Abstract

This document covers data protection and backup, specifically for NetApp® FlexGroup volumes. Topics include NetApp Snapshot™ copies, SnapMirror®, and other data protection and backup solutions. For data protection best practices pertaining to NetApp 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 on the NetApp product documentation pages.

Information Classification

Public
TABLE OF CONTENTS

1 Overview ................................................................................................................................................ 3
  1.1 Document Scope ...............................................................................................................................3
  1.2 Intended Audience .............................................................................................................................3
  1.3 Data Protection Terminology ...........................................................................................................3
  1.4 Data Protection Features with NetApp FlexGroup Volumes .............................................................6

2 Snapshot Copies with FlexGroup Volumes ....................................................................................... 6

3 SnapMirror and SnapVault with FlexGroup Volumes ....................................................................... 8

4 MetroCluster ....................................................................................................................................... 19

5 Backing Up FlexGroup Volumes ....................................................................................................... 19

6 FlexGroups as a Backup Repository: Customer Success Stories ............................................. 19

Where to Find Additional Information ............................................................................................. 24

Version History .................................................................................................................................... 24

Contact Us ........................................................................................................................................... 24

LIST OF TABLES

Table 1) Data protection features: NetApp FlexGroup volumes ...........................................................6
Table 2) Snapshot feature support with NetApp FlexGroup volumes ................................................7
Table 3) SnapMirror feature support with NetApp FlexGroup volumes ............................................8

LIST OF FIGURES

Figure 1) FlexGroup volume ..................................................................................................................4
Figure 2) Snapshot copies in FlexGroup volumes ..............................................................................7
Figure 3) SnapMirror versus SnapVault with FlexGroup volumes ....................................................10
Figure 4) Protecting a FlexGroup volume during deployment ............................................................13
Figure 5) Protecting a FlexGroup volume during deployment (advanced features) .........................13
Figure 6) Viewing unprotected volumes ............................................................................................14
Figure 7) Creating manual filters for protection relationships in System Manager .............................14
Figure 8) Protecting an existing FlexGroup volume ..........................................................................14
Figure 9) Protecting an existing FlexGroup volume: protect volumes ..........................................15
Figure 10) Protecting an existing FlexGroup volume: validate ........................................................15
Figure 11) Oracle RMAN backup to FlexGroup/Conversion/Migration to Cloud Workflow ..............21
Figure 12) FlexGroup volume design ..................................................................................................21
Figure 13) SQL Server Backup environment .....................................................................................22
Figure 14) Throughput and total operations during test runs .............................................................22
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 Data ONTAP® operating in 7-Mode. See the section Where to Find Additional Information for links to documents covering nonFlexGroup 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.

SVM

A storage virtual machine (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 LIFs.
- Each SVM has a root volume under which more volumes are mounted, extending the namespace.
- It can span several physical nodes.
- It is associated with one or more LIFs; clients access the data on the virtual server through the logical interfaces, which can live on any node in the cluster.

LIF

A LIF is essentially an IP address with associated characteristics such as a home port, failover ports, 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 enables near-zero-space, exact, writable virtual copies of datasets, including volumes, files, and LUNs. It offers rapid, space-efficient creation of extra data copies ideally suited for disaster recovery testing and test and development environments.

FlexGroup Volumes

FlexGroup volumes was introduced in ONTAP 9.1. 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 enables a true scale-out NAS file system that is able to use all resources in a cluster while blending capacity, performance, and simplicity in its deployment.

For more information regarding FlexGroup volumes, see TR-4557: FlexGroup Volume Technical Overview.

Logical Directory Replication/Unified Replication

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 provides 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. Snapshot copies can also be triggered manually.

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 with version independent SnapMirror, allows a single destination volume to serve as both a backup and disaster recovery copy.

Recovery Point Objective

Recovery point objective (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

Recovery time objective (RTO) refers to the amount of downtime that is deemed as acceptable in disaster recovery scenarios.

