vserver vsd
Vserver   Volume       Aggregate    State      Type       Size
Available Used%
--------- ------------ ------------ ---------- ---- ----------
---------- -----
vsd       dst          -            online     **RW**          2GB
1.54GB   22%
vsd       d2           -            online     DP           2GB
1.55GB   22%
vsd       root_vs0     aggr1        online     RW        100MB
94.02MB    5%
3 entries were displayed.
```

5. Redirect clients to the destination FlexGroup volume.

#### Reactivate the original source FlexGroup volume after disaster

When the source FlexGroup volume becomes available, you can resynchronize the original source and original destination FlexGroup volumes. Any new data on the destination FlexGroup volume is lost.

**About this task**

Any active quota rules on the destination volume are deactivated and the quota rules are deleted before resynchronization is performed.

You can use the `volume quota policy rule create` and `volume quota modify` commands to create and reactivate quota rules after the resynchronization operation is complete.

**Steps**

1. From the destination cluster, resynchronize the FlexGroup volume SnapMirror relationship: `snapmirror resync -destination-path dst_svm:dest_flexgroup`
2. View the status of the SnapMirror relationship: `snapmirror show -expand`

```
cluster2::> snapmirror show -expand

Progress
Source            Destination Mirror  Relationship   Total
Last
Path        Type  Path        State   Status         Progress  Healthy
Updated
----------- ---- ------------ ------- -------------- --------- -------
--------
vss:s       XDP  vsd:dst        Snapmirrored
                                    Idle           -         true    -
vss:s__0001 XDP  vsd:dst__0001  Snapmirrored
                                    Idle           -         true    -
vss:s__0002 XDP  vsd:dst__0002  Snapmirrored
                                    Idle           -         true    -
vss:s__0003 XDP  vsd:dst__0003  Snapmirrored
                                    Idle           -         true    -
vss:s__0004 XDP  vsd:dst__0004  Snapmirrored
                                    Idle           -         true    -
vss:s__0005 XDP  vsd:dst__0005  Snapmirrored
                                    Idle           -         true    -
vss:s__0006 XDP  vsd:dst__0006  Snapmirrored
                                    Idle           -         true    -
vss:s__0007 XDP  vsd:dst__0007  Snapmirrored
                                    Idle           -         true    -
vss:s__0008 XDP  vsd:dst__0008  Snapmirrored
                                    Idle           -         true    -
...
```

The SnapMirror relationship status of each constituent is `Snapmirrored`.

#### Reverse a SnapMirror relationship between FlexGroup volumes during disaster recovery

When a disaster disables the source FlexGroup volume of a SnapMirror relationship, you can use the destination FlexGroup volume to serve data while you repair or replace the source FlexGroup volume. After the source FlexGroup volume is online, you can make the original source FlexGroup volume a read-only destination and reverse the SnapMirror relationship.

**About this task**

Any active quota rules on the destination volume are deactivated and the quota rules are deleted before resynchronization is performed.

You can use the `volume quota policy rule create` and `volume quota modify` commands to create and reactivate quota rules after the resynchronization operation is complete.

**Steps**

1. On the original destination FlexGroup volume, remove the data protection mirror relationship between the source FlexGroup volume and the destination FlexGroup volume: `snapmirror delete -destination -path svm_name:volume_name`

```
cluster2::> snapmirror delete -destination-path vsd:dst
```

2. On the original source FlexGroup volume, remove the relationship information from the source FlexGroup volume: `snapmirror release -destination-path svm_name:volume_name -relationship -info-only`

   After deleting a SnapMirror relationship, you must remove the relationship information from the source FlexGroup volume before attempting a resynchronization operation.

```
cluster1::> snapmirror release -destination-path vsd:dst -relationship
-info-only true
```

3. On the new destination FlexGroup volume, create the mirror relationship: `snapmirror create -source-path src_svm_name:volume_name -destination-path dst_svm_name:volume_name -type XDP -policy MirrorAllSnapshots`

```
cluster1::> snapmirror create -source-path vsd:dst -destination-path
vss:src -type XDP -policy MirrorAllSnapshots
```

4. On the new destination FlexGroup volume, resynchronize the source FlexGroup: `snapmirror resync -source-path svm_name:volume_name`

```
cluster1::> snapmirror resync -source-path vsd:dst
```

5. Monitor the SnapMirror transfers: `snapmirror show -expand`

```
cluster2::> snapmirror show -expand

Progress
Source            Destination Mirror  Relationship   Total
Last
Path        Type  Path        State   Status         Progress  Healthy
Updated
----------- ---- ------------ ------- -------------- --------- -------
--------
vsd:dst       XDP  vss:src        Snapmirrored
                                      Idle           -         true    -
vss:dst__0001 XDP  vss:src__0001  Snapmirrored
                                      Idle           -         true    -
vsd:dst__0002 XDP  vss:src__0002  Snapmirrored
                                      Idle           -         true    -
vsd:dst__0003 XDP  vss:src__0003  Snapmirrored
                                      Idle           -         true    -
vsd:dst__0004 XDP  vss:src__0004  Snapmirrored
                                      Idle           -         true    -
vsd:dst__0005 XDP  vss:src__0005  Snapmirrored
                                      Idle           -         true    -
vsd:dst__0006 XDP  vss:src__0006  Snapmirrored
                                      Idle           -         true    -
vsd:dst__0007 XDP  vss:src__0007  Snapmirrored
                                      Idle           -         true    -
vsd:dst__0008 XDP  vss:src__0008  Snapmirrored
                                      Idle           -         true    -
...
```

The SnapMirror relationship status of each constituent shows as `Snapmirrored` that indicates that the resynchronization was successful.

### Expand FlexGroup volumes in a SnapMirror relationship

#### Expand FlexGroup volumes in a SnapMirror relationship

Beginning with ONTAP 9.3, you can expand the source FlexGroup volume and destination FlexGroup volume that are in a SnapMirror relationship by adding new constituents to the volumes. You can expand the destination volumes either manually or automatically.

#### About this task

- After expansion, the number of constituents in the source FlexGroup volume and destination FlexGroup volume of a SnapMirror relationship must match.

  If the number of constituents in the volumes does not match, the SnapMirror transfers fail.

- You should not perform any SnapMirror operation when the expansion process is in progress.
- If a disaster strikes before the expansion process is complete, you must break the SnapMirror relationship and wait until the operation succeeds.

> You should break the SnapMirror relationship when the expansion process is in progress only in the case of a disaster. In the case of a disaster, the break operation can take some time to complete. You should wait for the break operation to get completed successfully before performing a resync operation. If the break operation fails, you must retry the break operation. If the break operation fails, some of the new constituents might remain in the destination FlexGroup volume after the break operation. It is best to delete these constituents manually before proceeding further.

#### Expand the source FlexGroup volume of a SnapMirror relationship

Beginning with ONTAP 9.3, you can expand the source FlexGroup volume of a SnapMirror relationship by adding new constituents to the source volume. You can expand the source volume in the same way that you expand a regular FlexGroup volume (read-write volume).

**Steps**

1. Expand the source FlexGroup volume: `volume expand -vserver vserver_name -volume fg_src -aggr-list aggregate name,... [-aggr-list-multiplier constituents_per_aggr]`

```
cluster1::> volume expand -volume src_fg -aggr-list aggr1 -aggr-list
-multiplier 2 -vserver vs_src

Warning: The following number of constituents of size 50GB will be added
to FlexGroup "src_fg": 2.
Expanding the FlexGroup will cause the state of all Snapshot copies to
be set to "partial".
Partial Snapshot copies cannot be restored.
Do you want to continue? {y|n}: Y
[Job 146] Job succeeded: Successful
```

The state of all of the Snapshot copies that are taken before the volume is expanded changes to partial.

#### Expand the destination FlexGroup volume of a SnapMirror relationship

You can expand the destination FlexGroup volume and reestablish the SnapMirror relationship either automatically or manually. By default, the SnapMirror relationship is set for automatic expansion, and the destination FlexGroup volume expands automatically if the source volume expands.

**What you'll need**

- The source FlexGroup volume must have been expanded.
- The SnapMirror relationship must be in the `SnapMirrored` state.

The SnapMirror relationship must not be broken or deleted.

**About this task**

- When the destination FlexGroup volume is created, the volume is set up for automatic expansion by default.

  You can modify the destination FlexGroup volume for manual expansion, if required.

  The best practice is to expand the destination FlexGroup volume automatically.

- All SnapMirror operations fail until both the source FlexGroup volume and destination FlexGroup volume have expanded and have the same number of constituents.
- If you expand the destination FlexGroup volume after the SnapMirror relationship is broken or deleted, you cannot resync the original relationship again.

  If you intend to reuse the destination FlexGroup volume, you must not expand the volume after deleting the SnapMirror relationship.

**Choices**

- Perform an update transfer to expand the destination FlexGroup volume automatically:

  a. Perform a SnapMirror update transfer: `snapmirror update -destination-path svm:vol_name`

  b. Verify that the status of the SnapMirror relationship is in the `SnapMirrored` state: `snapmirror show`

