



Technical Report

# Data Protection and Backup

## NetApp FlexGroup Volumes

Justin Parisi, NetApp  
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### Abstract

This document covers data protection and backup, specifically for NetApp® FlexGroup volumes. Topics include Snapshot copies, SnapMirror®, and other data protection and backup solutions. For data protection best practices pertaining to FlexVol® volumes, see [TR-4015](#). For general FlexGroup volume information, see [TR-4557](#). For general FlexGroup volume best practices, see [TR-4571](#). For all other general data protection information, see the [data protection guide for your version of ONTAP® 9.x](#), found on NetApp's official product documentation pages.

### Information Classification

Public

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**Version History**

Version	Date	Document Version History
Version 1.0	April 2018	First edition.

# 1 Overview

## 1.1 Document Scope

This document intends to cover data protection best practices, considerations, and other related items as they pertain to NetApp FlexGroup volumes. This document is not intended to be used for FlexVol volume configurations, nor is it aimed at audiences using NetApp ONTAP operating in 7-Mode. See the section [Additional Resources](#) for links to documents covering non-FlexGroup volume configurations.

## 1.2 Intended Audience

This document's intended audience includes, but is not limited to:

- Storage administrators
- Storage architects
- Field resources
- Business decision makers

If there are any questions about the content of this document, refer to the [Contact Us](#) section of this document.

## 1.3 Data Protection Terminology

This section defines key terminology that's used when describing data protection terminology. This section is meant to help clarify terms that might be unfamiliar to readers of this document.

### Storage Virtual Machine (SVM)

- An SVM is a logical file system namespace capable of spanning beyond the boundaries of physical nodes in a cluster:
  - Clients can access virtual servers from any node in the cluster, but only through the associated logical interfaces (LIFs).
  - Each SVM has a root volume under which additional volumes are mounted, extending the namespace.
  - It can span several physical nodes.
  - It is associated with one or more logical interfaces; clients access the data on the virtual server through the logical interfaces, which can live on any node in the cluster.

### Logical Interface (LIF)

- A LIF is essentially an IP address with associated characteristics, such as a home port, a list of ports for failover, a firewall policy, a routing group, and so on:
  - Client network data access is through logical interfaces dedicated to the SVM.
  - An SVM can have more than one LIF. You can have many clients mounting one LIF or one client mounting several LIFs.
  - This fact means that IP addresses are no longer tied to a single physical interface.

## Data Protection

Data protection is the process of safeguarding data from corruption or loss due to sitewide outages, ransomware, or other unforeseen circumstances that can cost businesses valuable time and money.

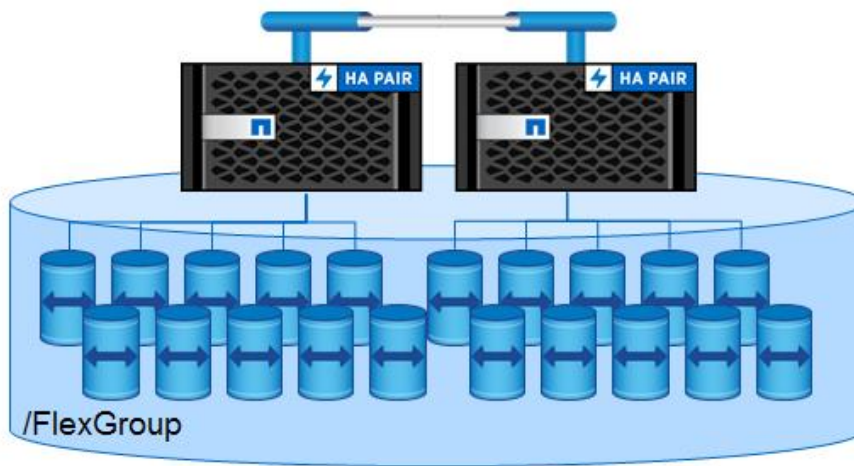
## FlexClone

NetApp FlexClone® technology allows for near-zero-space, exact, writable virtual copies of datasets, including volumes, files, and LUNs. It offers rapid, space-efficient creation of additional data copies ideally suited for disaster recovery testing and test and development environments.

## FlexGroup Volumes

With the introduction of ONTAP 9.1 came the inclusion of the FlexGroup volume. FlexGroup volumes take the concept of the FlexVol volume and use ONTAP to create a single large container composed of multiple FlexVol volume members. This approach allows for a true scale-out NAS file system that is able to leverage all resources in a cluster while blending capacity, performance, and simplicity in its deployment.

Figure 1) FlexGroup volume.



For more information regarding FlexGroup volumes, see [TR-4557: FlexGroup Volume Technical Overview](#).

## Logical Directory Replication/Unified Replication (XDP)

SnapMirror unified replication refers to the use of SnapMirror with the same (unified) logical replication engine as in NetApp SnapVault® technology. This unified relationship type is designated extended data protection (XDP) and provides single baseline functionality at the volume level, drastically reducing storage and network bandwidth, which translates immediately into cost savings.

