



Disk and tier (aggregate) management

ONTAP 9

NetApp
March 08, 2024

Table of Contents

- Disk and tier (aggregate) management 1
 - Disks and local tiers (aggregates) overview. 1
 - Manage local tiers (aggregates). 2
 - Manage disks 39
 - Manage RAID configurations 65
 - Manage Flash Pool local tiers (aggregates). 70

Disk and tier (aggregate) management

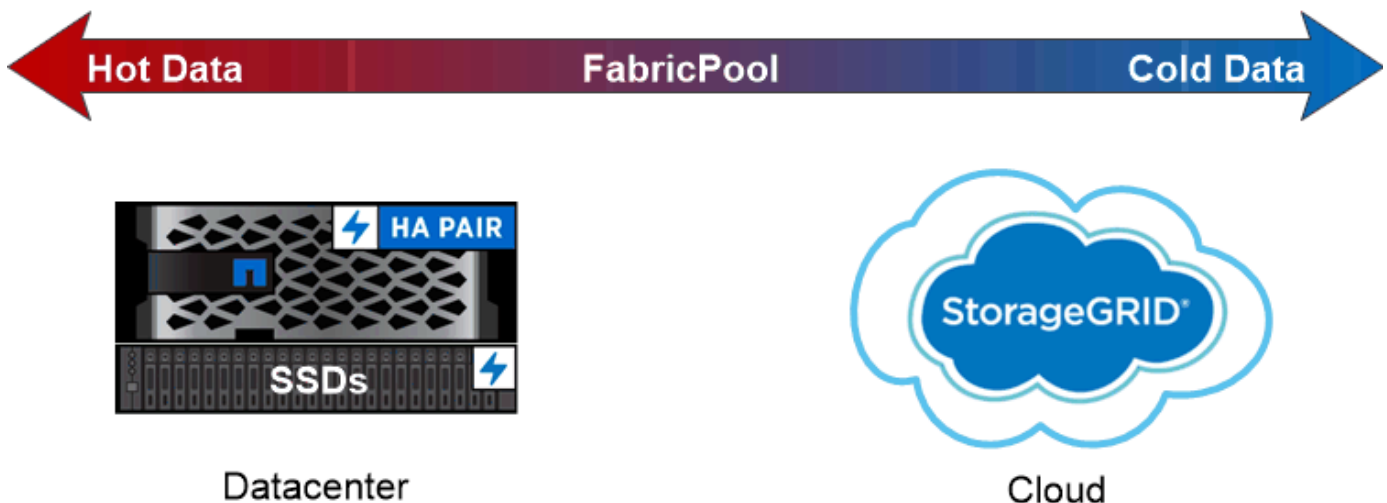
Disks and local tiers (aggregates) overview

You can manage ONTAP physical storage using System Manager and the CLI. You can create, expand, and manage local tiers (aggregates), work with Flash Pool local tiers (aggregates), manage disks, and manage RAID policies.

What local tiers (aggregates) are

Local tiers (also called *aggregates*) are containers for the disks managed by a node. You can use local tiers to isolate workloads with different performance demands, to tier data with different access patterns, or to segregate data for regulatory purposes.

- For business-critical applications that need the lowest possible latency and the highest possible performance, you might create a local tier consisting entirely of SSDs.
- To tier data with different access patterns, you can create a *hybrid local tier*, deploying flash as high-performance cache for a working data set, while using lower-cost HDDs or object storage for less frequently accessed data.
 - A *Flash Pool* consists of both SSDs and HDDs.
 - A *FabricPool* consists of an all-SSD local tier with an attached object store.
- If you need to segregate archived data from active data for regulatory purposes, you can use a local tier consisting of capacity HDDs, or a combination of performance and capacity HDDs.



You can use a FabricPool to tier data with different access patterns, deploying SSDs for frequently accessed “hot” data and object storage for rarely accessed “cold” data.

Working with local tiers (aggregates)

You can perform the following tasks:

- [Manage local tiers \(aggregates\)](#)
- [Manage disks](#)
- [Manage RAID configurations](#)
- [Manage Flash Pool tiers](#)

You perform these tasks if the following are true:

- You do not want to use an automated scripting tool.
- You want to use best practices, not explore every available option.
- You have a MetroCluster configuration and you are following the procedures in the [MetroCluster](#) documentation for initial configuration and guidelines for local tiers (aggregates) and disk management.

Related information

- [Manage FabricPool cloud tiers](#)

Manage local tiers (aggregates)

Manage local tiers (aggregates)

You can use System Manager or the ONTAP CLI to add local tiers (aggregates), manage their usage, and add capacity (disks) to them.

You can perform the following tasks:

- [Add \(create\) a local tier \(aggregate\)](#)

To add a local tier, you follow a specific workflow. You determine the number of disks or disk partitions that you need for the local tier and decide which method to use to create the local tier. You can add local tiers automatically by letting ONTAP assign the configuration, or you can manually specify the configuration.

- [Manage the use of local tiers \(aggregates\)](#)

For existing local tiers, you can rename them, set their media costs, or determine their drive and RAID group information. You can modify the RAID configuration of a local tier and assign local tiers to storage VMs (SVMs). You can modify the RAID configuration of a local tier and assign local tiers to storage VMs (SVMs). You can determine which volumes reside on a local tier and how much space they use on a local tier. You can control how much space that volumes can use. You can relocate local tier ownership with an HA pair. You can also delete a local tier.

- [Add capacity \(disks\) to a local tier \(aggregate\)](#)

Using different methods, you follow a specific workflow to add capacity. You can add disks to a local tier and add drives to a node or shelf. If needed, you can correct misaligned spare partitions.

Add (create) a local tier (aggregate)

Add a local tier (create an aggregate)

To add a local tier (create an aggregate), you follow a specific workflow.

You determine the number of disks or disk partitions that you need for the local tier and decide which method to use to create the local tier. You can add local tiers automatically by letting ONTAP assign the configuration, or you can manually specify the configuration.

- [Workflow to add a local tier \(aggregate\)](#)
- [Determine the number of disks or disk partitions required for a local tier \(aggregate\)](#)
- [Decide which local tier \(aggregate\) creation method to use](#)
- [Add local tiers \(aggregates\) automatically](#)
- [Add local tiers \(aggregates\) manually](#)

Workflow to add a local tier (aggregate)

Creating local tiers (aggregates) provides storage to volumes on your system.

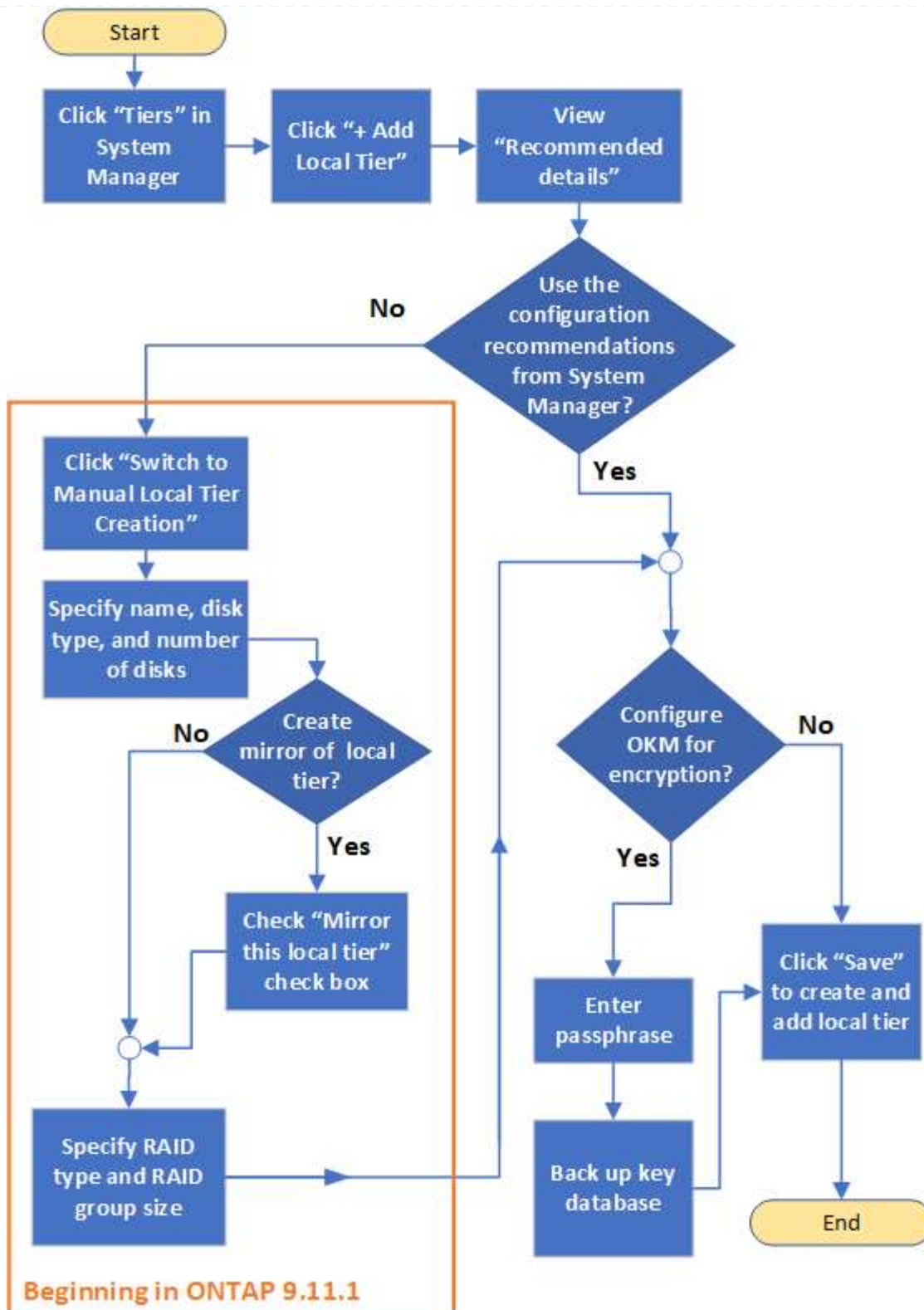
The workflow for creating local tiers (aggregates) is specific to the interface you use—System Manager or the CLI:

System Manager workflow

Use System Manager to add (create) a local tier

System Manager creates local tiers based on recommended best practices for configuring local tiers.