```
cluster2::> snapmirror show

Progress
Source            Destination Mirror  Relationship   Total
Last
Path        Type  Path        State   Status         Progress
Healthy Updated
----------- ---- ------------ ------- -------------- ---------
------- --------
vs_src:src_fg
            XDP  vs_dst:dst_fg
                              Snapmirrored
                                      Idle           -         true
-
```

  Based on the size and availability of aggregates, the aggregates are automatically selected, and new constituents that match the constituents of the source FlexGroup volume are added to the destination FlexGroup volume. After expansion, a resynchronization operation is automatically triggered.

- Expand the destination FlexGroup volume manually:

  a. If the SnapMirror relationship is in the auto-expand mode, set the SnapMirror relationship to the manual expand mode: `snapmirror modify -destination-path svm:vol_name -is-auto-expand`

`-enabled false`

```
cluster2::> snapmirror modify -destination-path vs_dst:dst_fg -is
-auto-expand-enabled false
Operation succeeded: snapmirror modify for the relationship with
destination "vs_dst:dst_fg".
```

b. Quiesce the SnapMirror relationship: `snapmirror quiesce -destination-path svm:vol_name`

```
cluster2::> snapmirror quiesce -destination-path vs_dst:dst_fg
Operation succeeded: snapmirror quiesce for destination
"vs_dst:dst_fg".
```

c. Expand the destination FlexGroup volume: `volume expand -vserver vserver_name -volume fg_name -aggr-list aggregate name,... [-aggr-list-multiplier constituents_per_aggr]`

```
cluster2::> volume expand -volume dst_fg -aggr-list aggr1 -aggr-list
-multiplier 2  -vserver vs_dst

Warning: The following number of constituents of size 50GB will be
added to FlexGroup "dst_fg": 2.
Do you want to continue? {y|n}: y
[Job 68] Job succeeded: Successful
```

d. Resynchronize the SnapMirror relationship: `snapmirror resync -destination-path svm:vol_name`

```
cluster2::> snapmirror resync -destination-path vs_dst:dst_fg
Operation is queued: snapmirror resync to destination
"vs_dst:dst_fg".
```

e. Verify that the status of the SnapMirror relationship is `SnapMirrored`: `snapmirror show`

```
cluster2::> snapmirror show

Progress
Source            Destination Mirror  Relationship   Total
Last
Path        Type  Path        State   Status         Progress
Healthy Updated
----------- ---- ------------ ------- -------------- ---------
------- --------
vs_src:src_fg
            XDP  vs_dst:dst_fg
                              Snapmirrored
                                      Idle           -         true
-
```

#### Perform a SnapMirror single file restore from a FlexGroup volume

Beginning with ONTAP 9.8, you can restore a single file from a FlexGroup SnapMirror vault or from a UDP destination.

**About this task**

- You can restore from a FlexGroup volume of any geometry to FlexGroup volume of any geometry
- Only one file per restore operation is supported
- You can restore to either the original source FlexGroup volume or to a new FlexGroup volume
- Remote fenced file lookup is not supported.

  Single file restore fails if the source file is fenced.
- You can restart or clean up an aborted single file restore
- You should clean up a failed single file restore transfer by using the `clean-up-failure` option of the `snapmirror restore` command
- Expansion of FlexGroup volumes is supported when a FlexGroup single file restore is in progress or in an aborted state

**Steps**

1. Restore a file from a FlexGroup volume:`snapmirror restore -destination-path destination_path -source-path source_path -file-list /f1 -throttle throttle -source-snapshot snapshot`

   The following is an example of a FlexGroup volume single file restore operation.

```
vserverA::> snapmirror restore -destination-path vs0:fg2 -source-path
vs0:fgd -file-list /f1 -throttle 5 -source-snapshot snapmirror.81072ce1-
d57b-11e9-94c0-005056a7e422_2159190496.2019-09-19_062631
[Job 135] Job is queued: snapmirror restore from source "vs0:fgd" for
```

```
the snapshot snapmirror.81072ce1-d57b-11e9-94c0-
005056a7e422_2159190496.2019-09-19_062631.
vserverA::> snapmirror show

Source              Destination Mirror   Relationship
Total Last
Path       Type   Path            State    Status           Progress
Healthy Updated
---------- ----      ------------     -------    ---------
----- --------- ------- --------
vs0:v1d RST    vs0:v2          -           Transferring Idle 83.12KB
true 09/19 11:38:42

vserverA::*> snapmirror show vs0:fg2

Source Path: vs0:fgd
Source Cluster: -
Source Vserver: vs0
Source Volume: fgd
Destination Path: vs0:fg2
Destination Cluster: -
Destination Vserver: vs0
Destination Volume: fg2
Relationship Type: RST
Relationship Group Type: none
Managing Vserver: vs0
SnapMirror Schedule: -
SnapMirror Policy Type: -
SnapMirror Policy: -
Tries Limit: -
Throttle (KB/sec): unlimited
Current Transfer Throttle (KB/sec): 2
Mirror State: -
Relationship Status: Transferring
File Restore File Count: 1
File Restore File List: f1
Transfer Snapshot: snapmirror.81072ce1-d57b-11e9-94c0-
005056a7e422_2159190496.2019-09-19_062631
Snapshot Progress: 2.87MB
Total Progress: 2.87MB
Network Compression Ratio: 1:1
Snapshot Checkpoint: 2.97KB
Newest Snapshot: -
Newest Snapshot Timestamp: -
Exported Snapshot: -
Exported Snapshot Timestamp: -
```

```
Healthy: true
Physical Replica: -
Relationship ID: e6081667-dacb-11e9-94c0-005056a7e422
Source Vserver UUID: 81072ce1-d57b-11e9-94c0-005056a7e422
Destination Vserver UUID: 81072ce1-d57b-11e9-94c0-005056a7e422
Current Operation ID: 138f12e6-dacc-11e9-94c0-005056a7e422
Transfer Type: cg_file_restore
Transfer Error: -
Last Transfer Type: -
Last Transfer Error: -
Last Transfer Error Codes: -
Last Transfer Size: -
Last Transfer Network Compression Ratio: -
Last Transfer Duration: -
Last Transfer From: -
Last Transfer End Timestamp: -
Unhealthy Reason: -
Progress Last Updated: 09/19 07:07:36
Relationship Capability: 8.2 and above
Lag Time: -
Current Transfer Priority: normal
SMTape Operation: -
Constituent Relationship: false
Destination Volume Node Name: vserverA
Identity Preserve Vserver DR: -
Number of Successful Updates: 0
Number of Failed Updates: 0
Number of Successful Resyncs: 0
Number of Failed Resyncs: 0
Number of Successful Breaks: 0
Number of Failed Breaks: 0
Total Transfer Bytes: 0
Total Transfer Time in Seconds: 0
Source Volume MSIDs Preserved: -
OpMask: ffffffffffffffff
Is Auto Expand Enabled: -
Source Endpoint UUID: -
Destination Endpoint UUID: -
Is Catalog Enabled: false
```

#### Restore a FlexGroup volume from a SnapVault backup

You can perform a full-volume restore operation of FlexGroup volumes from a Snapshot copy in the SnapVault secondary volume. You can restore the FlexGroup volume either to the original source volume or to a new FlexGroup volume.

**What you'll need**

You must be aware of certain considerations for restoring FlexGroup volumes.

Considerations for SnapVault restore operations for FlexGroup volumes

You must also be aware of certain considerations when you restore from SnapVault backups for FlexGroup volumes.

- Only baseline restore is supported with partial Snapshot copies from a SnapVault backup.

  The number of constituents in the destination volume must match the number of constituents in the source volume when the Snapshot copy was taken.

- If a restore operation fails, no other operations are allowed until the restore operation is complete.

  You can either retry the restore operation or run the restore operation with the `cleanup` parameter.

- A FlexGroup volume can be the source volume of only one backup relationship or restore relationship.

  A FlexGroup volume cannot be the source of two SnapVault relationships, two restore relationships, or a SnapVault relationship and a restore relationship.

- SnapVault backup and restore operations cannot run in parallel.

  When either a baseline restore operation or an incremental restore operation is in progress, you should quiesce the backup operations.

- You must abort a restore operation of a partial Snapshot copy from the destination FlexGroup volume.

  You cannot abort the restore operation of a partial Snapshot copy from the source volume.

- If you abort a restore operation, you must restart the restore operation with the same Snapshot copy that was used for the previous restore operation.

**About this task**

Any active quota rules on the destination FlexGroup volume are deactivated before the restore is performed.

You can use the `volume quota modify` command to reactivate quota rules after the restore operation is complete.

**Steps**

1. Restore the FlexGroup volume: `snapmirror restore -source-path src_svm:src_flexgroup -destination-path dest_svm:dest_flexgroup -snapshot snapshot_name`

   `snapshot_name` is the Snapshot copy that is to be restored from the source volume to the destination volume. If the Snapshot copy is not specified, the destination volume is restored from the latest Snapshot copy.