Version-Independence/Version-Flexibility with Data Protection

SnapMirror XDP offers the ability to replicate between ONTAP clusters that differ in 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 more feature support for NetApp FlexGroup volumes.

Table 1) Data protection features: NetApp FlexGroup volumes.

<table>
<thead>
<tr>
<th>Data Protection Feature/Software</th>
<th>First Supported ONTAP Version</th>
</tr>
</thead>
<tbody>
<tr>
<td>Snapshot copies</td>
<td>ONTAP 9.1</td>
</tr>
<tr>
<td>SnapRestore</td>
<td>ONTAP 9.1 (diagnostic privilege only)</td>
</tr>
<tr>
<td>Single-file SnapRestore (through ONTAP CLI)</td>
<td>N/A</td>
</tr>
<tr>
<td>Microsoft Windows Previous Versions tab</td>
<td>ONTAP 9.1</td>
</tr>
<tr>
<td>SnapMirror (data protection)</td>
<td>N/A</td>
</tr>
<tr>
<td>SnapVault</td>
<td>ONTAP 9.3</td>
</tr>
<tr>
<td>MirrorVault</td>
<td>ONTAP 9.3</td>
</tr>
<tr>
<td>Logical directory replication (XDP)</td>
<td>ONTAP 9.1</td>
</tr>
<tr>
<td>Version-independence/version-flexibility</td>
<td>ONTAP 9.1</td>
</tr>
<tr>
<td>Qtree SnapMirror</td>
<td>N/A</td>
</tr>
<tr>
<td>NDMP</td>
<td>N/A</td>
</tr>
<tr>
<td>NetApp SnapProtect®</td>
<td>N/A</td>
</tr>
<tr>
<td>NetApp SnapManager®</td>
<td>N/A</td>
</tr>
<tr>
<td>NetApp SnapCenter®</td>
<td>N/A</td>
</tr>
<tr>
<td>SVM DR</td>
<td>N/A (see SVM DR section of this document for details)</td>
</tr>
<tr>
<td>SnapMirror to NetApp Cloud Backup (formerly AltaVault)</td>
<td>N/A</td>
</tr>
<tr>
<td>MetroCluster™</td>
<td>ONTAP 9.6</td>
</tr>
<tr>
<td>XCP</td>
<td>All versions of ONTAP</td>
</tr>
<tr>
<td>1,023 NetApp Snapshot™ support</td>
<td>N/A</td>
</tr>
<tr>
<td>SnapMirror Synchronous</td>
<td>N/A</td>
</tr>
</tbody>
</table>

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 all together using the `snap restore` command (with a valid SnapRestore license). The `snap restore` command is only available at diagnostic privilege level 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>
<thead>
<tr>
<th>Snapshot Feature/Functionality</th>
<th>Supported?</th>
<th>ONTAP Version First Supported</th>
</tr>
</thead>
<tbody>
<tr>
<td>Snapshot create</td>
<td>Yes</td>
<td>9.0</td>
</tr>
<tr>
<td>Snapshot restore (diagnostic level only)</td>
<td>Yes</td>
<td>9.0</td>
</tr>
<tr>
<td>Single file SnapRestore from CLI</td>
<td>No</td>
<td>N/A</td>
</tr>
<tr>
<td>Previous Versions tab</td>
<td>Yes</td>
<td>9.1RC2</td>
</tr>
<tr>
<td><code>.snapshot</code> directory access</td>
<td>Yes</td>
<td>9.0</td>
</tr>
<tr>
<td>Support for 1,023 Snapshot copies</td>
<td>No</td>
<td>N/A (FlexVol support in 9.4)</td>
</tr>
</tbody>
</table>

### 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. 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 one second, depending on load on the system. If a Snapshot copy takes more than 10 seconds to complete, it fails.
Snapshot creation failures

If a Snapshot creation fails, ONTAP will log an event management system (EMS) error message:

```
wafl.snap.create.skip.reason: volume X skipping creation of daily.Y snapshot copy (snapshot creation could not be initiated within ten seconds).
```

This error generally happens when a Snapshot copy cannot finish in the 10 second timeout period. The 10 second value is not configurable.