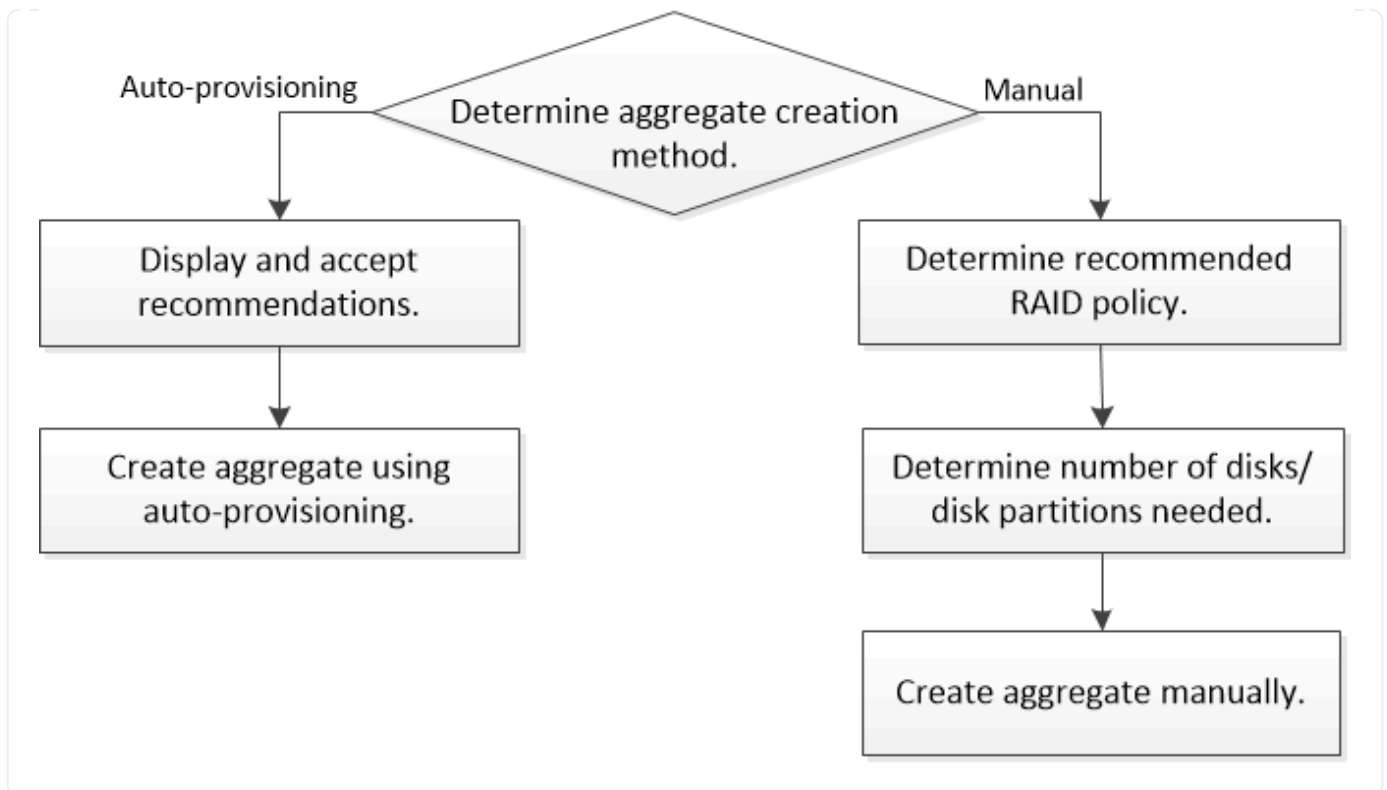
Beginning with ONTAP 9.11.1, you can decide to configure local tiers manually if you want a different configuration than the one recommended during the automatic process to add a local tier.



CLI workflow

Use the CLI to add (create) an aggregate

Beginning with ONTAP 9.2, ONTAP can provide recommended configurations when you create aggregates (auto-provisioning). If the recommended configurations, based on best practices, are appropriate in your environment, you can accept them to create the aggregates. Otherwise, you can create aggregates manually.



Determine the number of disks or disk partitions required for a local tier (aggregate)

You must have enough disks or disk partitions in your local tier (aggregate) to meet system and business requirements. You should also have the recommended number of hot spare disks or hot spare disk partitions to minimize the potential of data loss.

Root-data partitioning is enabled by default on certain configurations. Systems with root-data partitioning enabled use disk partitions to create local tiers. Systems that do not have root-data partitioning enabled use unpartitioned disks.

You must have enough disks or disk partitions to meet the minimum number required for your RAID policy and enough to meet your minimum capacity requirements.



In ONTAP, the usable space of the drive is less than the physical capacity of the drive. You can find the usable space of a specific drive and the minimum number of disks or disk partitions required for each RAID policy in the [Hardware Universe](#).

Determine usable space of a specific disk


The procedure you follow depends on the interface you use—System Manager or the CLI:

System Manager

Use System Manager to determine usable space of disks

Perform the following steps to view the usable size of a disk:

Steps

1. Go to **Storage > Tiers**
2. Click  next to the name of the local tier.
3. Select the **Disk Information** tab.

CLI

Use the CLI to determine usable space of disks

Perform the following step to view the usable size of a disk:

Step

1. Display spare disk information:

```
storage aggregate show-spare-disks
```

In addition to the number of disks or disk partitions necessary to create your RAID group and meet your capacity requirements, you should also have the minimum number of hot spare disks or hot spare disk partitions recommended for your aggregate:

- For all flash aggregates, you should have a minimum of one hot spare disk or disk partition.



The AFF C190 defaults to no spare drive. This exception is fully supported.

- For non-flash homogenous aggregates, you should have a minimum of two hot spare disks or disk partitions.
- For SSD storage pools, you should have a minimum of one hot spare disk for each HA pair.
- For Flash Pool aggregates, you should have a minimum of two spare disks for each HA pair. You can find more information on the supported RAID policies for Flash Pool aggregates in the [Hardware Universe](#).
- To support the use of the Maintenance Center and to avoid issues caused by multiple concurrent disk failures, you should have a minimum of four hot spares in multi-disk carriers.

Related information

[NetApp Hardware Universe](#)

[NetApp Technical Report 3838: Storage Subsystem Configuration Guide](#)

Decide which method to use to create local tiers (aggregates)

Although ONTAP provides best-practice recommendations for adding local tiers automatically (creating aggregates with auto-provisioning), you must determine whether the recommended configurations are supported in your environment. If they are not, you must make decisions about RAID policy and disk configuration and then create the local

tiers manually.

When a local tier is created automatically, ONTAP analyzes available spare disks in the cluster and generates a recommendation about how spare disks should be used to add local tiers according to best practices. ONTAP displays the recommended configurations. You can accept the recommendations or add the local tiers manually.

Before you can accept ONTAP recommendations

If any of the following disk conditions are present, they must be addressed before accepting the recommendations from ONTAP:

- Missing disks
- Fluctuation in spare disk numbers
- Unassigned disks
- Non-zeroed spares
- Disks undergoing maintenance testing

The `storage aggregate auto-provision man` page contains more information about these requirements.

When you must use the manual method

In many cases, the recommended layout of the local tier will be optimal for your environment. However, if your cluster is running ONTAP 9.1 or earlier, or your environment includes the following configurations, you must create the local tier using the manual method.



Beginning with ONTAP 9.11.1, you can manually add local tiers with System Manager.

- Aggregates using third-party array LUNs
- Virtual disks with Cloud Volumes ONTAP or ONTAP Select
- MetroCluster system
- SyncMirror
- MSATA disks
- FlashPool tiers (aggregates)
- Multiple disk types or sizes are connected to the node

Select the method to create local tiers (aggregates)

Choose which method you want to use:

- [Add \(create\) local tiers \(aggregates\) automatically](#)
- [Add \(create\) local tiers \(aggregates\) manually](#)

Related information

[ONTAP 9 commands](#)

Add local tiers automatically (create aggregates with auto-provisioning)

If the best-practice recommendation that ONTAP provides for automatically adding a local tier (creating an aggregate with auto-provisioning) is appropriate in your environment, you can accept the recommendation and let ONTAP add the local tier.

Before you begin

Disks must be owned by a node before they can be used in a local tier (aggregate). If your cluster is not configured to use automatic disk ownership assignment, you must [assign ownership manually](#).

System Manager

Steps

1. In System Manager, click **Storage > Tiers**.
2. From the **Tiers** page, click [+ Add Local Tier](#) to create a new local tier:

The **Add Local Tier** page shows the recommended number of local tiers that can be created on the nodes and the usable storage available.