```
vserverA::> snapmirror restore -source-path vserverB:dstFG -destination
-path vserverA:newFG -snapshot daily.2016-07-15_0010
Warning: This is a disruptive operation and the volume vserverA:newFG
will be read-only until the operation completes
Do you want to continue? {y|n}: y
```

#### Disable SVM protection on a FlexGroup volume

When the SVM DR flag is set to `protected` on a FlexGroup volume, you can set the flag to unprotected to disable SVM DR `protection` on a FlexGroup volume.

**What you'll need**

- The SVM DR relationship between the primary and secondary is healthy.
- SVM DR protection parameter is set to `protected`.

**Steps**

1. Disable protection by using the `volume modify` command to change the `vserver-dr-protection` parameter for the FlexGroup volume to `unprotected`.

```
cluster2::> volume modify -vserver vs1 -volume fg_src -vserver-dr
-protection unprotected
[Job 5384] Job is queued: Modify fg_src.
[Job 5384] Steps completed: 4 of 4.
cluster2::>
```

2. Update the SVM at the secondary site: `snapmirror update -destination-path destination_svm_name: -source-path Source_svm_name:`
3. Verify that the SnapMirror relationship is healthy: `snapmirror show`
4. Verify that the FlexGroup SnapMirror relationship has been removed: `snapmirror show -expand`

#### Enable SVM protection on a FlexGroup volume

When the SVM DR protection flag is set to `unprotected` on a FlexGroup volume, you can set the flag to `protected` to enable SVM DR protection.

**What you'll need**

- The SVM DR relationship between the primary and secondary is healthy.
- SVM DR protection parameter is set to `unprotected`.

**Steps**

1. Enable protection by using the `volume modify` to change the `vserver-dr-protection` parameter for the FlexGroup volume to `protected`.

```
cluster2::> volume modify -vserver vs1 -volume fg_src -vserver-dr
-protection protected
[Job 5384] Job is queued: Modify fg_src.
[Job 5384] Steps completed: 4 of 4.
cluster2::>
```

2. Update the SVM at the secondary site: `snapmirror update -destination-path destination_svm_name -source-path source_svm_name`

```
snapmirror update -destination-path vs1_dst: -source-path vs1:
```

3. Verify that the SnapMirror relationship is healthy: `snapmirror show`

```
cluster2::> snapmirror show

Progress
Source            Destination Mirror  Relationship   Total
Last
Path        Type  Path        State   Status         Progress  Healthy
Updated
----------- ---- ------------ ------- -------------- --------- -------
--------
vs1:        XDP  vs1_dst:     Snapmirrored
                                 Idle           -         true    -
```

4. Verify that the FlexGroup SnapMirror relationship is healthy: `snapmirror show -expand`

```
cluster2::> snapmirror show -expand

Progress
Source            Destination Mirror  Relationship   Total
Last
Path        Type  Path        State   Status         Progress  Healthy
Updated
----------- ---- ------------ ------- -------------- --------- -------
--------
vs1:        XDP  vs1_dst:     Snapmirrored
                                Idle           -         true    -
vs1:fg_src  XDP  vs1_dst:fg_src
                            Snapmirrored
                                Idle           -         true    -
vs1:fg_src__0001
            XDP  vs1_dst:fg_src__0001
                            Snapmirrored
                                Idle           -         true    -
vs1:fg_src__0002
            XDP  vs1_dst:fg_src__0002
                            Snapmirrored
                                Idle           -         true    -
vs1:fg_src__0003
            XDP  vs1_dst:fg_src__0003
                            Snapmirrored
                                Idle           -         true    -
vs1:fg_src__0004
            XDP  vs1_dst:fg_src__0004
                            Snapmirrored
                                Idle           -         true    -
6 entries were displayed.
```

## Convert FlexVol volumes to FlexGroup volumes

### Converting FlexVol volumes to FlexGroup volumes overview

If you want to expand a FlexVol volume beyond its space limit, you can convert the FlexVol volume to a FlexGroup volume. Beginning with ONTAP 9.7, you can convert standalone FlexVol volumes or FlexVol volumes that are in a SnapMirror relationship to FlexGroup volumes.

#### Considerations for converting FlexVol volumes to FlexGroup volumes

You should be aware of the features and operations that are supported before you decide to convert FlexVol volumes to FlexGroup volumes.

#### Operations not supported during conversion

The following operations are not allowed when volume conversion is in progress:

- Volume move
- Aggregate autobalance
- Aggregate relocation
- Planned takeover and giveback in a high-availability configuration
- Manual and automatic giveback in an high-availability configuration
- Cluster upgrade and revert
- FlexClone volume split
- Volume rehost
- Volume modify and autosize
- Volume rename
- Attaching an object store to an aggregate
- Negotiated switchover in MetroCluster configuration
- SnapMirror operations
- Restoring from a Snapshot copy
- Quota operations
- Storage efficiency operations

You can perform these operations on the FlexGroup volume after successful conversion.

#### Configurations that are not supported with FlexGroup volumes

- Offline or restricted volume
- SVM root volume
- SnapLock volumes
- SAN
- SMB 1.0
- NVMe namespaces
- Remote Volume Shadow Copy Service (VSS)

### Convert a FlexVol volume to a FlexGroup volume

Beginning with ONTAP 9.7, you can perform an in-place conversion of a FlexVol volume to a FlexGroup volume without requiring a data copy or additional disk space.

#### What you'll need

- Transitioned volumes can be converted to FlexGroup volumes.

  Converting transitioned volumes to FlexGroup volumes requires diag mode and should be performed only under NetApp Support supervision. It is highly recommended that you contact NetApp Support before you proceed with the conversion process.

- The FlexVol volume that is being converted must be online.
- The operations and configurations on the FlexVol volume must be compatible with the conversion process.

  An error message is generated if the FlexVol volume has any incompatibility and the volume conversion is aborted. You can take corrective actions and retry the conversion.

**Steps**

1. Verify that the FlexVol volume is online: `volume show vol_name -volume-style-extended,state`

```
cluster-1::> volume show my_volume -fields volume-style-extended,state
vserver volume    state  volume-style-extended
------- --------- ------ --------------------
vs0     my_volume online flexvol
```

2. Verify whether the FlexVol volume can be converted without issues:
   a. Log in to the advance privilege mode: `set -privilege advanced`
   b. Verify the conversion process: `volume conversion start -vserver vs1 -volume flexvol -check-only true`

      You must rectify all errors before converting the volume.

      > You cannot convert a FlexGroup volume back to a FlexVol volume. If you want to do so, you should contact support.

3. Start the conversion: `volume conversion start -vserver svm_name -volume vol_name`

```
cluster-1::*> volume conversion start -vserver vs0 -volume my_volume

Warning: Converting flexible volume "my_volume" in Vserver "vs0" to a
FlexGroup
         will cause the state of all Snapshot copies from the volume to
be set
         to "pre-conversion". Pre-conversion Snapshot copies cannot be
         restored.
Do you want to continue? {y|n}: y
[Job 57] Job succeeded: success
```

4. Verify that the conversion is successful: `volume show vol_name -fields -volume-style -extended,state`