## MirrorVault

A MirrorVault is a SnapMirror relationship that integrates SnapVault functionality into the replication, allowing asymmetric Snapshot copy counts on the source and destination. This replication is controlled by the MirrorAndVault policy in ONTAP.

## SnapMirror

SnapMirror provides asynchronous replication of volumes, independent of protocol, either in the cluster or to another ONTAP system for data protection and disaster recovery.

## **SnapRestore**

SnapRestore® is a licensable feature that enables the ability to restore data from Snapshot copies in ONTAP.

## **Snapshot Copies**

Snapshot copies are automatically scheduled point-in-time copies that take up no space and incur no performance overhead when created. Over time, Snapshot copies consume minimal storage space, because only changes to the active file system are written. Individual files and directories can be easily recovered from any Snapshot copy, and the entire volume can be restored back to any Snapshot state in seconds.

## **SnapVault**

Volumes can be copied for space-efficient, read-only, disk-to-disk backup either in the cluster or to another ONTAP system. SnapVault, when used in conjunction with version-independent SnapMirror, allows a single destination volume to serve as both a backup and disaster recovery copy.

## **Recovery Point Objective (RPO)**

RPO refers to the amount of data at risk. This value determines the acceptable loss in data recovery scenarios, because the more data you back up, the more cost is allocated to data protection infrastructure and management.

## **Recovery Time Objective (RTO)**

RTO refers to the amount of downtime that is deemed as acceptable in disaster recovery scenarios.

## **Version-Independent/Version-Flexible SnapMirror**

Version-independent/version-flexible SnapMirror offers the ability to replicate between ONTAP clusters, in two major releases of the ONTAP versions on source and destination clusters.

## 1.4 Data Protection Features with NetApp FlexGroup Volumes

Table 1 shows a list of data protection features and with what version of ONTAP they are currently supported with FlexGroup volumes. Check back for each new ONTAP release for additional feature support for NetApp FlexGroup volumes.

Table 1) Data protection features: NetApp FlexGroup volumes.

Data Protection Feature/Software	First Supported ONTAP Version
Snapshot copies	ONTAP 9.1
SnapRestore	ONTAP 9.1 (diag priv only)
Single-file SnapRestore	N/A
Microsoft Windows Previous Versions tab	ONTAP 9.1
FlexClone	N/A
SIS clone	N/A
SnapMirror (DP)	N/A
SnapVault	ONTAP 9.3
MirrorVault	ONTAP 9.3
Logical directory replication (XDP)	ONTAP 9.1
Version-independent/version-flexible SnapMirror	ONTAP 9.1
Qtree SnapMirror	N/A
NDMP	N/A
SnapProtect®	N/A
SnapManager®	N/A
SnapCenter®	N/A
SVM DR	N/A (see SVM DR section of this document for details)
SnapMirror to AltaVault™	N/A
MetroCluster™	N/A
Qtrees	ONTAP 9.3
XCP	All versions of ONTAP

## 2 Snapshot Copies with FlexGroup Volumes

Snapshot copies are point-in-time copies of a file system. ONTAP has supported Snapshot copies for decades, and NetApp is one of the pioneers of the technology.

When a NetApp Snapshot copy is created in ONTAP, inode pointers to the data in the active file system are created and are pointed to new locations in the storage. These pointers are read only from a client's perspective. As data is deleted from the active file system, it stays locked in a Snapshot copy until the

Snapshot copy is deleted. Thus, space is not freed up when data is deleted until a Snapshot copy is deleted.

Files can be restored individually from Snapshot copies from clients by navigating to the `.snapshot` directory in NFS or the `~snapshot` directory in CIFS/SMB or through the Previous Versions tab in Windows. Snapshot copies can also restore individual files through `snap restore` commands with FlexVol volumes. Also, volumes or aggregates can be restored en masse through the `snap restore` command (with a valid SnapRestore license). The `snap restore` command is only available at `diag` privilege for FlexGroup volumes.

ONTAP supports Snapshot copies with NetApp FlexGroup volumes, with most of the functionality that a Snapshot copy provides with regular FlexVol volumes. Table 2 shows which features are supported for Snapshot copies in ONTAP with NetApp FlexGroup volumes.