To avoid scenarios that can cause Snapshot copies to fail due to timeouts, consider the following best practices.

- Avoid creating Snapshot copies during scheduled RAID scrub windows.
- Avoid creating Snapshot copies on a FlexGroup volume when other volumes are experiencing peak workloads.
- If a cluster has multiple FlexGroup volumes, stagger the scheduled Snapshot copy creation not to occur simultaneously.
- Make an attempt at keeping the node’s CPU level between 40-70%.

If the issue persists, contact technical support for assistance.

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 automatically 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 effect 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 Logical Replication with Storage Efficiency (LRSE)/extended 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>
<thead>
<tr>
<th>SnapMirror Feature/Functionality</th>
<th>Supported?</th>
<th>ONTAP Version First Supported</th>
</tr>
</thead>
<tbody>
<tr>
<td>SnapMirror (block/DP)</td>
<td>No</td>
<td>N/A</td>
</tr>
<tr>
<td>SnapMirror (logical/XDP)</td>
<td>Yes</td>
<td>9.1RC1</td>
</tr>
<tr>
<td>SnapMirror Feature/Functionality</td>
<td>Supported?</td>
<td>ONTAP Version First Supported</td>
</tr>
<tr>
<td>---------------------------------------------------------------------</td>
<td>------------</td>
<td>-------------------------------</td>
</tr>
<tr>
<td>Version-flexible SnapMirror</td>
<td>Yes</td>
<td>9.1RC1</td>
</tr>
<tr>
<td>Qtree SnapMirror</td>
<td>No</td>
<td>Supported only in Data ONTAP operating in 7-Mode</td>
</tr>
<tr>
<td>SnapVault</td>
<td>Yes</td>
<td>9.3RC1</td>
</tr>
<tr>
<td>SnapLock®</td>
<td>No</td>
<td>N/A</td>
</tr>
<tr>
<td>Storage virtual machine disaster recovery (SVM DR)</td>
<td>No</td>
<td>N/A</td>
</tr>
<tr>
<td>Load-sharing mirrors (LS) (Data I/O)</td>
<td>No</td>
<td>N/A</td>
</tr>
<tr>
<td>Cascading SnapMirror relationships</td>
<td>No</td>
<td>N/A</td>
</tr>
<tr>
<td>FlexGroup expansion without SnapMirror rebaseline</td>
<td>Yes</td>
<td>9.3RC1</td>
</tr>
<tr>
<td>SnapMirror to Cloud Backup</td>
<td>No</td>
<td>N/A</td>
</tr>
<tr>
<td>NetApp SolidFire® to ONTAP SnapMirror</td>
<td>No</td>
<td>N/A</td>
</tr>
<tr>
<td>Unified SnapMirror and MirrorVault</td>
<td>Yes</td>
<td>9.3RC1</td>
</tr>
<tr>
<td>SnapMirror Synchronous</td>
<td>No</td>
<td>N/A</td>
</tr>
</tbody>
</table>

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 as follows:

- **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 archival use cases by providing a path to Snapshot copies older than what might exist on the source volume.
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 applying 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. Before 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 that the SVM and/or clusters are peered. See the SnapMirror documentation for more information about peering.
2. Create a destination volume with type data protection 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 relationship.
5. Initialize SnapMirror and SnapVault.
6. Select a Snapshot policy and label.
7. Create a schedule, a snapshot policy, and snapshot schedule.
8. Attach the schedule to the SnapMirror relationship.
Using “Protect” with FlexGroup Volumes in NetApp ONTAP System Manager

ONTAP 9.4 introduced the ability to use the robust “protect” functionality of System Manager 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 storage virtual machines (SVMs) to do a local SnapMirror configuration.