3. Click **Recommended details** to view the configuration recommended by System Manager.

System Manager displays the following information beginning with ONTAP 9.8:

- **Local tier name** (you can edit the local tier name beginning with ONTAP 9.10.1)
- **Node name**
- **Usable size**
- **Type of storage**

Beginning with ONTAP 9.10.1, additional information is displayed:

- **Disks:** showing the number, size, and type of the disks
- **Layout:** showing the RAID group layout, including which disks are parity or data and which slots are unused.
- **Spare disks:** showing the node name, the number and size of spare disks, and the type of storage.

4. Perform one of the following steps:

If you want to...	Then do this...
Accept the recommendations from System Manager.	Proceed to the step for configuring the Onboard Key Manager for encryption .
Manually configure the local tiers and not use the recommendations from System Manager.	<p>Proceed to Add a local tier (create aggregate) manually:</p> <ul style="list-style-type: none">• For ONTAP 9.10.1 and earlier, follow the steps to use the CLI.• Beginning with ONTAP 9.11.1, follow the steps to use System Manager.

5. (Optional): If the Onboard Key Manager has been installed, you can configure it for encryption. Check the **Configure Onboard Key Manager for encryption** check box.
 - a. Enter a passphrase.
 - b. Enter the passphrase again to confirm it.
 - c. Save the passphrase for future use in case the system needs to be recovered.
 - d. Back up the key database for future use.
6. Click **Save** to create the local tier and add it to your storage solution.

CLI

You run the `storage aggregate auto-provision` command to generate aggregate layout recommendations. You can then create aggregates after reviewing and approving ONTAP recommendations.

What you'll need

ONTAP 9.2 or later must be running on your cluster.

About this task

The default summary generated with the `storage aggregate auto-provision` command lists the recommended aggregates to be created, including names and usable size. You can view the list and determine whether you want to create the recommended aggregates when prompted.

You can also display a detailed summary by using the `-verbose` option, which displays the following reports:

- Per node summary of new aggregates to create, discovered spares, and remaining spare disks and partitions after aggregate creation
- New data aggregates to create with counts of disks and partitions to be used
- RAID group layout showing how spare disks and partitions will be used in new data aggregates to be created
- Details about spare disks and partitions remaining after aggregate creation

If you are familiar with the auto-provision method and your environment is correctly prepared, you can use the `-skip-confirmation` option to create the recommended aggregate without display and confirmation. The `storage aggregate auto-provision` command is not affected by the CLI session `-confirmations` setting.

The `storage aggregate auto-provision` [man page](#) contains more information about the aggregate layout recommendations.

Steps

1. Run the `storage aggregate auto-provision` command with the desired display options.
 - no options: Display standard summary
 - `-verbose` option: Display detailed summary
 - `-skip-confirmation` option: Create recommended aggregates without display or confirmation
2. Perform one of the following steps:

If you want to...	Then do this...
-------------------	-----------------

Accept the recommendations from ONTAP.

Review the display of recommended aggregates, and then respond to the prompt to create the recommended aggregates.

```
myA400-44556677::> storage aggregate auto-
provision
Node                               New Data Aggregate
Usable Size
-----
-----
myA400-364                         myA400_364_SSD_1
3.29TB
myA400-363                         myA400_363_SSD_1
1.46TB
-----
-----
Total:                             2      new data aggregates
4.75TB

Do you want to create recommended
aggregates? {y|n}: y

Info: Aggregate auto provision has
started. Use the "storage aggregate
      show-auto-provision-progress"
command to track the progress.

myA400-44556677::>
```

Manually configure the local tiers and **not** use the recommendations from ONTAP.

Proceed to [Add a local tier \(create aggregate\) manually](#).

Related information

[ONTAP 9 Commands](#)

Add local tiers (create aggregates) manually

If you do not want to add a local tier (create a aggregate) using the best-practice recommendations from ONTAP, you can perform the process manually.

Before you begin

Disks must be owned by a node before they can be used in a local tier (aggregate). If your cluster is not configured to use automatic disk ownership assignment, you must [assign ownership manually](#).

System Manager

Beginning with ONTAP 9.11.1, if you do not want to use the configuration recommended by System Manager to create a local tier, you can specify the configuration you want.

Steps

1. In System Manager, click **Storage > Tiers**.
2. From the **Tiers** page, click [+ Add Local Tier](#) to create a new local tier:

The **Add Local Tier** page shows the recommended number of local tiers that can be created on the nodes and the usable storage available.

3. When System Manager displays the storage recommendation for the local tier, click **Switch to Manual Local Tier Creation** in the **Spare Disks** section.

The **Add Local Tier** page displays fields that you use to configure the local tier.

4. In the first section of the **Add Local Tier** page, complete the following:
 - a. Enter the name of the local tier.
 - b. (Optional): Check the **Mirror this local tier** check box if you want to mirror the local tier.
 - c. Select a disk type.
 - d. Select the number of disks.
5. In the **RAID Configuration** section, complete the following:
 - a. Select the RAID type.
 - b. Select the RAID group size.
 - c. Click RAID allocation to view how the disks are allocated in the group.
6. (Optional): If the Onboard Key Manager has been installed, you can configure it for encryption in the **Encryption** section of the page. Check the **Configure Onboard Key Manager for encryption** check box.
 - a. Enter a passphrase.
 - b. Enter the passphrase again to confirm it.
 - c. Save the passphrase for future use in case the system needs to be recovered.
 - d. Back up the key database for future use.
7. Click **Save** to create the local tier and add it to your storage solution.

CLI

Before you create aggregates manually, you should review disk configuration options and simulate creation.

Then you can issue the `storage aggregate create` command and verify the results.

What you'll need

You must have determined the number of disks and the number of hot spare disks you need in the aggregate.

About this task

If root-data-data partitioning is enabled and you have 24 solid-state drives (SSDs) or fewer in your

configuration, it is recommended that your data partitions be assigned to different nodes.

The procedure for creating aggregates on systems with root-data partitioning and root-data-data partitioning enabled is the same as the procedure for creating aggregates on systems using unpartitioned disks. If root-data partitioning is enabled on your system, you should use the number of disk partitions for the `-diskcount` option. For root-data-data partitioning, the `-diskcount` option specifies the count of disks to use.



When creating multiple aggregates for use with FlexGroups, aggregates should be as close in size as possible.

The `storage aggregate create man` page contains more information about aggregate creation options and requirements.

Steps

1. View the list of spare disk partitions to verify that you have enough to create your aggregate:

```
storage aggregate show-spare-disks -original-owner node_name
```

Data partitions are displayed under `Local Data Usable`. A root partition cannot be used as a spare.

2. Simulate the creation of the aggregate:

```
storage aggregate create -aggregate aggregate_name -node node_name  
-raidtype raid_dp -diskcount number_of_disks_or_partitions -simulate true
```

3. If any warnings are displayed from the simulated command, adjust the command and repeat the simulation.

4. Create the aggregate:

```
storage aggregate create -aggregate aggr_name -node node_name -raidtype  
raid_dp -diskcount number_of_disks_or_partitions
```

5. Display the aggregate to verify that it was created:

```
storage aggregate show-status aggregate_name
```

Related information

[ONTAP 9 commands](#)

Manage the use of local tiers (aggregates)

Manage the use of local tiers (aggregates)

After you have created local tiers (aggregates), you can manage how they are used.

You can perform the following tasks:

- [Rename a local tier \(aggregate\)](#)

- [Set the media cost of a local tier \(aggregate\)](#)
- [Determine drive and RAID group information for a local tier \(aggregate\)](#)
- [Assign local tiers \(aggregates\) to storage VMs \(SVMs\)](#)
- [Determine which volumes reside on a local tier \(aggregate\)](#)
- [Determine and control a volume's space usages in a local tier \(aggregate\)](#)
- [Determine space usage in a local tier \(aggregate\)](#)
- [Relocate local tier \(aggregate\) ownership within an HA pair](#)
- [Delete a local tier \(aggregate\)](#)

Rename a local tier (aggregate)


You can rename a local tier (aggregate). The method you follow depends on the interface you use—System Manager or the CLI:

System Manager

Use System Manager to rename a local tier (aggregate)

Beginning with ONTAP 9.10.1, you can modify the name of a local tier (aggregate).

Steps

1. In System Manager, click **Storage > Tiers**.
2. Click  next to the name of the local tier.
3. Select **Rename**.
4. Specify a new name for the local tier.

CLI

Use the CLI to rename a local tier (aggregate)

Step

1. Using the CLI, rename the local tier (aggregate):

```
storage aggregate rename -aggregate aggr-name -newname aggr-new-name
```

The following example renames an aggregate named “aggr5” as “sales-aggr”:

```
> storage aggregate rename -aggregate aggr5 -newname sales-aggr
```

Set media cost of a local tier (aggregate)

Beginning with ONTAP 9.11.1, you can use System Manager to set the media cost of a local tier (aggregate).

Steps

1. In System Manager, click **Storage > Tiers**, then click **Set Media Cost** in the desired local tier (aggregate) tiles.
2. Select **active and inactive tiers** to enable comparison.
3. Enter a currency type and amount.

When you enter or change the media cost, the change is made in all media types.

Manually Fast zero drives

On systems freshly installed with ONTAP 9.4 or later and systems reinitialized with ONTAP 9.4 or later, *fast zeroing* is used to zero drives.

With *fast zeroing*, drives are zeroed in seconds. This is done automatically before provisioning and greatly reduces the time it takes to initialize the system, create aggregates, or expand aggregates when spare drives are added.