```
cluster-1::*> volume show my_volume -fields volume-style-extended,state
vserver volume    state  volume-style-extended
------- --------- ------ ---------------------
vs0     my_volume online flexgroup
```

**Results**

The FlexVol volume is converted to a single-member FlexGroup volume.

**After you finish**

You can expand the FlexGroup volume, as required.

### Convert a FlexVol volume SnapMirror relationship to a FlexGroup volume SnapMirror relationship

To convert a FlexVol volume SnapMirror relationship to a FlexGroup volume SnapMirror relationship in ONTAP, you must first convert the destination FlexVol volume followed by the source FlexVol volume.

**What you'll need**

- The FlexVol volume that is being converted must be online.
- The source FlexVol volume in the SnapMirror relationship must not be the source volume for multiple SnapMirror relationships.

  Fan-out SnapMirror relationships are not supported for FlexGroup volumes.

- The operations and configurations on the FlexVol volume must be compatible with the conversion process.

  An error message is generated if the FlexVol volume has any incompatibility and the volume conversion is aborted. You can take corrective actions and retry the conversion.

**About this task**

FlexGroup conversion is supported only for asynchronous SnapMirror relationships.

**Steps**

1. Verify that the SnapMirror relationship is healthy: `snapmirror show`

   Only XDP type mirror relationships can be converted.

```
cluster2::> snapmirror show

Progress
Source            Destination Mirror  Relationship   Total
Last
Path        Type  Path        State   Status         Progress  Healthy
Updated
----------- ---- ------------ ------- -------------- --------- -------
--------
vs0:src_dpv DP   vs2:dst_dpv  Snapmirrored
                                     Idle           -         true    -
vs0:src_xdp XDP  vs2:dst_xdp  Snapmirrored
                                     Idle           -         true    -
```

2. Verify whether the source volume is compatible for conversion:
   a. Log in to the advance privilege mode: `set -privilege advanced`
   b. Verify the conversion process: `volume conversion start -vserver vs1 -volume src_vol -check-only true`

      You must rectify all errors before converting the volume.
3. Convert the destination FlexVol volume to FlexGroup volume.
   a. Quiesce the FlexVol SnapMirror relationship: `snapmirror quiesce -destination-path dest_svm:dest_volume`

      ```
      cluster2::> snapmirror quiesce -destination-path vs2:dst_xdp
      ```

   b. Start the conversion: `volume conversion start -vserver dest_svm -volume dest_volume`

      ```
      cluster-1::> volume conversion start -vserver vs2 -volume dst_xdp

      Warning: After the volume is converted to a FlexGroup, it will not be
      possible
      to change it back to a flexible volume.
      Do you want to continue? {y|n}: y

      [Job 510] Job succeeded: SnapMirror destination volume "dst_xdp" has
      been successfully converted to a FlexGroup volume.
      You must now convert the relationship's source volume, "vs0:src_xdp",
      to a FlexGroup.
      Then, re-establish the SnapMirror relationship using the "snapmirror
      resync" command.
      ```

4. Convert the source FlexVol volume to FlexGroup volume: `volume conversion start -vserver src_svm_name -volume src_vol_name`

```
cluster-1::> volume conversion start -vserver vs0 -volume src_xdp

Warning: Converting flexible volume "src_xdp" in Vserver "vs0" to a
FlexGroup
         will cause the state of all Snapshot copies from the volume to
be set
         to "pre-conversion". Pre-conversion Snapshot copies cannot be
         restored.
Do you want to continue? {y|n}: y
[Job 57] Job succeeded: success
```

5. Resync the relationship: `snapmirror resync -destination-path dest_svm_name:dest_volume`