2. 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.
Cluster Peering
If you plan on implementing intercluster SnapMirror, cluster peering is needed. In ONTAP 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.

Protecting a New FlexGroup Volume
When a new FlexGroup volume is created, storage administrators can easily protect the volume with a SnapMirror or SnapVault relationship, provided the cluster has been peered successfully with another cluster.

Note: Both clusters must have a SnapMirror license.
After the “Create” button is clicked, ONTAP 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.

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 regarding 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 data protection status, which fences off RW access to the volumes and maintains consistency in the volumes. Resyncs might 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 during 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, similar 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 data protection 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 commands 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 or later 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 earlier than 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 data protection volume.
4. Perform `volume expand` of the source FlexGroup volume.
5. Perform `volume create` of a new destination FlexGroup data protection volume with same size and constituent count as the source FlexGroup volume.

Growing the member volumes without needing to rebaseline the relationship is supported with SnapMirror and FlexGroup as of ONTAP 9.3.

**FlexGroup SnapMirror Guidelines**

- The guidelines for Snapshot copies also apply to SnapMirror. Partial Snapshot copies fail the entire snapshot 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 NetApp AFF A700 all-flash storage system cluster can be mirrored to a single-node FAS2600 series node as long as it has the same number of member volumes.
- For optimal results, SnapMirror schedule intervals should not be less than 30 minutes.

<table>
<thead>
<tr>
<th>Member Volume Count Limits for FlexGroup volumes participating in SnapMirror relationships</th>
<th>&lt; ONTAP 9.4</th>
<th>&gt; ONTAP 9.5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Member volume count</td>
<td>32</td>
<td>200</td>
</tr>
<tr>
<td>Member volume count per node*</td>
<td>N/A</td>
<td>50</td>
</tr>
<tr>
<td>Member volume count per node (multiple FlexGroup volumes)**</td>
<td>N/A</td>
<td>500</td>
</tr>
<tr>
<td>Member volume count per cluster (all FlexGroup volumes)**</td>
<td>100</td>
<td>6,000</td>
</tr>
</tbody>
</table>

* Exceeding this limit can affect RPO.

** Same limits as FlexVol volumes

**How SVM Disaster Recovery Behaves When FlexGroup Volumes Are Present**

If you are currently using SVM disaster recovery in your cluster, you cannot use FlexGroup volumes in the same SVM. Also, if you try to create an SVM disaster recovery relationship in an SVM where FlexGroup volumes are present, the command fails with an error. If you want to use FlexGroup volumes with a cluster using SVM disaster recovery, create an SVM for the FlexGroup volumes.
4 MetroCluster

ONTAP 9.6 introduces support for FlexGroups on MetroCluster deployments (FC and IP).

MetroCluster software is a solution that combines array-based clustering with synchronous replication to deliver continuous availability and zero data loss at the lowest cost. There are no stated limitations or caveats for FlexGroup volumes with MetroCluster.

For more information about MetroCluster, see TR-4705: NetApp MetroCluster Solution Design and Architecture.

5 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 you are using a NAS-based backup solution, either back up the file system during off-peak hours or else run the backups on a replica of the file system. For example run the backups on a SnapMirror and SnapVault destination. Some backup vendors provide interaction with ONTAP APIs that can make backups faster and more efficient. Check with your backup vendor for information about the level of support provided with ONTAP systems and FlexGroup volumes.

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.

6 FlexGroups as a Backup Repository: Customer Success Stories

FlexGroup volumes are being used in various ways. A common use case for FlexGroup volumes is using one as a backup repository. Due to its ability to spread performance and capacity across cluster nodes, and providing a viable single namespace, FlexGroup volumes provide an excellent way to store archival data.

The following section covers two different customer success stories, where FlexGroup volumes are playing a pivotal role in providing a high-performing, resilient, backup target.

Use Case 1: Backing up Oracle RMAN Databases

This customer is running a large Oracle database on AIX and is looking to migrate the database to PostGRES SQL Server in the cloud to reduce costs of maintenance and storage. Some of the challenges this customer is facing for this migration are:

Immensely capacity needs
The database is 890TB (and growing around 10TB per month) and must be staged to a single namespace.