Fast zeroing is supported on both SSDs and HDDs.



Fast zeroing is not supported on systems upgraded from ONTAP 9.3 or earlier. ONTAP 9.4 or later must be freshly installed or the system must be reinitialized. In ONTAP 9.3 and earlier, drives are also automatically zeroed by ONTAP, however, the process takes longer.

If you need to manually zero a drive, you can use one of the following methods. In ONTAP 9.4 and later, manually zeroing a drive also takes only seconds.

CLI command

Use a CLI command to fast-zero drives

About this task

Admin privileges are required to use this command.

Steps

1. Enter the CLI command:

```
storage disk zerospares
```

Boot menu options

Select options from the boot menu to fast-zero drives

About this task

- The fast zeroing enhancement does not support systems upgraded from a release earlier than ONTAP 9.4.
- If any node on the cluster contains a local tier (aggregate) with fast-zeroed drives, then you cannot revert the cluster to ONTAP 9.2 or earlier.

Steps

1. From the boot menu, select one of the following options:
 - (4) Clean configuration and initialize all disks
 - (9a) Unpartition all disks and remove their ownership information
 - (9b) Clean configuration and initialize node with whole disks

Manually assign disk ownership

Disks must be owned by a node before they can be used in a local tier (aggregate).

If your cluster is not configured to use automatic disk ownership assignment, you must assign ownership manually.

You cannot reassign ownership of a disk that is in use in a local tier.

Steps

1. Using the CLI, display all unowned disks:

```
storage disk show -container-type unassigned
```

2. Assign each disk:

```
storage disk assign -disk disk_name -owner owner_name
```

You can use the wildcard character to assign more than one disk at once. If you are reassigning a spare disk that is already owned by a different node, you must use the “-force” option.

Determine drive and RAID group information for a local tier (aggregate)

Some local tier (aggregate) administration tasks require that you know what types of drives compose the local tier, their size, checksum, and status, whether they are shared with other local tiers, and the size and composition of the RAID groups.

Step

1. Show the drives for the aggregate, by RAID group:

```
storage aggregate show-status aggr_name
```

The drives are displayed for each RAID group in the aggregate.

You can see the RAID type of the drive (data, parity, dparity) in the `Position` column. If the `Position` column displays `shared`, then the drive is shared: if it is an HDD, it is a partitioned disk; if it is an SSD, it is part of a storage pool.

Example: A Flash Pool aggregate using an SSD storage pool and data partitions

```
cluster1::> storage aggregate show-status nodeA_fp_1
```

Owner Node: cluster1-a

Aggregate: nodeA_fp_1 (online, mixed_raid_type, hybrid) (block checksums)

Plex: /nodeA_fp_1/plex0 (online, normal, active, pool0)

RAID Group /nodeA_fp_1/plex0/rg0 (normal, block checksums, raid_dp)

Position	Disk	Pool	Type	RPM	Usable Size	Physical Size	Status
shared	2.0.1	0	SAS	10000	472.9GB	547.1GB	(normal)
shared	2.0.3	0	SAS	10000	472.9GB	547.1GB	(normal)
shared	2.0.5	0	SAS	10000	472.9GB	547.1GB	(normal)
shared	2.0.7	0	SAS	10000	472.9GB	547.1GB	(normal)
shared	2.0.9	0	SAS	10000	472.9GB	547.1GB	(normal)
shared	2.0.11	0	SAS	10000	472.9GB	547.1GB	(normal)

RAID Group /nodeA_flashpool_1/plex0/rg1

(normal, block checksums, raid4) (Storage Pool: SmallSP)

Position	Disk	Pool	Type	RPM	Usable Size	Physical Size	Status
shared	2.0.13	0	SSD	-	186.2GB	745.2GB	(normal)
shared	2.0.12	0	SSD	-	186.2GB	745.2GB	(normal)

8 entries were displayed.

Assign local tiers (aggregates) to storage VMs (SVMs)

If you assign one or more local tiers (aggregates) to a storage virtual machine (storage VM or SVM, formerly known as Vserver), then you can use only those local tiers to contain volumes for that storage VM (SVM).

What you'll need

The storage VM and the local tiers you want to assign to that storage VM must already exist.

About this task

Assigning local tiers to your storage VMs helps you keep your storage VMs isolated from each other; this is especially important in a multi-tenancy environment.

Steps

- 1. Check the list of local tiers (aggregates) already assigned to the SVM:

```
vserver show -fields aggr-list
```

The aggregates currently assigned to the SVM are displayed. If there are no aggregates assigned, “-” is displayed.

- 2. Add or remove assigned aggregates, depending on your requirements:

If you want to...	Use this command...
Assign additional aggregates	<code>vserver add-aggregates</code>
Unassign aggregates	<code>vserver remove-aggregates</code>

The listed aggregates are assigned to or removed from the SVM. If the SVM already has volumes that use an aggregate that is not assigned to the SVM, a warning message is displayed, but the command is completed successfully. Any aggregates that were already assigned to the SVM and that were not named in the command are unaffected.

Example

In the following example, the aggregates aggr1 and aggr2 are assigned to SVM svm1:

```
vserver add-aggregates -vserver svm1 -aggregates aggr1,aggr2
```

Determine which volumes reside on a local tier (aggregate)

You might need to determine which volumes reside on a local tier (aggregate) before performing operations on the local tier, such as relocating it or taking it offline.

Steps

- 1. To display the volumes that reside on an aggregate, enter

```
volume show -aggregate aggregate_name
```

All volumes that reside on the specified aggregate are displayed.

Determine and control a volume's space usage in a local tier (aggregate)

You can determine which FlexVol volumes are using the most space in a local tier (aggregate) and specifically which features within the volume.

The `volume show-footprint` command provides information about a volume's footprint, or its space usage within the containing aggregate.

The `volume show-footprint` command shows details about the space usage of each volume in an aggregate, including offline volumes. This command bridges the gap between the output of the `volume show-space` and `aggregate show-space` commands. All percentages are calculated as a percent of aggregate size.

The following example shows the `volume show-footprint` command output for a volume called `testvol`:

```
cluster1::> volume show-footprint testvol

Vserver : thevs
Volume  : testvol

Feature                                Used      Used%
-----
Volume Data Footprint                  120.6MB    4%
Volume Guarantee                       1.88GB    71%
Flexible Volume Metadata               11.38MB    0%
Delayed Frees                          1.36MB    0%
Total Footprint                        2.01GB    76%
```

The following table explains some of the key rows of the output of the `volume show-footprint` command and what you can do to try to decrease space usage by that feature:

Row/feature name	Description/contents of row	Some ways to decrease
Volume Data Footprint	The total amount of space used in the containing aggregate by a volume's data in the active file system and the space used by the volume's Snapshot copies. This row does not include reserved space.	<ul style="list-style-type: none">• Deleting data from the volume.• Deleting Snapshot copies from the volume.
Volume Guarantee	The amount of space reserved by the volume in the aggregate for future writes. The amount of space reserved depends on the guarantee type of the volume.	Changing the type of guarantee for the volume to <code>none</code> .

Flexible Volume Metadata	The total amount of space used in the aggregate by the volume's metadata files.	No direct method to control.
Delayed Frees	Blocks that ONTAP used for performance and cannot be immediately freed. For SnapMirror destinations, this row has a value of 0 and is not displayed.	No direct method to control.
File Operation Metadata	The total amount of space reserved for file operation metadata.	No direct method to control.
Total Footprint	The total amount of space that the volume uses in the aggregate. It is the sum of all of the rows.	Any of the methods used to decrease space used by a volume.

Related information

[NetApp Technical Report 3483: Thin Provisioning in a NetApp SAN or IP SAN Enterprise Environment](#)

Determine space usage in a local tier (aggregate)

You can view how much space is used by all of the volumes in one or more local tiers (aggregates) so that you can take actions to free more space.

WAFL reserves 10% of the total disk space for aggregate level metadata and performance. The space used for maintaining the volumes in the aggregate comes out of the WAFL reserve and cannot be changed.



Beginning in ONTAP 9.12.1 and later, the WAFL reserve for aggregates greater than 30TB is reduced from 10% to 5% for AFF platforms and for the FAS500f platforms. Beginning in ONTAP 9.14.1, this same reduction applies to aggregates on all FAS platforms, resulting in 5% more usable space in the aggregates.

You can view space usage by all volumes in one or more aggregates with the `aggregate show-space` command. This helps you see which volumes are consuming the most space in their containing aggregates so that you can take actions to free more space.

The used space in an aggregate is directly affected by the space used in the FlexVol volumes it contains. Measures that you take to increase space in a volume also affect space in the aggregate.

The following rows are included in the `aggregate show-space` command output:

- **Volume Footprints**

The total of all volume footprints within the aggregate. It includes all of the space that is used or reserved by all data and metadata of all volumes in the containing aggregate.

- **Aggregate Metadata**

The total file system metadata required by the aggregate, such as allocation bitmaps and inode files.

- **Snapshot Reserve**

The amount of space reserved for aggregate Snapshot copies, based on volume size. It is considered used space and is not available to volume or aggregate data or metadata.

- **Snapshot Reserve Unusable**

The amount of space originally allocated for aggregate Snapshot reserve that is unavailable for aggregate Snapshot copies because it is being used by volumes associated with the aggregate. Can occur only for aggregates with a non-zero aggregate Snapshot reserve.

- **Total Used**

The sum of all space used or reserved in the aggregate by volumes, metadata, or Snapshot copies.