**Table 2) Snapshot feature support with NetApp FlexGroup volumes.**

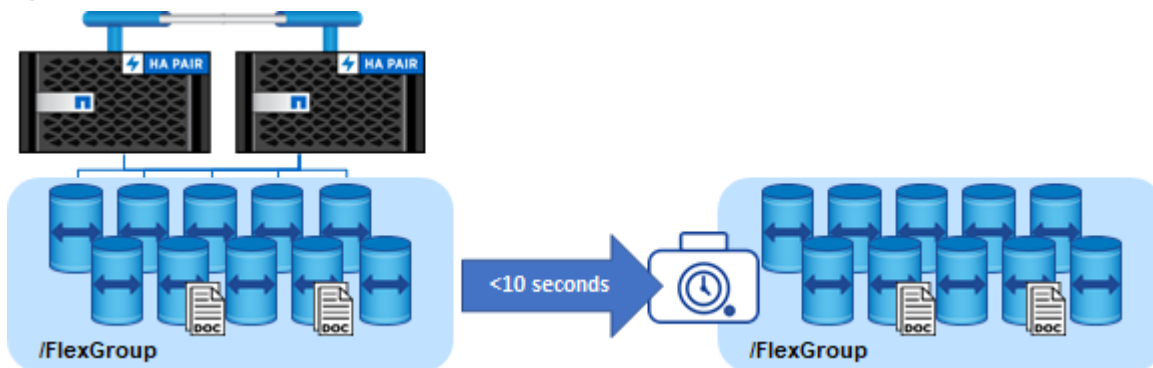
Snapshot Feature/Functionality	Supported?	ONTAP Version First Supported
Snapshot create	Yes	9.0
Snapshot restore (diag level only)	Yes	9.0
Single file SnapRestore from CLI	No	N/A
Previous Versions tab	Yes	9.1RC2
<code>.snapshot</code> directory access	Yes	9.0
Support for 1,023 Snapshot copies	No	N/A (FlexVol support in 9.4)

## How Snapshot Copies Work with NetApp FlexGroup

NetApp FlexGroup volumes are made up of a group of FlexVol member volumes. Snapshot copies are still made at the FlexVol volume level, so when a FlexGroup Snapshot copy must be created, the member volumes must be coordinated to create a consistent Snapshot copy of the file system. Keep in mind that a FlexGroup volume makes generous use of remote hard links. Therefore, if a Snapshot copy is made of a member volume and the hard link isn't captured in flight, or if a hard link is captured without the associated file, the Snapshot copy is essentially no good.

As a result, a NetApp FlexGroup volume fences off data access during a Snapshot job and flushes cache entries so that the Snapshot copy is consistent. This process is similar to the Snapshot process that is used for SAN LUNs or for crash-consistent or application-consistent Snapshot copies, such as with VMware virtual machines. During this access fencing, reads and writes are paused for no more than 10 seconds in a worst case scenario. Generally, this process completes in around 1 second, depending on load on the system. If a Snapshot copy takes more than 10 seconds to complete, it fails.

Figure 2) Snapshot copies in FlexGroup volumes.



### FlexGroup Snapshot Guidelines

- If any FlexVol member volume cannot make a Snapshot copy because of space or performance issues, then the FlexGroup Snapshot copy is marked as “invalid” and is cleaned up by ONTAP. Invalid Snapshot copies are not viewable by default through the CLI. The process is transparent to storage administrators.
- If a Snapshot copy is considered as “partial,” it can’t be used in SnapRestore operations. However, partial Snapshot copies can be used to restore individual files from .snapshot directories or the Previous Version tab.
- SnapRestore is an all-or-nothing proposition. When you restore a FlexGroup volume, you restore the entire container. Member FlexVol volumes cannot be restored individually.
- If a FlexGroup volume is modified to include more members, previously created Snapshot copies are considered as “partial” and are available only for .snapshot directory or Previous Version access from clients.
- Because of the impact of fencing the FlexGroup volume access during Snapshot copy creation, Snapshot schedules should be in 30-minute or greater intervals.

## 3 SnapMirror and SnapVault with FlexGroup Volumes

SnapMirror support for FlexGroup volumes is present in ONTAP 9.1RC1 and later. SnapVault support is present in ONTAP 9.3 and later.

The current support includes only the logical replication engine (logical storage replication engine [LSRE]/external data protection [XDP] relationships). Table 3 shows a list of SnapMirror features supported with NetApp FlexGroup and the version of ONTAP in which the feature was first introduced.

Table 3) SnapMirror feature support with NetApp FlexGroup volumes.

SnapMirror Feature/Functionality	Supported?	ONTAP Version First Supported
SnapMirror (block/DP)	No	N/A
SnapMirror (logical/XDP)	Yes	9.1RC1
Version-flexible SnapMirror	Yes	9.1RC1
Qtree SnapMirror	No	Supported only in 7-Mode
SnapVault	Yes	9.3RC1
SnapLock®	No	N/A