**Converting from legacy application to modern application.**

The source database is running on AIX, which is Big Endian. The target application will be running Little Endian. The database has to be dumped, converted, and then moved to the cloud.

**Must remain online during migration.**

The database must remain running during the migration, with a small cutover window. Incremental updates of changes will be needed as the conversion/migration occurs.

**Backup/Conversion/Migration Steps**

The following steps occur when completing the migration task of a database that is greater than 800TB.

- AIX server performs an RMAN backup of the database to an NFS file system. The NFS file system is a FlexGroup. It is necessary to use a FlexGroup because RMAN needs one mount point to direct the RMAN dump and it needs to support >100TB. FlexGroup works well because RMAN can generate output in parallel to several target files which are spread across four aggregates on two controllers. Transfer speed is important and FlexGroup helps with that by using parallel operations and load balancing across nodes and aggregates.

- A Linux server performs The Big Endian to Little Endian conversion; an NFS mount is required. The conversion ends up as a Little-Endian database on a FC LUN.

- The converted database is then replicated to a second NetApp array (array 2). After the initial dump of the database has been confirmed and fully replicated to array-2, array-2 is shipped to an Equinix data center and direct-connected to Amazon Web Services (AWS).

- The process repeats several times except it is RMAN Level-1 dumps (incrementals) which are dumped, converted, and replicated to the array-2 in Equinix. A final incremental is processed and the database is shut down on the AIX system and brought up on the PostGRES SQL Server system in AWS.
Use Case 2: Backing up SQL Server Databases

In this environment, the customer wanted to perform compressed backups of 5,000 Microsoft SQL servers over SMB. This test was done with approximately 200 servers to vet out the solution, with a slow ramp up over the course of a few months.

But this database isn’t only a backup target – it will also be replicated to a disaster recovery site using SnapMirror for extra data protection.
Each site has a 6-node FAS8200 cluster running ONTAP 9.4 using 6TB near-line SAS (NL-SAS) encrypted drives. Each cluster holds 3PB of usable capacity. The clusters use 30 FlexGroup volumes and use qtrees within the volumes for data organization.

The FlexGroup volumes are 64TB each and the member volumes are 2.6TB apiece, with four members per node across six nodes (24 total members per FlexGroup volume).

Results

This customer needed a single namespace that could collect ~150TB worth of MSSQL backup data over a 12-hour period. That's ~12TB/hour at ~3.5GB per second.

During testing we used 222 servers at site A and 171 servers at site B. During the test, each cluster's CPU was at 95% utilization and the backup jobs (sequential writes) were able to accomplish approximately 8.4GB per second, which is ~2.4x the amount of throughput the job needed. At this rate, the backups could complete in approximately ~5 hours, rather than the 12-hour window. Also, this SMB workload performed approximately 120,000 IOPS. When more clients are added to this workload, we expect the throughput to max out at around 9GB per second.
Data Protection

In addition to the performance seen on the FlexGroup for the production workload, this customer was also able to achieve a high rate of transfer for the SnapMirror relationships between sites – 8.4GB per second for the SnapMirror transfer. This means that the replication window for a 150TB dataset would be about 5.5 hours for the initial transfer. After that, the deltas should be able to complete well within the required transfer window, providing a solid disaster recovery plan for these MSSQL backups.

Scale Out Performance

This 6-node cluster was able to push over 8.4GB per second to a FlexGroup volume. In our Customer Proof of Concept labs, we’ve seen near-linear performance gains by adding nodes to a cluster. The following graphs show throughput results for a single node NetApp AFF A700 and a 2-node AFF A700.

Figure 15) CPOC scale-out throughput results.

Note: If you want to add more performance to your backup workload, you can add more nodes.