- **Total Physical Used**

The amount of space being used for data now (rather than being reserved for future use). Includes space used by aggregate Snapshot copies.

The following example shows the `aggregate show-space` command output for an aggregate whose Snapshot reserve is 5%. If the Snapshot reserve was 0, the row would not be displayed.

```
cluster1::> storage aggregate show-space

Aggregate : wqa_gx106_aggr1

Feature                               Used      Used%
-----
Volume Footprints                    101.0MB    0%
Aggregate Metadata                     300KB     0%
Snapshot Reserve                      5.98GB     5%

Total Used                           6.07GB     5%
Total Physical Used                   34.82KB    0%
```

Related Information

- [Knowledge Base article: Space Usage](#)
- [Free up 5% of your storage capacity by upgrading to ONTAP 9.12.1](#)

Relocate ownership of a local tier (aggregate) within an HA pair

You can change the ownership of local tiers (aggregates) among the nodes in an HA pair without interrupting service from the local tiers.

Both nodes in an HA pair are physically connected to each other's disks or array LUNs. Each disk or array LUN is owned by one of the nodes.

Ownership of all disks or array LUNs within a local tier (aggregate) changes temporarily from one node to the other when a takeover occurs. However, local tiers relocation operations can also permanently change the

ownership (for example, if done for load balancing). The ownership changes without any data-copy processes or physical movement of the disks or array LUNs.

About this task

- Because volume count limits are validated programmatically during local tier relocation operations, it is not necessary to check for this manually.

If the volume count exceeds the supported limit, the local tier relocation operation fails with a relevant error message.

- You should not initiate local tier relocation when system-level operations are in progress on either the source or the destination node; likewise, you should not start these operations during the local tier relocation.

These operations can include the following:

- Takeover
 - Giveback
 - Shutdown
 - Another local tier relocation operation
 - Disk ownership changes
 - Local tier or volume configuration operations
 - Storage controller replacement
 - ONTAP upgrade
 - ONTAP revert
- If you have a MetroCluster configuration, you should not initiate local tier relocation while disaster recovery operations (*switchover*, *healing*, or *switchback*) are in progress.
 - If you have a MetroCluster configuration and initiate local tier relocation on a switched-over local tier, the operation might fail because it exceeds the DR partner's volume limit count.
 - You should not initiate local tier relocation on aggregates that are corrupt or undergoing maintenance.
 - Before initiating the local tier relocation, you should save any core dumps on the source and destination nodes.

Steps

1. View the aggregates on the node to confirm which aggregates to move and ensure they are online and in good condition:

```
storage aggregate show -node source-node
```

The following command shows six aggregates on the four nodes in the cluster. All aggregates are online. Node1 and Node3 form an HA pair and Node2 and Node4 form an HA pair.

```
cluster::> storage aggregate show
```

Aggregate	Size	Available	Used%	State	#Vols	Nodes	RAID	Status
aggr_0	239.0GB	11.13GB	95%	online	1	node1	raid_dp,	normal
aggr_1	239.0GB	11.13GB	95%	online	1	node1	raid_dp,	normal
aggr_2	239.0GB	11.13GB	95%	online	1	node2	raid_dp,	normal
aggr_3	239.0GB	11.13GB	95%	online	1	node2	raid_dp,	normal
aggr_4	239.0GB	238.9GB	0%	online	5	node3	raid_dp,	normal
aggr_5	239.0GB	239.0GB	0%	online	4	node4	raid_dp,	normal

6 entries were displayed.

2. Issue the command to start the aggregate relocation:

```
storage aggregate relocation start -aggregate-list aggregate-1, aggregate-2...
-node source-node -destination destination-node
```

The following command moves the aggregates aggr_1 and aggr_2 from Node1 to Node3. Node3 is Node1's HA partner. The aggregates can be moved only within the HA pair.

```
cluster::> storage aggregate relocation start -aggregate-list aggr_1,
aggr_2 -node node1 -destination node3
Run the storage aggregate relocation show command to check relocation
status.
node1::storage aggregate>
```

3. Monitor the progress of the aggregate relocation with the storage aggregate relocation show command:

```
storage aggregate relocation show -node source-node
```

The following command shows the progress of the aggregates that are being moved to Node3:

```
cluster::> storage aggregate relocation show -node node1
Source Aggregate      Destination      Relocation Status
-----
node1
      aggr_1          node3            In progress, module: waf1
      aggr_2          node3            Not attempted yet
2 entries were displayed.
node1::storage aggregate>
```

When the relocation is complete, the output of this command shows each aggregate with a relocation status of “Done”.

Delete a local tier (aggregate)

You can delete a local tier (aggregate) if there are no volumes on the local tier.

The `storage aggregate delete` command deletes a storage aggregate. The command fails if there are volumes present on the aggregate. If the aggregate has an object store attached to it, then in addition to deleting the aggregate, the command deletes the objects in the object store as well. No changes are made to the object store configuration as part of this command.

The following example deletes an aggregate named “aggr1”:

```
> storage aggregate delete -aggregate aggr1
```

Commands for aggregate relocation

There are specific ONTAP commands for relocating aggregate ownership within an HA pair.

If you want to...	Use this command...
Start the aggregate relocation process	<code>storage aggregate relocation start</code>
Monitor the aggregate relocation process	<code>storage aggregate relocation show</code>

Related information

[ONTAP 9 Commands](#)

Commands for managing aggregates

You use the `storage aggregate` command to manage your aggregates.

If you want to...	Use this command...
Display the size of the cache for all Flash Pool aggregates	<code>storage aggregate show -fields hybrid-cache-size-total -hybrid-cache-size -total >0</code>
Display disk information and status for an aggregate	<code>storage aggregate show-status</code>
Display spare disks by node	<code>storage aggregate show-spare-disks</code>
Display the root aggregates in the cluster	<code>storage aggregate show -has-mroot true</code>
Display basic information and status for aggregates	<code>storage aggregate show</code>
Display the type of storage used in an aggregate	<code>storage aggregate show -fields storage-type</code>
Bring an aggregate online	<code>storage aggregate online</code>
Delete an aggregate	<code>storage aggregate delete</code>
Put an aggregate into the restricted state	<code>storage aggregate restrict</code>
Rename an aggregate	<code>storage aggregate rename</code>
Take an aggregate offline	<code>storage aggregate offline</code>
Change the RAID type for an aggregate	<code>storage aggregate modify -raidtype</code>

Related information

[ONTAP 9 Commands](#)

Add capacity (disks) to a local tier (aggregate)

Add capacity (disks) to a local tier (aggregate)

Using different methods, you follow a specific workflow to add capacity.

- [Workflow to add capacity to a local tier \(aggregate\)](#)
- [Methods to create space in a local tier \(aggregate\)](#)

You can add disks to a local tier and add drives to a node or shelf.

If needed, you can correct misaligned spare partitions.

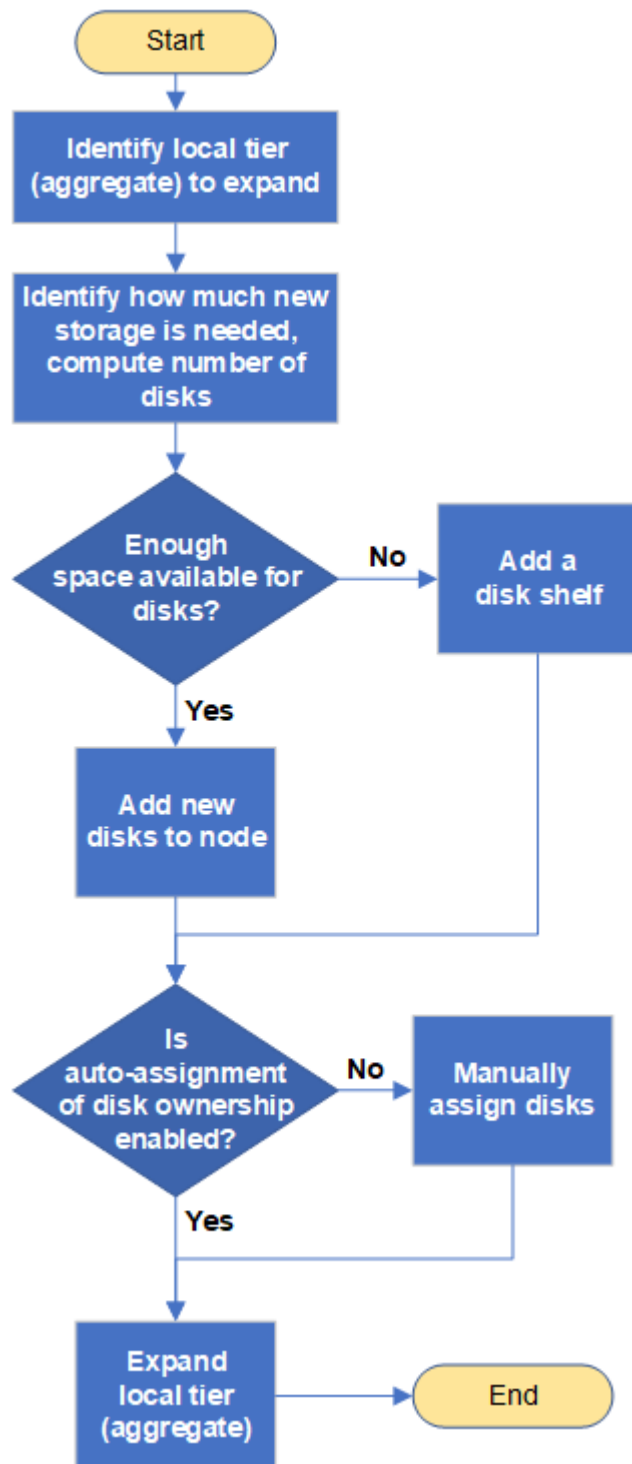
- [Add disks to a local tier \(aggregate\)](#)

- Add drives to a node or shelf
- Correct misaligned spare partitions

Workflow to add capacity to a local tier (expanding an aggregate)

To add capacity to a local tier (expand an aggregate) you must first identify which local tier you want to add to, determine how much new storage is needed, install new disks, assign disk ownership, and create a new RAID group, if needed.