```
cluster2::> snapmirror resync -destination-path vs2:dst_xdp
```

**After you finish**

You must ensure that when the source FlexGroup volume is expanded to include more constituents, the destination volume is also expanded.

# Improve performance for multiple clients with FlexCache

You can use FlexCache volumes to speed up access to data or to offload traffic from heavily accessed volumes. FlexCache volumes are ideal for read-intensive workloads, especially where clients need to access the same data repeatedly.

The topics in this section show you how to manage FlexCache volumes with System Manager in ONTAP 9.7 and later releases.If you are using the classic System Manager (available only in ONTAP 9.7 and earlier), see this topic:

- Create FlexCache volumes

The FlexCache volume can be on the same cluster as or on a different cluster than that of the remote volume. If the remote volume is on a different cluster, you need to have already peered the clusters and storage VMs.

> If an HA pair is using encrypting SAS or NVMe drives (SED, NSE, FIPS), you must follow the instructions in the topic Returning a FIPS drive or SED to unprotected mode for all drives within the HA pair prior to initializing the system (boot options 4 or 9). Failure to do this may result in future data loss if the drives are repurposed.

**Steps**

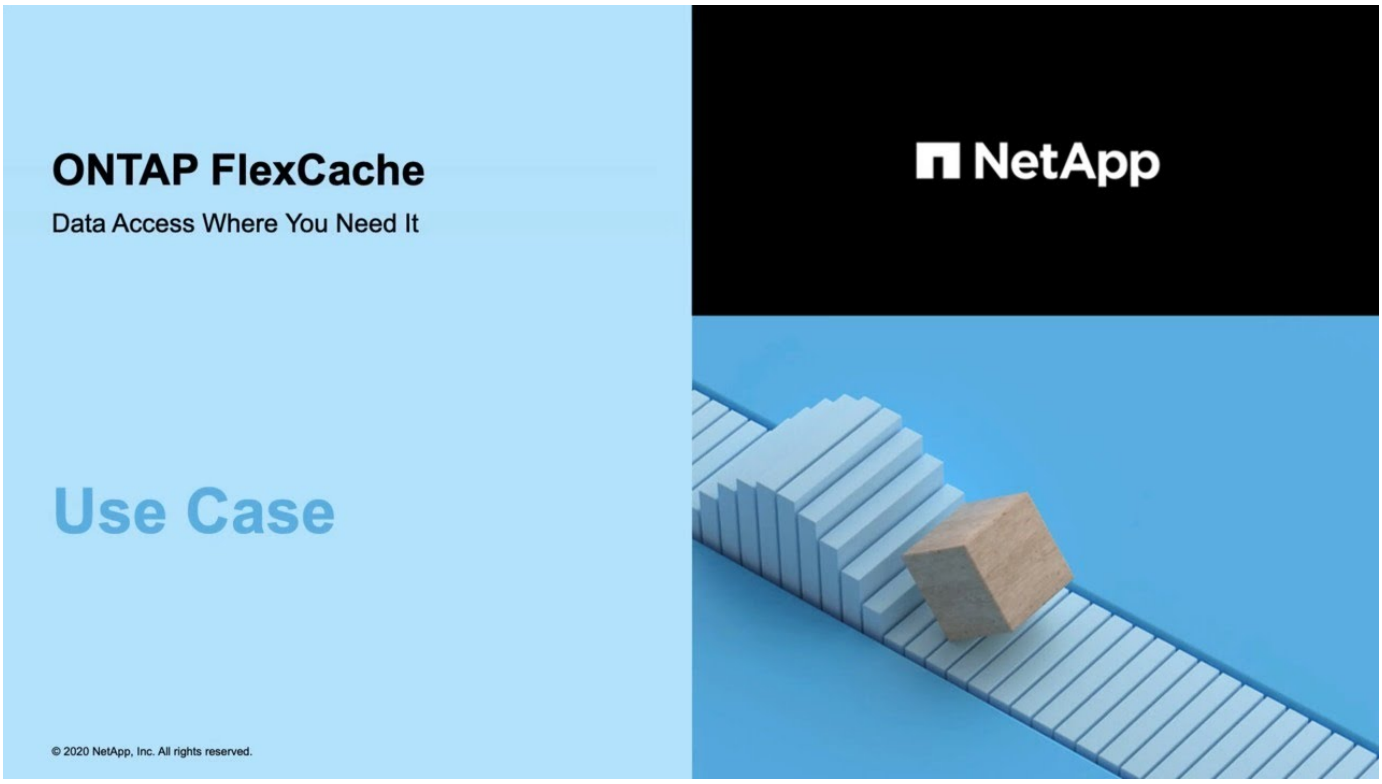
1. Click **Storage > Volumes**.
2. Click **Add**.

3. Click **More Options** and then select **Add as cache for a remote volume**.
    a. If you are running ONTAP 9.8 or later and you want to disable QoS or choose a custom QoS policy, click **More Options** and then, under **Storage and Optimization** select **Performance Service Level**.

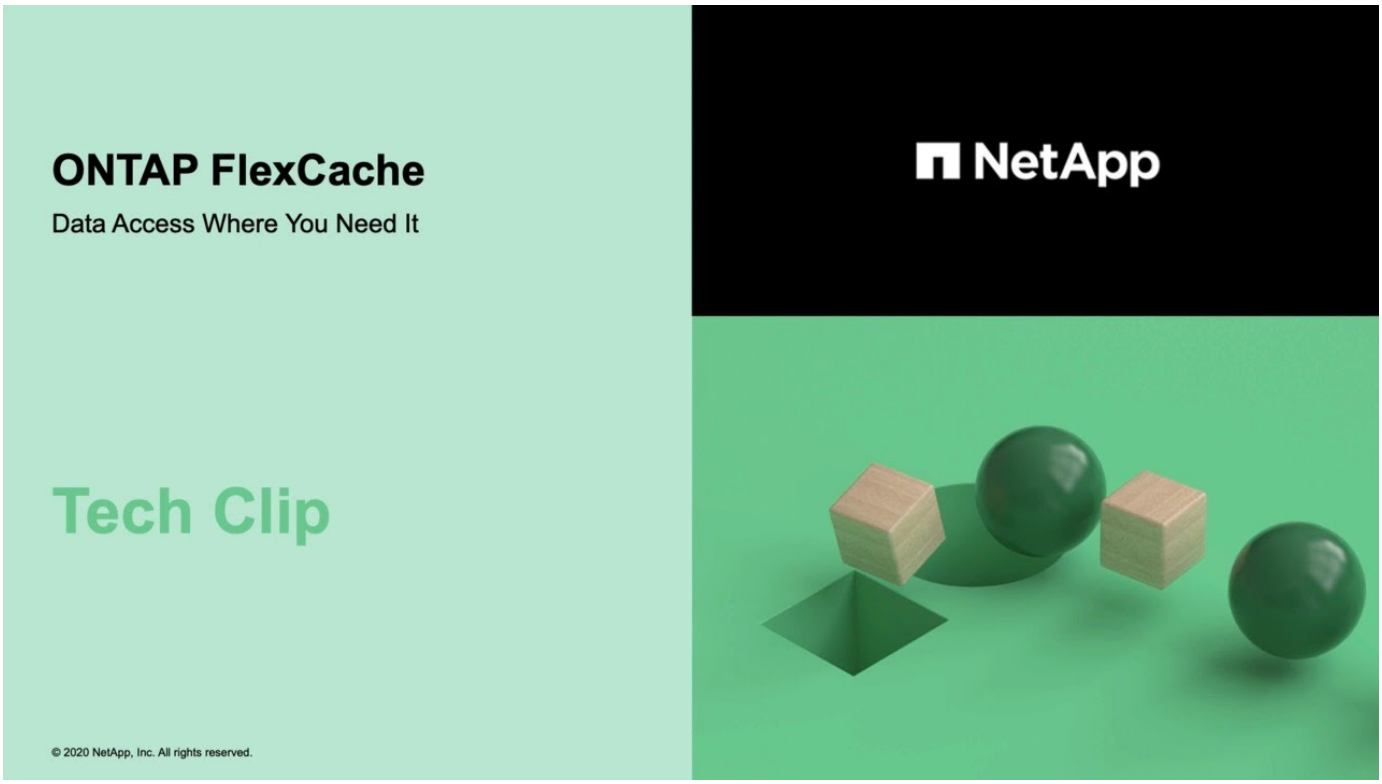
For any new data requests, the FlexCache volume requests the data from the remote volume and stores it. All the subsequent read requests for the data are then served directly from the FlexCache volume.

## Videos

**How FlexCache can reduce WAN latency and read times for global data**




**Learn about the performance benefits of ONTAP FlexCache!**




# FlexCache volumes management with the CLI

## FlexCache volumes management overview with the CLI

You can configure and manage FlexCache volumes for accelerating data access.

Use these procedures to configure FlexCache volumes if the following are true:

- You are running ONTAP 9.5 or later.
- You want to use the ONTAP command-line interface (CLI), not System Manager or an automated scripting tool.
- You want to use best practices, not explore every available option.

  Details about command syntax are available from the CLI help and the ONTAP man pages.

- You have cluster administrator privileges, not SVM administrator privileges.

## Use FlexCache volumes to accelerate data access overview

A FlexCache volume is a sparsely populated volume that is backed by an origin volume. The FlexCache volume can be on the same cluster as or on a different cluster than that of the origin volume. The FlexCache volume provides access to data in the origin volume without requiring that all of the data be in the FlexCache volume.

In ONTAP 9.5, the origin volume is a FlexVol volume and the FlexCache volume is a FlexGroup volume. An origin volume supports NFSv3, NFSv4, and SMB protocols. A FlexCache volume supports only NFSv3 protocol in ONTAP 9.5. Beginning with ONTAP 9.8, a FlexCache volume also supports SMB protocol. Beginning with ONTAP 9.10.1, a FlexCache volume supports the NFSv4 protocol. For a table summary of

supported features in FlexCache volumes, refer to Supported and unsupported features for FlexCache volumes.

Beginning with ONTAP 9.7, FlexGroup volumes are also supported as source volumes.

> In ONTAP 9 releases earlier than 9.5, origin FlexVol volumes can only serve data to FlexCache volumes created on systems running Data ONTAP 8.2.x operating in 7-Mode. Beginning with ONTAP 9.5, origin FlexVol volumes can also serve data to FlexCache volumes on ONTAP 9 systems. For information about migrating from 7-mode FlexCache to ONTAP 9 FlexCache, NetApp Technical Report 4743: FlexCache Volumes in NetApp ONTAP.

A FlexCache volume directly serves read requests if the volume contains the data requested by the client. Otherwise, the FlexCache volume requests the data from the origin volume and stores the data before serving the client request. Subsequent read requests for the data are then served directly from the FlexCache volume. This improves performance when the same data is accessed repeatedly, because after the first request, the data no longer has to travel across the network, or be served from an overloaded system.

Beginning with ONTAP 9.9.1, FlexCache volumes cache a directory listing for "file not found" errors that occur when a file no longer exists on the origin volume. This helps reduce network traffic by removing the need to send multiple calls to the origin when clients search for non-existent files.

Beginning with ONTAP 9.10.1, global file locking can be enabled across FlexCache volumes to favor consistency, ensuring modifications to an origin volume are distributed simultaneously to FlexCache volumes. Global file locking can only be enabled from the CLI.

You can use FlexCache volumes to speed up access to data or to offload traffic from heavily accessed volumes. FlexCache volumes help improve performance, especially when clients need to access the same data repeatedly, because the data can be served directly without having to access the origin volume. Therefore, you can use FlexCache volumes to handle system workloads that are read-intensive.

Any write operation is applied at the origin volume.

## Typical FlexCache deployments

FlexCache volumes are typically used for read-intensive workloads. You can have a FlexCache volume in the same cluster to accelerate performance for frequently accessed data or “hot objects”. You can also have FlexCache volumes to distribute data across multiple clusters to reduce WAN latencies.

You can have FlexCache deployments with AFF, FAS, or ONTAP Select systems. Beginning with ONTAP 9.6, FlexCache deployments are also supported with Cloud Volumes ONTAP.

#### Performance acceleration for hot volumes

In a LAN deployment, the FlexCache volume is in the same cluster as the origin cluster. The FlexCache volume can be located in the same SVM as or in a different SVM than that of the origin volume.

The FlexCache volume is used for CPU-intensive workloads to offload work from busy file servers and to free system resources. You can use multiple mount points corresponding to different FlexCache volumes for reducing network latency because the data access load is shared among all of the caching systems. This type of LAN deployment reduces the workload of an overloaded storage system.

#### Cross-cluster data distribution

In a WAN deployment, the FlexCache volume is remote from the data center and is in a different cluster than the origin volume. When clients request data, the FlexCache volume caches popular data, giving the end user faster access to information. This type of WAN deployment decreases the average access time for remote clients.