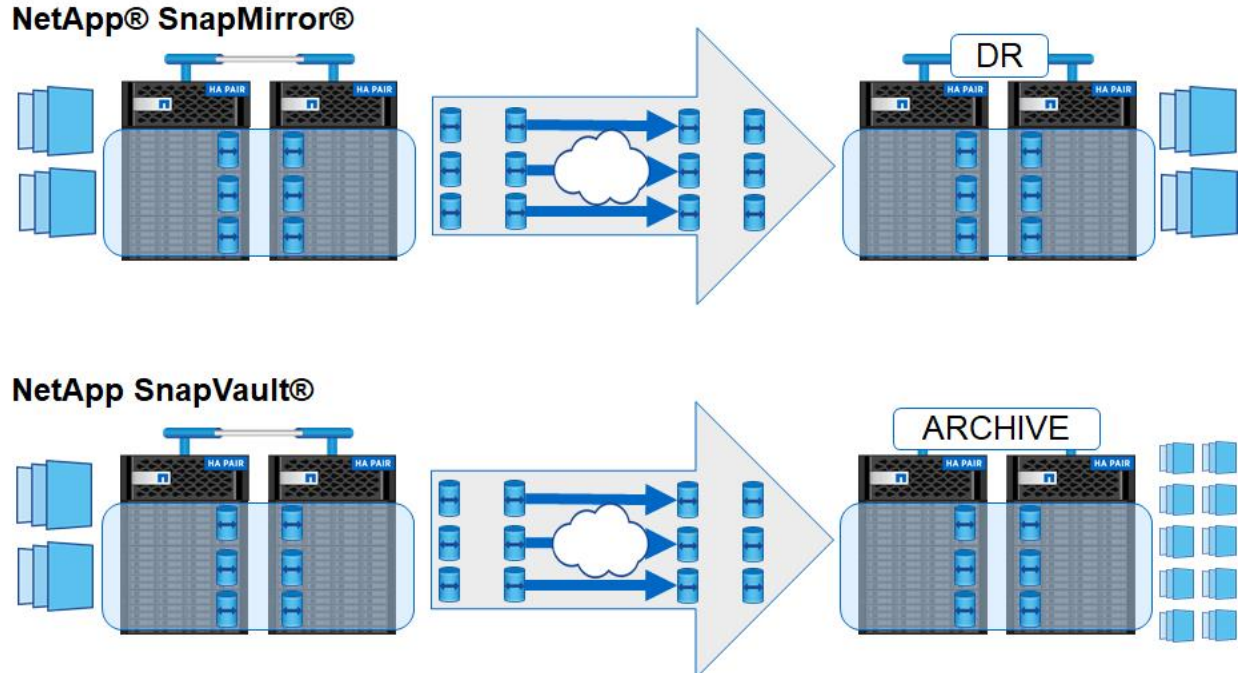
SnapMirror Feature/Functionality	Supported?	ONTAP Version First Supported
Storage virtual machine disaster recovery (SVM DR)	No	N/A
Load-sharing mirrors (LS)	No	N/A
Cascading SnapMirror relationships	No	N/A
FlexGroup expansion without SnapMirror rebaseline	Yes	9.3RC1
SnapMirror to AltaVault	No	N/A
SolidFire® to ONTAP SnapMirror	No	N/A
Unified SnapMirror and MirrorVault	Yes	9.3RC1

## SnapMirror or SnapVault?

ONTAP 9.3 adds support for SnapVault for FlexGroup volumes. This support enables storage administrators to replicate FlexGroup volumes asynchronously to a destination volume and preserve more Snapshot copies than what exist on the source volume. SnapMirror and SnapVault use cases can be broken down thusly:

- **SnapMirror relationships** are intended for disaster recovery and provide an exact replica of the source volume, including the number of Snapshot copies on the source.
- **SnapVault relationships** are intended for backup and archive use cases by providing a path to Snapshot copies older than what might exist on the source volume.

Figure 3) SnapMirror vs. SnapVault with FlexGroup volumes.



## How SnapMirror Works with NetApp FlexGroup

SnapMirror with NetApp FlexGroup operates much like Snapshot copies do, because the basis of a SnapMirror copy is the Snapshot copy. Access is fenced, and all volumes must make Snapshot copies at

the same time to promote consistency. After that similarity, however, SnapMirror operates by leveraging concurrent transfers of the member volume constituents to the disaster recovery site. All members transfer at the same time; there is no way to mirror individual member volumes with SnapMirror. If Snapshot copies fail on the source for any member, the SnapMirror transfer does not initiate.

## **Creating a SnapMirror and SnapVault Relationship for a FlexGroup Volume**

The following section covers basic steps for creating a SnapMirror and SnapVault relationship for a NetApp FlexGroup volume. Prior to ONTAP 9.4, creating such a relationship was done primarily using the command line. ONTAP 9.4 brings a plethora of simplicity enhancements for deploying and protecting FlexGroup volumes.

### **Basic General Steps for Creating a SnapMirror and SnapVault Relationship with FlexGroup (ONTAP 9.3 and Later)**

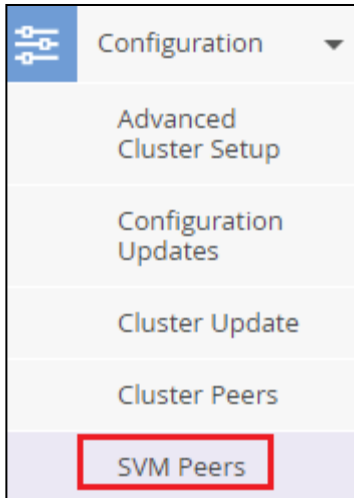
1. Make sure the SVM and/or clusters are peered. See the SnapMirror documentation for more information about peering.
2. Create a destination volume with type DP that has the same number of member volumes as the source volume and equal or greater capacity. For example, an eight-member source volume needs an eight-member destination.
3. Select a SnapMirror and SnapVault policy.
4. Create the SnapMirror and SnapVault relationship.
5. Initialize SnapMirror and SnapVault.
6. Select a Snapshot policy and label.
7. Create a schedule.