You can use either System Manager or the CLI to add capacity.



Methods to create space in an local tier (aggregate)

If a local tier (aggregate) runs out of free space, various problems can result that range from loss of data to disabling a volume's guarantee. There are multiple ways to make more space in a local tier.

All of the methods have various consequences. Prior to taking any action, you should read the relevant section in the documentation.

The following are some common ways to make space in local tier, in order of least to most consequences:

- Add disks to the local tier.
- Move some volumes to another local tier with available space.
- Shrink the size of volume-guaranteed volumes in the local tier.
- Delete unneeded volume Snapshot copies if the volume's guarantee type is "none".
- Delete unneeded volumes.
- Enable space-saving features, such as deduplication or compression.
- (Temporarily) disable features that are using a large amount of metadata .

Add capacity to a local tier (add disks to an aggregate)

You can add disks to an local tier (aggregate) so that it can provide more storage to its associated volumes.

System Manager (ONTAP 9.8 and later)

Use System Manager to add capacity (ONTAP 9.8 and later)

You can add capacity to a local tier by adding capacity disks.



Beginning with ONTAP 9.12.1, you can use System Manager to view the committed capacity of a local tier to determine if additional capacity is required for the local tier. See [Monitor capacity in System Manager](#).

About this task

You perform this task only if you have installed ONTAP 9.8 or later. If you installed an earlier version of ONTAP, refer to the tab (or section) labeled "System Manager (ONTAP 9.7 and earlier)".

Steps

1. Click **Storage > Tiers**.
2. Click  next to the name of the local tier to which you want to add capacity.
3. Click **Add Capacity**.



If there are no spare disks that you can add, then the **Add Capacity** option is not shown, and you cannot increase the capacity of the local tier.

4. Perform the following steps, based on the version of ONTAP that is installed:

If this version of ONTAP is installed...	Perform these steps...
ONTAP 9.8, 9.9, or 9.10.1	<ol style="list-style-type: none">1. If the node contains multiple storage tiers, then select the number of disks you want to add to the local tier. Otherwise, if the node contains only a single storage tier, the added capacity is estimated automatically.2. Click Add.
Beginning with ONTAP 9.11.1	<ol style="list-style-type: none">1. Select the disk type and number of disks.2. If you want to add disks to a new RAID group, check the check box. The RAID allocation is displayed.3. Click Save.

5. (Optional) The process takes some time to complete. If you want to run the process in the background, select **Run in Background**.
6. After the process completes, you can view the increased capacity amount in the local tier information at **Storage > Tiers**.

System Manager (ONTAP 9.7 and earlier)

Use System Manager to add capacity (ONTAP 9.7 and earlier)

You can add capacity to a local tier (aggregate) by adding capacity disks.

About this task

You perform this task only if you have installed ONTAP 9.7 or earlier. If you installed ONTAP 9.8 or later, refer to [Use System Manager to add capacity \(ONTAP 9.8 or later\)](#).

Steps

1. (For ONTAP 9.7 only) Click **(Return to classic version)**.
2. Click **Hardware and Diagnostics > Aggregates**.
3. Select the aggregate to which you want to add capacity disks, and then click **Actions > Add Capacity**.



You should add disks that are of the same size as the other disks in the aggregate.

4. (For ONTAP 9.7 only) Click **Switch to the new experience**.
5. Click **Storage > Tiers** to verify the size of the new aggregate.

CLI

Use the CLI to add capacity

The procedure for adding partitioned disks to an aggregate is similar to the procedure for adding unpartitioned disks.

What you'll need

You must know what the RAID group size is for the aggregate you are adding the storage to.

About this task

When you expand an aggregate, you should be aware of whether you are adding partition or unpartitioned disks to the aggregate. When you add unpartitioned drives to an existing aggregate, the size of the existing RAID groups is inherited by the new RAID group, which can affect the number of parity disks required. If an unpartitioned disk is added to a RAID group composed of partitioned disks, the new disk is partitioned, leaving an unused spare partition.

When you provision partitions, you must ensure that you do not leave the node without a drive with both partitions as spare. If you do, and the node experiences a controller disruption, valuable information about the problem (the core file) might not be available to provide to the technical support.



Do not use the `disklist` command to expand your aggregates. This could cause partition misalignment.

Steps

1. Show the available spare storage on the system that owns the aggregate:

```
storage aggregate show-spare-disks -original-owner node_name
```

You can use the `-is-disk-shared` parameter to show only partitioned drives or only unpartitioned drives.


```
cl1-s2::> storage aggregate show-spare-disks -original-owner cl1-s2
-is-disk-shared true
```

Original Owner: cl1-s2

Pool0

Shared HDD Spares

				Local	
Local				Data	
Root Physical					
Disk			Type	RPM	Checksum Usable
Usable	Size	Status			

1.0.1			BSAS	7200	block 753.8GB
73.89GB	828.0GB	zeroed			
1.0.2			BSAS	7200	block 753.8GB
0B	828.0GB	zeroed			
1.0.3			BSAS	7200	block 753.8GB
0B	828.0GB	zeroed			
1.0.4			BSAS	7200	block 753.8GB
0B	828.0GB	zeroed			
1.0.8			BSAS	7200	block 753.8GB
0B	828.0GB	zeroed			
1.0.9			BSAS	7200	block 753.8GB
0B	828.0GB	zeroed			
1.0.10			BSAS	7200	block 0B
73.89GB	828.0GB	zeroed			
2 entries were displayed.					

2. Show the current RAID groups for the aggregate:

```
storage aggregate show-status aggr_name
```

```
cl1-s2::> storage aggregate show-status -aggregate data_1
```

Owner Node: cl1-s2

Aggregate: data_1 (online, raid_dp) (block checksums)

Plex: /data_1/plex0 (online, normal, active, pool0)

RAID Group /data_1/plex0/rg0 (normal, block checksums)

	Position	Disk	Pool	Type	RPM	Usable Size	Physical Size	Status
	-----	-----	----	----	-----	-----	-----	

shared	1.0.10	0	BSAS	7200	753.8GB	828.0GB		
(normal)								
shared	1.0.5	0	BSAS	7200	753.8GB	828.0GB		
(normal)								
shared	1.0.6	0	BSAS	7200	753.8GB	828.0GB		
(normal)								
shared	1.0.11	0	BSAS	7200	753.8GB	828.0GB		
(normal)								
shared	1.0.0	0	BSAS	7200	753.8GB	828.0GB		
(normal)								

5 entries were displayed.

3. Simulate adding the storage to the aggregate:

```
storage aggregate add-disks -aggregate aggr_name -diskcount  
number_of_disks_or_partitions -simulate true
```

You can see the result of the storage addition without actually provisioning any storage. If any warnings are displayed from the simulated command, you can adjust the command and repeat the simulation.

```
cl1-s2::> storage aggregate add-disks -aggregate aggr_test
-diskcount 5 -simulate true
```

Disks would be added to aggregate "aggr_test" on node "cl1-s2" in the following manner:

First Plex

```
RAID Group rg0, 5 disks (block checksum, raid_dp)

Physical                                     Usable
Position  Disk                               Type      Size
Size
-----
shared    1.11.4                             SSD        415.8GB
415.8GB
shared    1.11.18                            SSD        415.8GB
415.8GB
shared    1.11.19                            SSD        415.8GB
415.8GB
shared    1.11.20                            SSD        415.8GB
415.8GB
shared    1.11.21                            SSD        415.8GB
415.8GB
```

Aggregate capacity available for volume use would be increased by 1.83TB.

4. Add the storage to the aggregate:

```
storage aggregate add-disks -aggregate aggr_name -raidgroup new -diskcount
number_of_disks_or_partitions
```

When creating a Flash Pool aggregate, if you are adding disks with a different checksum than the aggregate, or if you are adding disks to a mixed checksum aggregate, you must use the `-checksumstyle` parameter.

If you are adding disks to a Flash Pool aggregate, you must use the `-disktype` parameter to specify the disk type.