The FlexCache volume is placed as close as possible to the remote office. Client requests are then explicitly directed to the FlexCache volume. If valid data exists in the cache, that data is served directly to the client. If the data does not exist in the cache, the data is retrieved across the WAN from the origin system, cached in the FlexCache volume, and then served to the client.

## Supported and unsupported features for FlexCache volumes

You must be aware of the features that are supported by FlexCache volumes and their origin volumes.

| Feature | Supported at the origin volume? | Supported at the FlexCache volume? |
|---|---|---|
| Antivirus | Yes<br><br>Supported beginning with ONTAP 9.7 | Not applicable |
| Auditing | Yes<br><br>Supported beginning with ONTAP 9.7 | Yes<br><br>Supported beginning with ONTAP 9.7 |
| Cloud Volumes ONTAP | Yes<br><br>Supported beginning with ONTAP 9.6 | Yes<br><br>Supported beginning with ONTAP 9.6 |
| Compaction | Yes<br><br>Supported beginning with ONTAP 9.6 | Yes<br><br>Supported beginning with ONTAP 9.7 |
| Compression | Yes<br><br>Supported beginning with ONTAP 9.6 | Yes<br><br>Supported beginning with ONTAP 9.6 |

| | | |
|---|---|---|
| Deduplication | Yes | Yes<br><br>Inline deduplication is supported on FlexCache volumes beginning with ONTAP 9.6. Cross-volume deduplication is supported on FlexCache volumes beginning with ONTAP 9.7. |
| FabricPool | Yes | Yes<br><br>Supported beginning with ONTAP 9.7 |
| FlexCache DR | Yes | Yes<br><br>Supported beginning with ONTAP 9.9.1, with NFSv3 protocol, only. FlexCache volumes must be in separate SVMs or in separate clusters. |
| FlexGroup volume | Yes<br><br>Supported beginning with ONTAP 9.7 | Yes |
| FlexVol volume | Yes | No |
| FPolicy | Yes<br><br>Supported beginning with ONTAP 9.7 | Yes<br><br>Supported for NFS beginning with ONTAP 9.7 |
| MetroCluster configuration | Yes<br><br>Supported beginning with ONTAP 9.7 | Yes<br><br>Supported beginning with ONTAP 9.7 |
| NetApp Volume Encryption (NVE) | Yes<br><br>Supported beginning with ONTAP 9.6 | Yes<br><br>Supported beginning with ONTAP 9.6 |
| NFSv3 | Yes | Yes |
| NFSv4 | Yes | Yes<br><br>Supported beginning with ONTAP 9.10.1 |

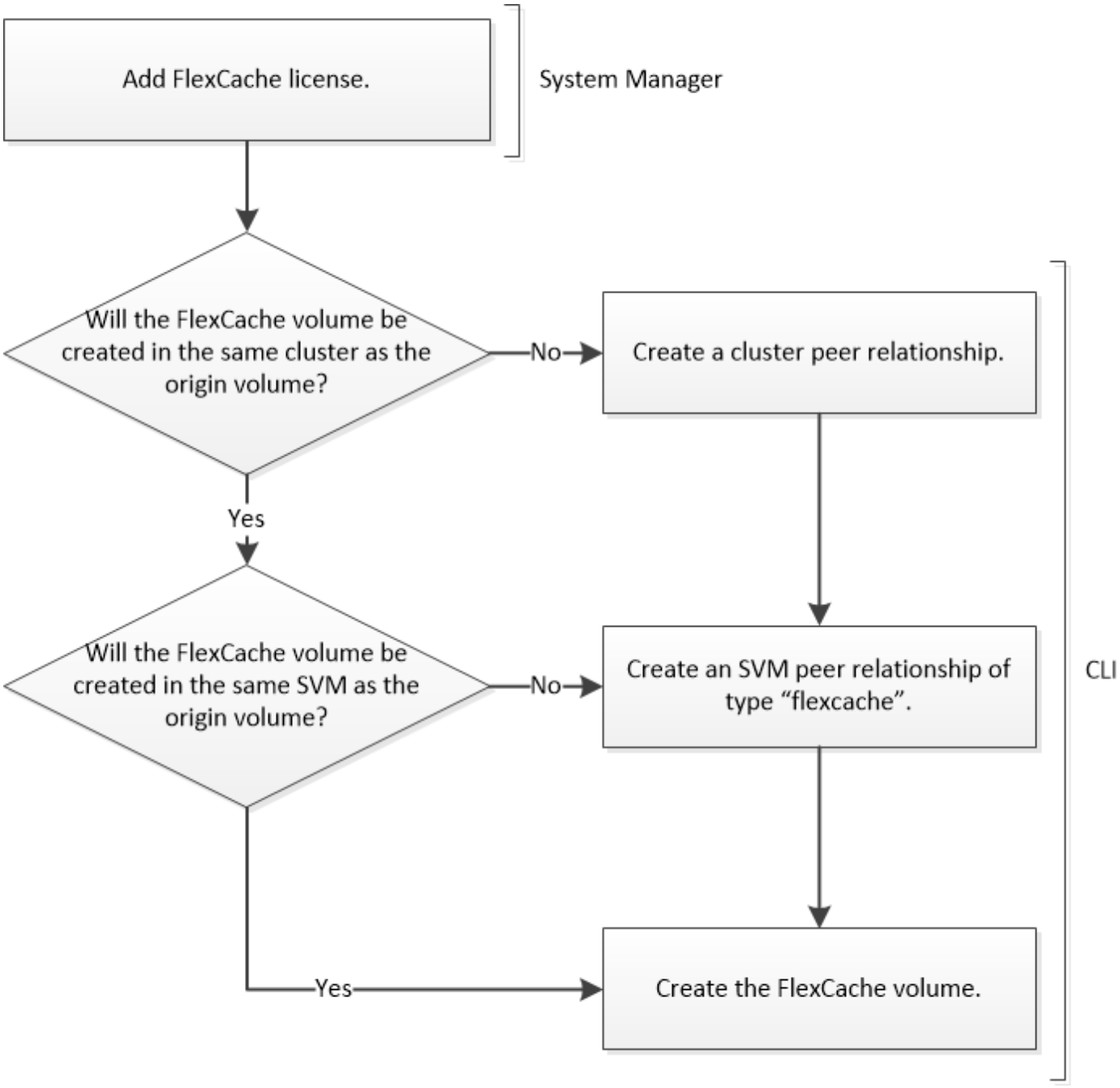
| | | |
|---|---|---|
| QoS | Yes | Yes<br><br>File-level QoS is not supported for FlexCache volumes. |
| Qtrees | Yes<br><br>Supported beginning with ONTAP 9.6 | No |
| Quotas | Yes | No<br><br>Beginning with ONTAP 9.6, remote quota (rquota) is supported at FlexCache volumes. |
| SMB | Yes | Yes<br><br>Supported beginning with ONTAP 9.8. |
| SnapLock volumes | No | No |
| SnapMirror Asynchronous relationships | Yes | No<br><br>• The primary volume or secondary volume in a SnapMirror relationship cannot be a FlexCache volume.<br>• Only the primary volume of a SnapMirror relationship can be a FlexCache origin volume.<br><br>Beginning with ONTAP 9.8, a SnapMirror secondary volume can be a FlexCache origin volume.<br><br>• You can have a FlexCache volume from an origin primary volume in SnapMirror relationship, but not from a secondary volume. |
| SnapMirror Synchronous relationships | No | No |

| | | |
|---|---|---|
| SnapRestore | Yes | No |
| Snapshot copies | Yes | No |
| SVM DR configuration | Yes<br><br>Supported beginning withONTAP 9.5. The primary SVM of an SVM DR relationship can have the origin volume; however, if the SVM DR relationship is broken, the FlexCache relationship must be re-created with a new origin volume. | No<br><br>You can have FlexCache volumes in primary SVMs, but not in secondary SVMs. Any FlexCache volume in the primary SVM is not replicated as part of the SVM DR relationship. |
| Storage-level Access Guard (SLAG) | No | No |
| Thin provisioning | Yes | Yes<br><br>Supported beginning with ONTAP 9.7 |
| Volume cloning | Yes<br><br>Cloning of an origin volume and the files in the origin volume is supported beginning with ONTAP 9.6. | No |
| Volume move | Yes | Yes (only for volume constituents)<br><br>Moving volume constituents of a FlexCache volume is supported from ONTAP 9.6 onwards. |
| Volume rehost | No | No |

## FlexCache volume creation

#### FlexCache volume creation workflow

You must first install the FlexCache license from System Manager. You can then create a FlexCache volume in the same cluster or in a remote cluster by using the CLI.




You must be running ONTAP 9.5 or later.

You can use FlexCache volumes in the same cluster for accelerated performance when accessing hot volumes. You can use FlexCache volumes in different clusters for improving the performance of cross-cluster data distribution.

#### Add a FlexCache license

If you are running ONTAP 9.6 or earlier, you must install a FlexCache license, which is a capacity-based and term-based license, by using System Manager.

##### About this task

The FlexCache license is a cluster-wide license. The license includes an entitled usage limit that you purchase for using FlexCache volumes in the cluster. The space usage by FlexCache volumes across the cluster must

not exceed the capacity of the entitled usage limit. If you need to increase the usage limit of the license, you should contact your sales representative.

Beginning with ONTAP 9.7, the capacity-based license is not required. The FlexCache license is bundled with the ONTAP package.

**Steps**

1. Download the NetApp License File for the FlexCache license from the NetApp Support Site.

   NetApp Support

2. Use System Manager to upload the FlexCache license to the cluster:
   a. Click the **Configurations** > **Cluster** > **Licenses** tab.
   b. In the **Packages** window, click **Add**.
   c. In the **Add License Packages** dialog box, click **Choose Files** to select the NetApp License File that you downloaded, and then click **Add** to upload the file to the cluster.

## Process to create a FlexCache volume

### Create a FlexCache volume

You can create a FlexCache volume in the same cluster for improving performance when accessing a hot object. If you have data centers in different locations, you can create FlexCache volumes on remote clusters for accelerating data access.

**About this task**

The FlexCache volume is always a FlexGroup volume, and not a FlexVol volume.

Beginning withONTAP 9.7, FlexGroup volumes are also supported at the origin of the FlexCache relationship.

**Steps**

1. If the FlexCache volume to be created is in a different cluster, create a cluster peer relationship:
   a. On the destination cluster, create a peer relationship with the data protection source cluster:

      ```
      cluster peer create -generate-passphrase -offer-expiration MM/DD/YYYY
      HH:MM:SS|1…7days|1…168hours -peer-addrs peer_LIF_IPs -initial-allowed
      -vserver-peers svm_name,..|* -ipspace ipspace_name
      ```

      Beginning with ONTAP 9.6, TLS encryption is enabled by default when creating a cluster peer relationship. TLS encryption is supported for the intercluster communication between the origin and FlexCache volumes. You can also disable TLS encryption for the cluster peer relationship, if required.