## **Using the “Protect” Functionality with FlexGroup Volumes in OnCommand System Manager**

ONTAP 9.4 introduced the ability to leverage OnCommand® System Manager’s robust “protect” functionality for NetApp FlexGroup volumes. This functionality can be used at the time of the FlexGroup volume’s deployment or after the FlexGroup volume has already been deployed.

### **Peering a Cluster**

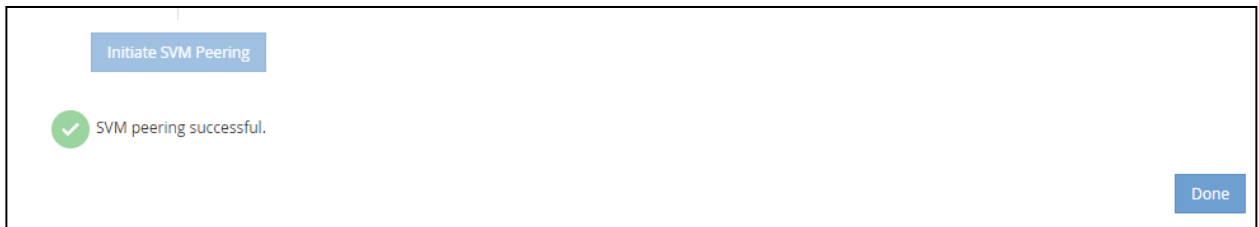
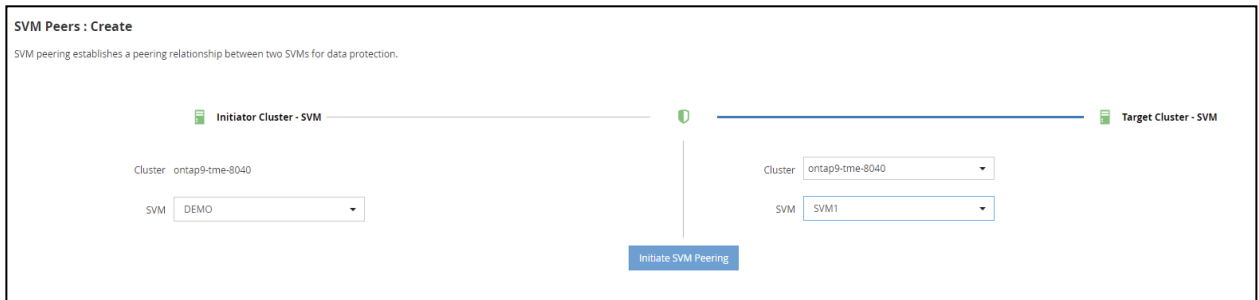
1. Click “Configuration” in the left menu, then “SVM Peers” (for local SnapMirror) or “Cluster Peers” (for remote SnapMirror) if you haven’t already peered the source and destination. In this example, we’re peering SVMs to do a local SnapMirror configuration.



- Peer the SVM or cluster.

### **SVM Peering**

Click “Create” and choose your SVMs. Click “Initiate SVM peering.” In a few seconds, you should see “SVM peering successful.” Click Done.



The screenshot shows a table titled 'SVM Peers'. The table has four columns: 'SVM', 'Peered SVM', 'Peered Cluster', and 'Status'. There are two rows of data, each with a checkbox in the first column.

SVM	Peered SVM	Peered Cluster	Status
<input type="checkbox"/> DEMO	SVM1	ontap9-tme-8040	peered
<input type="checkbox"/> SVM1	DEMO	ontap9-tme-8040	peered

## Cluster Peering

Cluster peering is needed if you plan on implementing intercluster SnapMirror. In OnCommand System Manager for ONTAP 9.3 and later, this peering is done with “cluster peers.” Doing this peering also allows you to peer SVMs in the same configuration steps.

Peering establishes a trust relationship between clusters or SVMs for sharing resources and replicating data with SnapMirror.

Intercluster LIFs are required to peer with the remote clusters.

### Intercluster LIF Details per Node

IPspace:

ontap9-tme-8040-01	10.193.67.57
ontap9-tme-8040-02	10.193.67.59

## Protecting a New FlexGroup Volume

When a new FlexGroup volume is created, storage administrators have the option to easily protect the volume with a SnapMirror or SnapVault relationship, provided the cluster has been peered successfully with another cluster.

Figure 4) Protecting a FlexGroup volume during deployment.

### Volumes: Create FlexGroup Volume

Enter FlexGroup Volume Details ⚙️

Name:

Protocols Enabled: CIFS, NFS

⚠️ It is recommended that you enable 64-bit NFSv3 FSIDs and File Identifiers on SVM "DEMO" to avoid conflicts between File IDs on a FlexGroup volume. Navigate to SVM Settings -> NFS -> Edit to enable 64-bit NFSv3 FSIDs and File Identifiers.