You can use the `-disksize` parameter to specify a size of the disks to add. Only disks with approximately the specified size are selected for addition to the aggregate.

```
cl1-s2::> storage aggregate add-disks -aggregate data_1 -raidgroup
new -diskcount 5
```

5. Verify that the storage was added successfully:

```
storage aggregate show-status -aggregate aggr_name
```

```
cl1-s2::> storage aggregate show-status -aggregate data_1

Owner Node: cl1-s2
Aggregate: data_1 (online, raid_dp) (block checksums)
Plex: /data_1/plex0 (online, normal, active, pool0)
RAID Group /data_1/plex0/rg0 (normal, block checksums)

Physical                                                                 Usable
  Position Disk                                     Pool Type      RPM      Size
Size Status
-----
-----
      shared   1.0.10                                0    BSAS      7200  753.8GB
828.0GB (normal)
      shared   1.0.5                                  0    BSAS      7200  753.8GB
828.0GB (normal)
      shared   1.0.6                                  0    BSAS      7200  753.8GB
828.0GB (normal)
      shared   1.0.11                                 0    BSAS      7200  753.8GB
828.0GB (normal)
      shared   1.0.0                                  0    BSAS      7200  753.8GB
828.0GB (normal)
      shared   1.0.2                                  0    BSAS      7200  753.8GB
828.0GB (normal)
      shared   1.0.3                                  0    BSAS      7200  753.8GB
828.0GB (normal)
      shared   1.0.4                                  0    BSAS      7200  753.8GB
828.0GB (normal)
      shared   1.0.8                                  0    BSAS      7200  753.8GB
828.0GB (normal)
      shared   1.0.9                                  0    BSAS      7200  753.8GB
828.0GB (normal)
10 entries were displayed.
```

6. Verify that the node still has at least one drive with both the root partition and the data partition as spare:

```
storage aggregate show-spare-disks -original-owner node_name
```

```
cl1-s2::> storage aggregate show-spare-disks -original-owner cl1-s2
-is-disk-shared true
```

Original Owner: cl1-s2

Pool0

Shared HDD Spares

			Local		Data	
Root Physical						
Disk	Type	RPM	Checksum	Usable		
Usable	Size	Status				
1.0.1	BSAS	7200	block	753.8GB		
73.89GB	828.0GB	zeroed				
1.0.10	BSAS	7200	block	0B		
73.89GB	828.0GB	zeroed				
2 entries were displayed.						

Add drives to a node or shelf

You add drives to a node or shelf to increase the number of hot spares or to add space to local tier (aggregate).

Before you begin

The drive you want to add must be supported by your platform. You can confirm using the [NetApp Hardware Universe](#).

The minimum number of drives you should add in a single procedure is six. Adding a single drive might reduce performance.

Steps for the NetApp Hardware Universe

1. In the **Products** dropdown menu, select your hardware configuration
2. Select your platform.
3. Select the version of ONTAP you are running then **Show Results**.
4. Beneath the graphic, select **Click here to see alternate views**. Choose the view that matches your configuration.



Steps to install the drives

1. Check the [NetApp Support Site](#) for newer drive and shelf firmware and Disk Qualification Package files.

If your node or shelf does not have the latest versions, update them before installing the new drive.

Drive firmware is automatically updated (nondisruptively) on new drives that do not have current firmware versions.

2. Properly ground yourself.
3. Gently remove the bezel from the front of the platform.
4. Identify the correct slot for the new drive.



The correct slots for adding drives vary depending on the platform model and ONTAP version. In some cases you need to add drives to specific slots in sequence. For example, in an AFF A800 you add the drives at specific intervals leaving clusters of empty slots. Whereas, in an AFF A220 you add new drives to the next empty slots running from the outside towards the middle of the shelf.

Refer to the steps in **Before you begin** to identify the correct slots for your configuration in the [NetApp Hardware Universe](#).

5. Insert the new drive:
 - a. With the cam handle in the open position, use both hands to insert the new drive.
 - b. Push until the drive stops.
 - c. Close the cam handle so that the drive is fully seated into the mid plane and the handle clicks into place. Be sure to close the cam handle slowly so that it aligns correctly with the face of the drive.
6. Verify that the drive's activity LED (green) is illuminated.

When the drive's activity LED is solid, it means that the drive has power. When the drive's activity LED is blinking, it means that the drive has power and I/O is in progress. If the drive firmware is automatically updating, the LED blinks.

7. To add another drive, repeat Steps 4 through 6.

The new drives are not recognized until they are assigned to a node. You can assign the new drives manually, or you can wait for ONTAP to automatically assign the new drives if your node follows the rules for drive auto-assignment.

8. After the new drives have all been recognized, verify that they have been added and their ownership is specified correctly.

Steps to confirm installation

1. Display the list of disks:

```
storage aggregate show-spare-disks
```

You should see the new drives, owned by the correct node.

2. Optionally (for ONTAP 9.3 and earlier only), zero the newly added drives:

```
storage disk zerospares
```

Drives that have been used previously in an ONTAP local tier (aggregate) must be zeroed before they can be added to another aggregate. In ONTAP 9.3 and earlier, zeroing can take hours to complete, depending on the size of the non-zeroed drives in the node. Zeroing the drives now can prevent delays in case you need to quickly increase the size of an local tier. This is not an issue in ONTAP 9.4 or later where drives are zeroed using *fast zeroing* which takes only seconds.

Results

The new drives are ready. You can add them to a local tier (aggregate), place them onto the list of hot spares, or add them when you create a new local tier.

Correct misaligned spare partitions

When you add partitioned disks to a local tier (aggregate), you must leave a disk with both the root and data partition available as a spare for every node. If you do not and your node experiences a disruption, ONTAP cannot dump the core to the spare data partition.

Before you begin

You must have both a spare data partition and a spare root partition on the same type of disk owned by the same node.

Steps

1. Using the CLI, display the spare partitions for the node:

```
storage aggregate show-spare-disks -original-owner node_name
```

Note which disk has a spare data partition (spare_data) and which disk has a spare root partition (spare_root). The spare partition will show a non-zero value under the Local Data Usable or Local Root Usable column.

2. Replace the disk with a spare data partition with the disk with the spare root partition:

```
storage disk replace -disk spare_data -replacement spare_root -action start
```

You can copy the data in either direction; however, copying the root partition takes less time to complete.

3. Monitor the progress of the disk replacement:

```
storage aggregate show-status -aggregate aggr_name
```

4. After the replacement operation is complete, display the spares again to confirm that you have a full spare disk:

```
storage aggregate show-spare-disks -original-owner node_name
```

You should see a spare disk with usable space under both “Local Data Usable” and Local Root Usable.

Example

You display your spare partitions for node c1-01 and see that your spare partitions are not aligned:

```
c1::> storage aggregate show-spare-disks -original-owner c1-01
```

Original Owner: c1-01

Pool0

Shared HDD Spares

Disk	Type	RPM	Checksum	Local Data Usable	Local Root Usable	Physical Size
1.0.1	BSAS	7200	block	753.8GB	0B	828.0GB
1.0.10	BSAS	7200	block	0B	73.89GB	828.0GB

You start the disk replacement job:

```
c1::> storage disk replace -disk 1.0.1 -replacement 1.0.10 -action start
```

While you are waiting for the replacement operation to finish, you display the progress of the operation:

```
c1::> storage aggregate show-status -aggregate aggr0_1
```

Owner Node: c1-01

Aggregate: aggr0_1 (online, raid_dp) (block checksums)

Plex: /aggr0_1/plex0 (online, normal, active, pool0)

RAID Group /aggr0_1/plex0/rg0 (normal, block checksums)

Position	Disk	Pool	Type	RPM	Usable Size	Physical Size	Status
shared	1.0.1	0	BSAS	7200	73.89GB	828.0GB	(replacing, copy in progress)
shared	1.0.10	0	BSAS	7200	73.89GB	828.0GB	(copy 63% completed)
shared	1.0.0	0	BSAS	7200	73.89GB	828.0GB	(normal)
shared	1.0.11	0	BSAS	7200	73.89GB	828.0GB	(normal)
shared	1.0.6	0	BSAS	7200	73.89GB	828.0GB	(normal)
shared	1.0.5	0	BSAS	7200	73.89GB	828.0GB	(normal)

After the replacement operation is complete, confirm that you have a full spare disk:


```
ie2220::> storage aggregate show-spare-disks -original-owner c1-01
```

Original Owner: c1-01

Pool0

Shared HDD Spares

				Local Data Usable	Local Root Usable	Physical Size
Disk	Type	RPM	Checksum			
1.0.1	BSAS	7200	block	753.8GB	73.89GB	828.0GB

Manage disks

Overview of managing disks

You can perform various procedures to manage disks in your system.

- **Aspects of managing disks**

- [When you need to update the Disk Qualification Package](#)
- [How hot spare disks work](#)
- [How low spare warnings can help you manage your spare disks](#)
- [Additional root-data partitioning management options](#)

- **Disk and partition ownership**

- [Disk and partition ownership](#)

- **Failed disk removal**

- [Remove a failed disk](#)

- **Disk sanitization**

- [Disk sanitization](#)

How hot spare disks work

A hot spare disk is a disk that is assigned to a storage system and is ready for use, but is not in use by a RAID group and does not hold any data.

If a disk failure occurs within a RAID group, the hot spare disk is automatically assigned to the RAID group to replace the failed disks. The data of the failed disk is reconstructed on the hot spare replacement disk in the background from the RAID parity disk. The reconstruction activity is logged in the `/etc/message` file and an AutoSupport message is sent.

If the available hot spare disk is not the same size as the failed disk, a disk of the next larger size is chosen and then downsized to match the size of the disk that it is replacing.

Spare requirements for multi-disk carrier disk

Maintaining the proper number of spares for disks in multi-disk carriers is critical for optimizing storage redundancy and minimizing the amount of time that ONTAP must spend copying disks to achieve an optimal disk layout.

You must maintain a minimum of two hot spares for multi-disk carrier disks at all times. To support the use of the Maintenance Center and to avoid issues caused by multiple concurrent disk failures, you should maintain at least four hot spares for steady state operation, and replace failed disks promptly.