```
cluster02::> cluster peer create -generate-passphrase -offer
-expiration 2days -initial-allowed-vserver-peers *

                    Passphrase: UCa+6lRVICXeL/gq1WrK7ShR
               Expiration Time: 6/7/2017 08:16:10 EST
  Initial Allowed Vserver Peers: *
            Intercluster LIF IP: 192.140.112.101
              Peer Cluster Name: Clus_7ShR (temporary generated)

Warning: make a note of the passphrase - it cannot be displayed
again.
```

b. On the source cluster, authenticate the source cluster to the destination cluster:

`cluster peer create -peer-addrs peer_LIF_IPs -ipspace ipspace`

```
cluster01::> cluster peer create -peer-addrs
192.140.112.101,192.140.112.102

Notice: Use a generated passphrase or choose a passphrase of 8 or
more characters.
        To ensure the authenticity of the peering relationship, use a
phrase or sequence of characters that would be hard to guess.

Enter the passphrase:
Confirm the passphrase:

Clusters cluster02 and cluster01 are peered.
```

2. If the FlexCache volume is in a different SVM than that of the origin volume, create an SVM peer relationship with `flexcache` as the application:

a. If the SVM is in a different cluster, create an SVM permission for the peering SVMs:

`vserver peer permission create -peer-cluster cluster_name -vserver svm-name -applications flexcache`

The following example illustrates how to create an SVM peer permission that applies for all of the local SVMs:

```
cluster1::> vserver peer permission create -peer-cluster cluster2
-vserver "*" -applications flexcache

Warning: This Vserver peer permission applies to all local Vservers.
After that no explict
"vserver peer accept" command required for Vserver peer relationship
creation request
from peer cluster "cluster2" with any of the local Vservers. Do you
want to continue? {y|n}: y
```

b. Create the SVM peer relationship:

```
vserver peer create -vserver local_SVM -peer-vserver remote_SVM -peer
cluster cluster_name -applications flexcache
```

3. Create a FlexCache volume:

```
volume flexcache create -vserver cache_svm -volume cache_vol_name -auto
-provision-as flexgroup -size vol_size -origin-vserver origin_svm -origin
-volume origin_vol_name
```

The following example creates a FlexCache volume and automatically selects existing aggregates for provisioning:

```
cluster1::> volume flexcache create -vserver vs_1 -volume fc1 -auto
-provision-as flexgroup -origin-volume vol_1 -size 160MB -origin-vserver
vs_1
[Job 443] Job succeeded: Successful
```

The following example creates a FlexCache volume and sets the junction path:

```
cluster1::> flexcache create -vserver vs34 -volume fc4 -aggr-list
aggr34,aggr43 -origin-volume origin1 -size 400m -junction-path /fc4
[Job 903] Job succeeded: Successful
```

4. Verify the FlexCache relationship from the FlexCache volume and the origin volume.

a. View the FlexCache relationship in the cluster:

```
volume flexcache show
```

```
cluster1::> volume flexcache show
Vserver Volume      Size       Origin-Vserver Origin-Volume Origin-
Cluster
------- ----------- ---------- -------------- -------------
--------------
vs_1    fc1         160MB      vs_1           vol_1
cluster1
```

b. View all of the FlexCache relationships in the origin cluster:

`volume flexcache origin show-caches`

```
cluster::> volume flexcache origin show-caches
Origin-Vserver Origin-Volume   Cache-Vserver    Cache-Volume   Cache-
Cluster
-------------- --------------- ---------------  --------------
---------------
vs0            ovol1           vs1              cfg1           clusA
vs0            ovol1           vs2              cfg2           clusB
vs_1           vol_1           vs_1             fc1
cluster1
```

**Result**

The FlexCache volume is successfully created. Clients can mount the volume by using the junction path of the FlexCache volume.

**Related information**

Cluster and SVM peering

ONTAP 9 commands

#### Guidelines for sizing a FlexCache volume

## You must be aware of the limits for FlexCache volumes before you start provisioning the volumes.

The size limit of a FlexVol volume is applicable to an origin volume. The size of a FlexCache volume can be less than or equal to the origin volume. The best practice for the size of a FlexCache volume is to be at least 10 percent of the size of the origin volume.

You must also be aware of the following additional limits on FlexCache volumes:

| Limit | ONTAP 9.5-9.6 | ONTAP 9.7 | ONTAP 9.8 and later |
|---|---|---|---|

| | | | |
|---|---|---|---|
| Maximum number of FlexCache volumes that you can create from an origin volume | 10 | 10 | 100 |
| Recommended maximum number of origin volumes per node | 10 | 100 | 100 |
| Recommended maximum number of FlexCache volumes per node | 10 | 100 | 100 |
| Recommended maximum number of FlexGroup constituents in a FlexCache volume per node | 40 | 800 | 800 |
| Maximum number of constituents per FlexCache volume per node | 32 | 32 | 32 |

**Related information**

NetApp Interoperability

#### Considerations for auditing FlexCache volumes

Beginning with ONTAP 9.7, you can audit NFS file access events in FlexCache relationships using native ONTAP auditing and file policy management with FPolicy. FPolicy is not supported for FlexCache volumes with SMB. Native auditing and FPolicy are configured and managed with the same CLI commands used for FlexVol volumes. However, there is some different behavior with FlexCache volumes.

- **Native auditing**
  - You can't use a FlexCache volume as the destination for audit logs.
  - If you want to audit read and writes on FlexCache volumes, you must configure auditing on both the cache SVM as well as on the origin SVM.

    This is because file system operations are audited where they are processed. That is, reads are audited on the cache SVM and writes are audited on the origin SVM.
  - To track the origin of write operations, the SVM UUID and MSID are appended in the audit log to identify the FlexCache volume from which the write originated.
  - Although system access control lists (SACLs) can be set on a file using NFSv4 or SMB protocols, FlexCache volumes support only NFSv3. Therefore, SACLs can only be set on the origin volume.
- **FPolicy**
  - Although writes to a FlexCache volume are committed on the origin volume, FPolicy configurations monitor the writes on the cache volume. This is unlike native auditing, in which the writes are audited on the origin volume.
  - While ONTAP does not require the same FPolicy configuration on cache and origin SVMs, it is recommended that you deploy two similar configurations. You can do so by creating a new FPolicy policy for the cache, configured like that of the origin SVM but with the scope of the new policy limited to the cache SVM.

## Manage a FlexCache relationship

### View the connection status of a FlexCache relationship

Beginning with ONTAP 9.6, you can view the connection status of a FlexCache relationship and take any corrective action if the connection status between the origin and FlexCache volumes goes to the disconnected mode.

#### About this task

A FlexCache relationship can have one of the following connection status:

- `connected`
- `disconnected`
- `unknown`

#### Steps

1. Log in to the advanced privilege mode:

   ```
   set -privilege advanced
   ```

2. Verify the connection status of all the FlexCache relationships in the cluster:

   ```
   volume flexcache connection-status show
   ```