Encrypted:

Aggregates: Aggregates are selected as per best practices

Size:

#### Protection

Volume Protection:

Volume Relationship Type:

Source  Destination Volume

Cluster: ontap9-tme-8040

SVM: DEMO

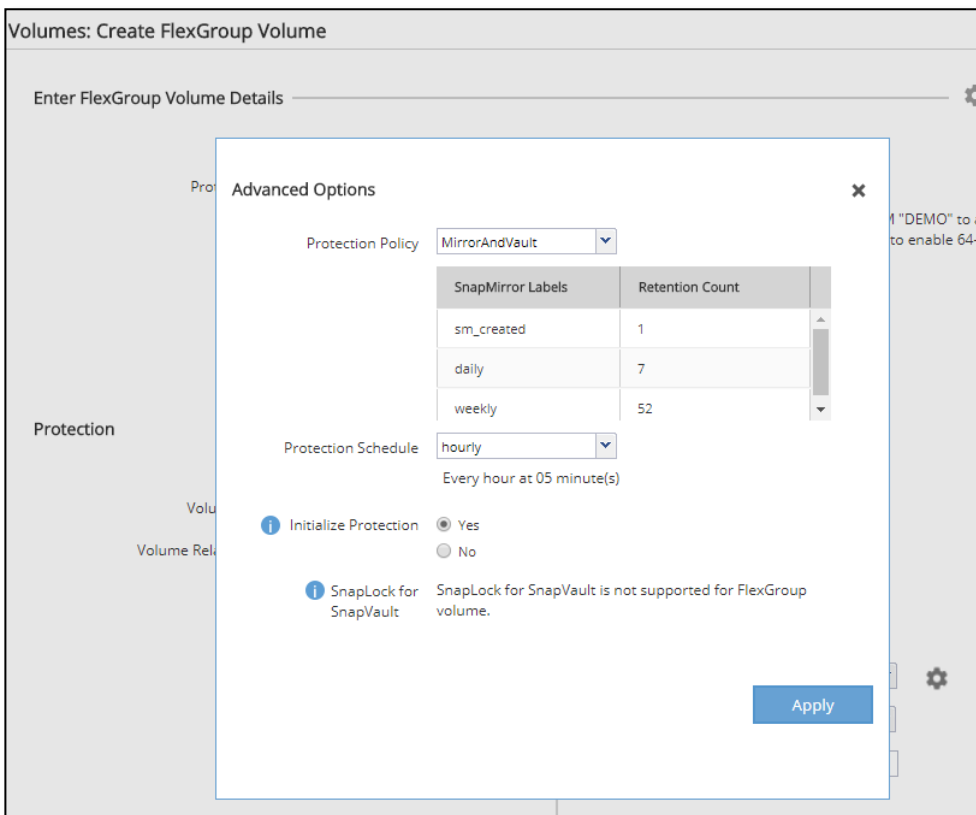
Volume FlexGroup\_SRC

Cluster:

SVM:

Volume Name Suffix:

Figure 5) Protecting a FlexGroup volume during deployment (advanced features).

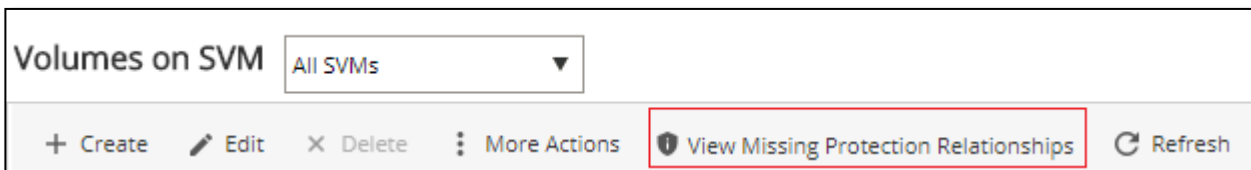


After the “Create” button is clicked, OnCommand System Manager creates the source and destination volumes with the correct size and geometries. If the “Initialize Protection” field is left at the default value, then the relationship also initializes automatically.

### Protecting an Existing FlexGroup Volume

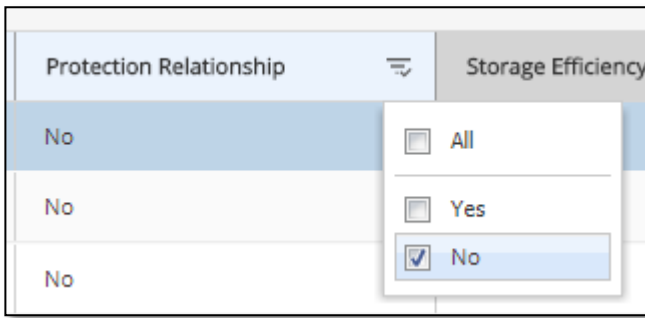
If a FlexGroup volume has already been created without a SnapMirror or SnapVault relationship, System Manager can be used to query for unprotected volumes and then retroactively protect them. To query for unprotected volumes, click “View Missing Protection Relationships” in the volumes screen.