Conclusion

Not only is a FlexGroup volume great for small or high file count workloads such as EDA and software builds, but it also can handle high throughput requirements for larger streaming files. It also reduces backup windows by scaling out storage across multiple nodes and applies all your cluster resources while maintaining performance even with spinning disk.
Where to Find Additional Information

To learn more about the information described in this document, refer to the following documents and/or websites:

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

Version History

<table>
<thead>
<tr>
<th>Version</th>
<th>Date</th>
<th>Document Version History</th>
</tr>
</thead>
<tbody>
<tr>
<td>Version 1.0</td>
<td>April 2018</td>
<td>First edition.</td>
</tr>
<tr>
<td>Version 2.0</td>
<td>November 2018</td>
<td>ONTAP 9.5</td>
</tr>
<tr>
<td>Version 2.1</td>
<td>June 2019</td>
<td>ONTAP 9.6</td>
</tr>
</tbody>
</table>

Contact Us

Let us know how we can improve this technical report.
Contact us at docfeedback@netapp.com.
Include TECHNICAL REPORT 4678 in the subject line.
Refer to the Interoperability Matrix Tool (IMT) on the NetApp Support site to validate that the exact product and feature versions described in this document are supported for your specific environment. The NetApp IMT defines the product components and versions that can be used to construct configurations that are supported by NetApp. Specific results depend on each customer’s installation in accordance with published specifications.

Copyright Information

Copyright © 2019 NetApp, Inc. All Rights Reserved. Printed in the U.S. No part of this document covered by copyright may be reproduced in any form or by any means—graphic, electronic, or mechanical, including photocopying, recording, taping, or storage in an electronic retrieval system—without prior written permission of the copyright owner.

Software derived from copyrighted NetApp material is subject to the following license and disclaimer:

THIS SOFTWARE IS PROVIDED BY NETAPP “AS IS” AND WITHOUT ANY EXPRESS OR IMPLIED WARRANTIES, INCLUDING, BUT NOT LIMITED TO, THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE, WHICH ARE HEREBY DISCLAIMED. IN NO EVENT SHALL NETAPP BE LIABLE FOR ANY DIRECT, INDIRECT, INCIDENTAL, SPECIAL, EXEMPLARY, OR CONSEQUENTIAL DAMAGES (INCLUDING, BUT NOT LIMITED TO, PROCUREMENT OF SUBSTITUTE GOODS OR SERVICES; LOSS OF USE, DATA, OR PROFITS; OR BUSINESS INTERRUPTION) HOWEVER CAUSED AND ON ANY THEORY OF LIABILITY, WHETHER IN CONTRACT, STRICT LIABILITY, OR TORT (INCLUDING NEGLIGENCE OR OTHERWISE) ARISING IN ANY WAY OUT OF THE USE OF THIS SOFTWARE, EVEN IF ADVISED OF THE POSSIBILITY OF SUCH DAMAGE.

NetApp reserves the right to change any products described herein at any time, and without notice. NetApp assumes no responsibility or liability arising from the use of products described herein, except as expressly agreed to in writing by NetApp. The use or purchase of this product does not convey a license under any patent rights, trademark rights, or any other intellectual property rights of NetApp.

The product described in this manual may be protected by one or more U.S. patents, foreign patents, or pending applications.

Data contained herein pertains to a commercial item (as defined in FAR 2.101) and is proprietary to NetApp, Inc. The U.S. Government has a non-exclusive, non-transferrable, non-sublicensable, worldwide, limited irrevocable license to use the Data only in connection with and in support of the U.S. Government contract under which the Data was delivered. Except as provided herein, the Data may not be used, disclosed, reproduced, modified, performed, or displayed without the prior written approval of NetApp, Inc. United States Government license rights for the Department of Defense are limited to those rights identified in DFARS clause 252.227-7015(b).

Trademark Information

NETAPP, the NETAPP logo, and the marks listed at http://www.netapp.com/TM are trademarks of NetApp, Inc. Other company and product names may be trademarks of their respective owners.