```
cluster::*> volume flexcache connection-status show

Node: cluster-01


                         Remote                              Remote
Connection

+Vserver      Volume     Vserver      Remote Volume       Endpoint
Status

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

vs_1          vol_origin     vs_2     fc_11__0001         cache
connected

vs_1          vol_origin     vs_2     fc_11__0002         cache
connected

vs_1          vol_origin     vs_2     fc_11__0003         cache
connected

vs_1          vol_origin     vs_2     fc_11__0004         cache
connected

vs_2          fc_11          vs_1     vol_origin          origin
connected
```

#### Synchronize properties of a FlexCache volume from an origin volume

Some of the volume properties of the FlexCache volume must always be synchronized with those of the origin volume. If the volume properties of a FlexCache volume fail to synchronize automatically after the properties are modified at the origin volume, you can manually synchronize the properties.

##### About this task

The following volume properties of a FlexCache volume must always be synchronized with those of the origin volume:

- Security style (`-security-style`)
- Volume name (`-volume-name`)
- Maximum directory size (`-maxdir-size`)
- Minimum read ahead (`-min-readahead`)

**Step**

1. From the FlexCache volume, synchronize the volume properties:

```
volume flexcache sync-properties -vserver svm_name -volume flexcache_volume
```

```
cluster1::> volume flexcache sync-properties -vserver vs1 -volume fc1
```

### Update the configurations of a FlexCache relationship

After events such as volume move, aggregate relocation, or storage failover, the volume configuration information on the origin volume and FlexCache volume is updated automatically. In case the automatic updates fail, an EMS message is generated and then you must manually update the configuration for the FlexCache relationship.

If the origin volume and the FlexCache volume are in the disconnected mode, you might need to perform some additional operations to update a FlexCache relationship manually.

**About this task**

If you want to update the configurations of a FlexCache volume, you must run the command from the origin volume. If you want to update the configurations of an origin volume, you must run the command from the FlexCache volume.

**Step**

1. Update the configuration of the FlexCache relationship:

```
volume flexcache config-refresh -peer-vserver peer_svm -peer-volume
peer_volume_to_update -peer-endpoint-type [origin | cache]
```

### Enable global file locking

Beginning with ONTAP 9.10.1, global file locking can be applied to prevent reads across all related cached files.

**About this task**

By default, FlexCache volumes favor availability over consistency. Without global file locking, any modification to an origin will be distributed to FlexCache volumes, but they might not be updated simultaneously. Global file locking favors consistency across volumes over availability. With global file locking enabled, modifications to the origin will be suspended until all FlexCache volumes are online.

> You should only enable global file locking when you have control over the reliability of the connections between cache and origin due to suspension and possible timeouts of modifications when FlexCache volumes are offline.

Global file locking requires the clusters containing the origin and all associated caches to be running ONTAP 9.9.1 or later. Global file locking can be enabled on new or existing FlexCache volumes. The command can be run on one volume and will apply to all associated volumes.

You must be in the advanced privilege level to enable global file locking.

The process to enable global file locking depends on whether the origin has existing caches.

- Enable global file locking on new FlexCache volumes
- Enable global file locking on existing FlexCache volumes

#### Enable global file locking on new FlexCache volumes

**Steps**

1. Create the FlexCache volume with `-is-global-file-locking` set to true:

   ```
   volume flexcache create volume volume_name -is-global-file-locking-enabled
   true
   ```

   The default value of `-is-global-file-locking` is “false”. When any subsequent `volume flexcache create` commands are run on a volume, they must be passed with `-is-global-file-locking enabled` set to “true”.

#### Enable global file locking on existing FlexCache volumes

**Steps**

1. Global file locking must be set from the origin volume.
2. The origin cannot have any other existing relationships (for example, SnapMirror). Any existing relationships must be dissociated. All caches and volumes must be connected at the time of running the command. To check the connection status, run:

   ```
   volume flexcache connection-status show
   ```

   The status for all the listed volumes should display as “`connected.`” For more information, see Viewing the status of a FlexCache relationship or Synchronizing properties of a FlexCache volume from an origin.

3. Enable global file locking on the caches:

   ```
   volume flexcache origin config show/modify -volume volume_name -is-global-file
   -locking-enabled true
   ```

If reverting to a version of ONTAP earlier than 9.9.1, global file lock must first be disabled on the origin and associated caches. This can be managed by running:

```
volume flexcache prepare-to-downgrade -disable-feature-set 9.10.0
```

### Prepopulate a FlexCache volume

You can prepopulate a FlexCache volume to reduce the time it takes to access cached data.

#### What you’ll need

- You must be a cluster administrator at the advanced privilege level
- The paths you pass for prepopulation must be valid or the prepopulate operation fails.

#### About this task

- Prepopulate reads files only and crawls through directories
- The is-recursion flag applies to the entire list of directories passed to prepopulate

**Steps**

1. Prepopulate a FlexCache volume:

   ```
   volume flexcache prepopulate -cache-vserver vserver_name -cache-volume -path
   -list path_list -is-recursion true|false
   ```

   This example includes a single directory path for prepopulation:

   ```
   cluster1::*> flexcache prepopulate start -cache-vserver vs2 -cache
   -volume fg_cachevol_1 -path-list /dir1
     (volume flexcache prepopulate start)
   [JobId 207]: FlexCache prepopulate job queued.
   ```

   This example includes a list of several paths for prepopulation:

   ```
   cluster1::*> flexcache prepopulate start -cache-vserver vs2 -cache
   -volume fg_cachevol_1 -path-list /dir1,/dir2,/dir3,/dir4
     (volume flexcache prepopulate start)
   [JobId 208]: FlexCache prepopulate job queued.
   ```

2. Display the number of files read:

   ```
   job show -id job_ID -ins
   ```

### Delete a FlexCache relationship

You can delete a FlexCache relationship and the FlexCache volume if you no longer require the FlexCache volume.

**Steps**

1. From the cluster that has the FlexCache volume, take the FlexCache volume offline:

   ```
   volume offline -vserver svm_name -volume volume_name
   ```

2. Delete the FlexCache volume:

   ```
   volume flexcache delete -vserver svm_name -volume volume_name
   ```

   The FlexCache relationship details are removed from the origin volume and the FlexCache volume.

   If the `volume flexcache delete` command fails to clean up the origin side configuration, you are prompted to run the `volume flexcache origin cleanup-cache-relationship` command. In this scenario, go to Step 3.

3. From the origin cluster, clean up the FlexCache relationship details from the origin volume:

```
volume flexcache origin cleanup-cache-relationship -origin-volume
origin_volume -origin-vserver origin_svm -cache-vserver flexcache_svm -cache
-volume flexcache_vol
```

> If you run the `volume flexcache origin cleanup-cache-relationship` command, the FlexCache relationship is deleted and cannot be reestablished.

```
cluster1::> volume flexcache origin cleanup-cache-relationship -origin
-volume origin1 -origin-vserver vs34 -cache-vserver vs56 -cache-volume
fc1

Warning: This command only needs to be run if "volume flexcache delete"
fails on
         the FlexCache cluster and prompts you to run this command. The
cache
         configuration will be deleted and cannot be reestablished for
the
         cache relationship between origin of a FlexCache volume
         "origin1" in Vserver "vs34" and FlexCache volume
         "fc1" in Vserver "vs56".
Do you want to continue? {y|n}: y
```

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