Figure 6) Viewing unprotected volumes.



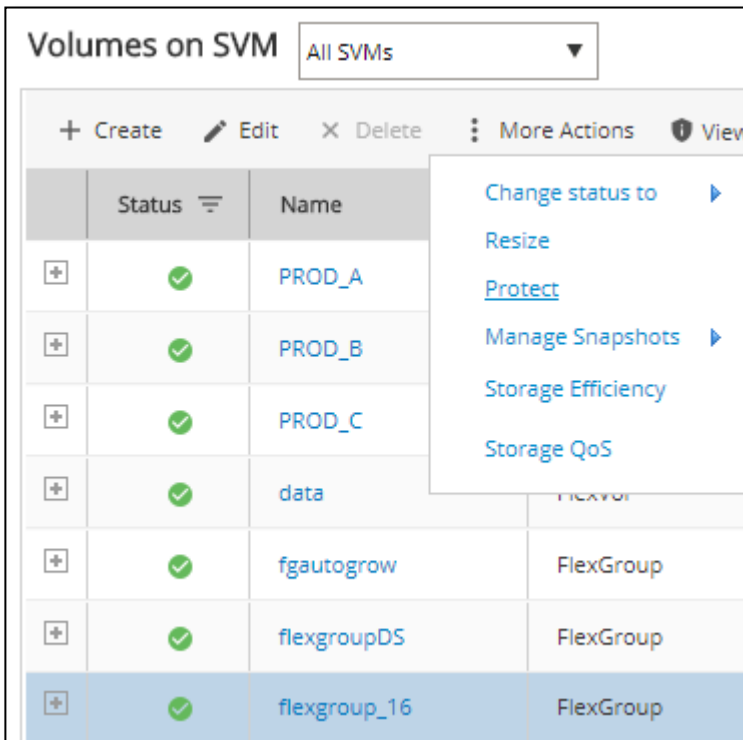
This query filters out all volumes that show “Protection Relationship = yes.” You can also accomplish this result by manually selecting “No” in the menu option.

Figure 7) Creating manual filters for protection relationships in System Manager.



To protect an existing FlexGroup volume, simply click the volume to highlight it and click “More Actions” in the menu screen. Select “Protect.”

Figure 8) Protecting an existing FlexGroup volume.



This selection brings you to the “Protect Volumes” wizard. From here, simply specify your destination cluster and desired destination volume suffix name.

Figure 9) Protecting an existing FlexGroup volume: protect volumes.

From there, click “Validate” to check for labels.

Figure 10) Protecting an existing FlexGroup volume: validate.

Volumes	SVMs	Snapshot Matching La...	Other labels from Sna...	Other labels from Prot...
flexgroup_16	DEMO			sm_created,daily,weekly

If all looks good, click “Save” to complete the operation.

## SnapMirror and SnapVault Considerations

The following section covers some considerations that need to be made with regard to SnapMirror and SnapVault use with FlexGroup volumes.

### SnapMirror Resync Considerations

A `snapmirror resync` operation restores or redefines a SnapMirror source or destination relationship that was broken with the `snapmirror break` command. When a resync occurs, a common Snapshot copy between the primary and secondary FlexGroup volumes is used to restore the FlexGroup volume to a common checkpoint. With this approach, any data accumulated on the secondary volume after a SnapMirror break is lost. An appropriate confirmation occurs when `snapmirror resync` is run. After running the resync, all member volumes in the FlexGroup volume are set to a DP status, which fences off RW access to the volumes and maintains consistency in the volumes. Resyncs may report failures if a FlexGroup volume's source or destination has been expanded (more member volumes added) between the previous `snapmirror break` and `snapmirror resync` commands.

### SnapMirror Restore Considerations

SnapMirror restore operations restore the entire contents of a Snapshot copy from one volume to another volume. A SnapMirror relationship of type RST is created from the source volume to the destination volume by the `snapmirror restore` command. This relationship lasts for the duration of the restore operation and is deleted when the command completes successfully.

When using `snapmirror restore` to recover from a backup, the entire FlexGroup volume is restored, similarly to Snapshot restore. Again, keep in mind the following:

- Individual member volumes cannot be restored.
- Single-file SnapRestore (using ONTAP CLI or GUI) is not supported, but users can restore single files from clients using the Previous Version tab in CIFS/SMB or the `.snapshot` directory in NFS.
- When an RW volume is converted to a DP volume and reverted to RW, any data accumulated beyond the latest Snapshot copy is lost. Before restoring a SnapMirror volume, take a new Snapshot copy on the primary volume to avoid data loss.

### Expanding a FlexGroup Volume/Adding New Member Volumes

Volume expansion can be used to increase the number of member volumes in a FlexGroup volume to add capacity and scale out a volume across multiple nodes in a cluster.

The `volume expand` command does not work natively with FlexGroup volumes participating in SnapMirror relationships earlier than ONTAP 9.3, because those required a rebaseline of the SnapMirror relationship. ONTAP 9.3 introduced the enhancement to allow volume expansion on FlexGroup volumes participating in a SnapMirror relationship without the need to rebaseline. As of ONTAP 9.3, ONTAP adjusts the FlexGroup member volume count on the next SnapMirror update.

**Note:** NetApp recommends upgrading to ONTAP 9.3 when using SnapMirror with FlexGroup volumes.

### Expanding FlexGroup Volumes in SnapMirror Relationships Prior to ONTAP 9.3

To expand a volume (to add more members) in a SnapMirror relationship prior to ONTAP 9.3, perform the following steps:

1. Perform `snapmirror delete` of the existing relationship on the destination.
2. Perform `snapmirror release` on the source.
3. Perform `volume delete` of the destination FlexGroup DP volume.
4. Perform `volume expand` of the source FlexGroup volume.



5. Perform `volume create` of a new destination FlexGroup DP volume with same size and constituent count as the source FlexGroup volume.
6. Perform `snapmirror initialize` of the new relationship (rebaseline).

Growing the member volumes without needing to rebaseline the relationship is supported with SnapMirror and FlexGroup.

### FlexGroup SnapMirror Guidelines

- The guidelines for Snapshot copies also apply to SnapMirror. Partial Snapshot copies fail the entire operation. Snapshot copies are taken as a group. Access is fenced off for no longer than 10 seconds.
- FlexGroup volumes that are being copied using SnapMirror must have an equal number of member volumes on source and destination.
- Prior to ONTAP 9.3, if a FlexGroup volume is expanded to include more members, the SnapMirror relationship must be rebaselined using a new secondary FlexGroup volume with the correct number of member volumes. After ONTAP 9.3, ONTAP handles the SnapMirror relationship adjustment.
- Destination FlexGroup volumes can be larger than source volumes, but cannot be smaller.
- Destination FlexGroup volumes can reside on any supported ONTAP architecture, regardless of hardware, provided the capacity and member volume requirements are met. For example, a FlexGroup volume that lives on a four-node A700 cluster can be mirrored to a single-node FAS2600 series node as long as it has the same number of member volumes.
- SnapMirror supports only 32 member volumes (up to ~3PB) per FlexGroup volume and 100 member volumes per cluster prior to ONTAP 9.4. ONTAP 9.4 and later supports up to 200 member volumes per FlexGroup volume, with no clusterwide limit, provided the SnapMirror schedules are staggered.
- For optimal results, SnapMirror schedule intervals should not be less than 30 minutes.

### How SVM Disaster Recovery(DR) Behaves When FlexGroup Volumes Are Present

If you are currently leveraging SVM DR in your cluster, you cannot use FlexGroup volumes in the same SVM. Additionally, if you try to create an SVM DR relationship in an SVM where FlexGroup volumes are present, the command fails with the following error:

```
Error: command failed: A Vserver DR relationship between Vserver "DEMO" and Vserver "DEMO-DR" is not supported because they are on the same cluster "ontap9-tme-8040".
```

If you want to use FlexGroup volumes with a cluster using SVM DR, create a new SVM for the FlexGroup volumes.

## 4 Backing Up FlexGroup Volumes

NetApp ONTAP FlexGroup volumes do not support NDMP, mainly because of the inability for NDMP to discern between what a file is and what a remote hardlink is in ONTAP. Therefore, there are three main methods to back up FlexGroup volumes.

### NAS-Based Backups

One way to back up a FlexGroup volume is to use CIFS/SMB or NFS protocols to copy files. However, in high-file count environments, this approach can take a long time and can add undue stress on a cluster as the backup utility crawls the files and metadata. Therefore, if using a NAS-based backup solution, either back up the file system in off hours or run the backups on a replica of the file system, such as on a SnapMirror and SnapVault destination. If NDMP-to-tape backups are required, copy the FlexGroup files to back up into a FlexVol volume and use NDMP to back up from the FlexVol volume.

### SnapMirror and SnapVault

As previously mentioned, FlexGroup volumes support both SnapMirror and SnapVault replication technologies. SnapMirror is more suitable for disaster recovery. SnapVault is used to keep asynchronous Snapshot copies on a destination system and is a better fit for a backup solution. ONTAP uses the same license and replication engine for both technologies, making management of relationships simpler.

## Additional Resources

- TR-4015: SnapMirror Configuration and Best Practices Guide  
[www.netapp.com/us/media/tr-4015.pdf](http://www.netapp.com/us/media/tr-4015.pdf)
- TR-4557: NetApp FlexGroup Volume Technical Overview  
[www.netapp.com/us/media/tr-4557.pdf](http://www.netapp.com/us/media/tr-4557.pdf)
- TR-4571: NetApp FlexGroup Volume Best Practice Guide  
[www.netapp.com/us/media/tr-4571.pdf](http://www.netapp.com/us/media/tr-4571.pdf)

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