If two disks fail at the same time with only two available hot spares, ONTAP might not be able to swap the contents of both the failed disk and its carrier mate to the spare disks. This scenario is called a stalemate. If this happens, you are notified through EMS messages and AutoSupport messages. When the replacement carriers become available, you must follow the instructions that are provided by the EMS messages.

For more information, see Knowledge Base article [RAID Layout Cannot Be Autocorrected - AutoSupport message](#)

How low spare warnings can help you manage your spare disks

By default, warnings are issued to the console and logs if you have fewer than one hot spare drive that matches the attributes of each drive in your storage system.

You can change the threshold value for these warning messages to ensure that your system adheres to best practices.

About this task

You should set the “min_spare_count” RAID option to “2” to ensure that you always have the minimum recommended number of spare disks.

Step

1. Set the option to “2”:

```
storage raid-options modify -node nodename -name min_spare_count -value 2
```

Additional root-data partitioning management options

Beginning with ONTAP 9.2, a new root-data partitioning option is available from the Boot Menu that provides additional management features for disks that are configured for root-data partitioning.

The following management features are available under the Boot Menu Option 9.

- **Unpartition all disks and remove their ownership information**

This option is useful if your system is configured for root-data partitioning and you need to reinitialize it with a different configuration.

- **Clean configuration and initialize node with partitioned disks**

This option is useful for the following:

- Your system is not configured for root-data partitioning and you would like to configure it for root-data partitioning

- Your system is incorrectly configured for root-data partitioning and you need to correct it
- You have an AFF platform or a FAS platform with only SSDs attached that is configured for the previous version of root-data partitioning and you want to upgrade it to the newer version of root-data partitioning to gain increased storage efficiency
- **Clean configuration and initialize node with whole disks**

This option is useful if you need to:

- Unpartition existing partitions
- Remove local disk ownership
- Reinitialize your system with whole disks using RAID-DP

When you need to update the Disk Qualification Package

The Disk Qualification Package (DQP) adds full support for newly qualified drives. Before you update drive firmware or add new drive types or sizes to a cluster, you must update the DQP. A best practice is to also update the DQP regularly; for example, every quarter or semi-annually.

You need to download and install the DQP in the following situations:

- Whenever you add a new drive type or size to the node

For example, if you already have 1-TB drives and add 2-TB drives, you need to check for the latest DQP update.

- Whenever you update the disk firmware
- Whenever newer disk firmware or DQP files are available
- Whenever you upgrade to a new version of ONTAP.

The DQP is not updated as part of an ONTAP upgrade.

Related information

[NetApp Downloads: Disk Qualification Package](#)

[NetApp Downloads: Disk Drive Firmware](#)

Disk and partition ownership

Disk and partition ownership

You can manage the ownership of disks and partitions.

You can perform the following tasks:

- [Display disk and partition ownership](#)

You can view disk ownership to determine which node controls the storage. You can also view the partition ownership on systems that use shared disks.

- **Change settings for automatic assignment of disk ownership**

You can select a non-default policy for automatically assigning disk ownership or disable automatic assignment of disk ownership.

- **Manually assign ownership of unpartitioned disks**

If your cluster is not configured to use automatic disk ownership assignment, you must assign ownership manually.

- **Manually assign ownership of partitioned disks**

You can set the ownership of the container disk or the partitions manually or by using auto-assignment—just as you do for unpartitioned disks.

- **Remove a failed disk**

A disk that has failed completely is no longer considered by ONTAP to be a usable disk, and you can immediately disconnect the disk from the shelf.

- **Remove ownership from a disk**

ONTAP writes disk ownership information to the disk. Before you remove a spare disk or its shelf from a node, you should remove its ownership information so that it can be properly integrated into another node.

About automatic assignment of disk ownership

The automatic assignment of unowned disks is enabled by default. Automatic disk ownership assignments occur 10 minutes after system initialization and every five minutes during normal system operation.

When you add new disks to a system – for example, when replacing failed disks, responding to a low spares message, or adding capacity – the default auto-assignment policy assigns ownership of the disk to a node as a spare. You can disable automatic assignment or select a different auto-assignment policy using the `storage disk option modify` command.

The default auto-assignment policy is based on platform-specific characteristics, but it uses one of the following methods to assign disk ownership:

Assignment method	Effect on node assignments	Platforms
bay	Even-numbered bays are assigned to node A and odd-numbered bays to node B.	Entry-level systems in an HA configuration with a single, shared shelf.
shelf	All disks in the shelf are assigned to node A.	Entry-level systems in an HA configuration with one stack of two or more shelves, and MetroCluster configurations with one stack per node, two or more shelves.

split shelf	Disks on the left side of the shelf are assigned to node A and on the right side to Node B. Partial shelves on new systems are shipped from the factory with disks populated from the shelf edge toward the center.	AFF C190 systems and some MetroCluster configurations.
stack	All disks in the stack are assigned to node A.	Stand-alone entry-level systems and all other configurations.

If the default assignment method is not desirable in your environment, you can specify the bay, shelf, or stack assignment method using the `-autoassign-policy` parameter to the `storage disk option modify` command. Note the following rules:

- If you try to use the `bay autoassign-policy` for a non-entry level platform, it will fail.
- There is no corresponding non-default policy for specifying the split-shelf method.

You can also manage disk assignment manually using the `storage disk assign` command.

- If you disable auto-assignment, new disks are not available as spares until they are assigned to a node with the `storage disk assign` command.
- If you want disks to be auto-assigned and you have multiple stacks or shelves that must have different ownership, one disk must have been manually assigned on each stack or shelf so that automatic ownership assignment works on each stack or shelf.
- If auto-assignment is enabled and you manually assign a single drive to a node that isn't specified in the active policy, auto-assignment stops working and an EMS message is displayed.

Learn more about [manually assigning disk ownership](#).

You can display the current auto-assignment settings with the `storage disk option show` command.

Display disk and partition ownership

You can view disk ownership to determine which node controls the storage. You can also view the partition ownership on systems that use shared disks.

Steps

1. Display the ownership of physical disks:

```
storage disk show -ownership
```

```
cluster::> storage disk show -ownership
```

Disk Home ID	Aggregate Reserver	Home Pool	Owner	DR	Home ID	Owner ID	DR
1.0.0 2014941509	aggr0_2 Pool0	node2	node2	-	2014941509	2014941509	-
1.0.1 2014941509	aggr0_2 Pool0	node2	node2	-	2014941509	2014941509	-
1.0.2 2014941219	aggr0_1 Pool0	node1	node1	-	2014941219	2014941219	-
1.0.3 2014941219	- Pool0	node1	node1	-	2014941219	2014941219	-

2. If you have a system that uses shared disks, you can display the partition ownership:

```
storage disk show -partition-ownership
```

```
cluster::> storage disk show -partition-ownership
```

Container Disk Owner ID	Container Aggregate	Root Owner	Root Owner ID	Data Owner	Data Owner ID	Owner
1.0.0 1886742616	-	node1	1886742616	node1	1886742616	node1
1.0.1 1886742616	-	node1	1886742616	node1	1886742616	node1
1.0.2 1886742657	-	node2	1886742657	node2	1886742657	node2
1.0.3 1886742657	-	node2	1886742657	node2	1886742657	node2

Change settings for automatic assignment of disk ownership

You can use the `storage disk option modify` command to select a non-default policy for automatically assigning disk ownership or to disable automatic assignment of disk ownership.

Learn about [automatic assignment of disk ownership](#).

Steps

1. Modify automatic disk assignment:

a. If you want to select a non-default policy, enter:

```
storage disk option modify -autoassign-policy autoassign_policy -node  
node_name
```

- Use `stack` as the *autoassign_policy* to configure automatic ownership at the stack or loop level.
- Use `shelf` as the *autoassign_policy* to configure automatic ownership at the shelf level.
- Use `bay` as the *autoassign_policy* to configure automatic ownership at the bay level.

b. If you want to disable automatic disk ownership assignment, enter:

```
storage disk option modify -autoassign off -node node_name
```

2. Verify the automatic assignment settings for the disks:

```
storage disk option show
```

```
cluster1::> storage disk option show
```

Node	BKg. FW. Upd.	Auto Copy	Auto Assign	Auto Assign Policy
-----	-----	-----	-----	-----
cluster1-1	on	on	on	default
cluster1-2	on	on	on	default

Manually assign disk ownership

Disks must be owned by a node before they can be used in a local tier (aggregate).

If your cluster is not configured to use automatic disk ownership assignment, you must assign ownership manually.

You cannot reassign ownership of a disk that is in use in a local tier.

Steps

1. Using the CLI, display all unowned disks:

```
storage disk show -container-type unassigned
```

2. Assign each disk:

```
storage disk assign -disk disk_name -owner owner_name
```

You can use the wildcard character to assign more than one disk at once. If you are reassigning a spare disk that is already owned by a different node, you must use the “-force” option.

Manually assign ownership of partitioned disks overview

Using the CLI, you can set the ownership of the container disk or the partitions manually or by using auto-assignment—just as you do for unpartitioned disks.



If a container disk fails in a half-populated shelf and is replaced, ONTAP will not auto-assign ownership. In this case, any assignment of new disks will need to be done manually. To make auto-assign work on half-populated shelves, place disks equally on lower half and 6 on far right bays to begin with. That is, 6 disks from bays 0-5 and 6 disks from bays 18-23. After the container disk is assigned in an ADP-configured system, ONTAP’s software will handle any partitioning and partition assignments that are required, without user intervention.

You can perform the following tasks in the CLI:

Manually assign disks with root-data partitioning

For root-data partitioning, there are three owned entities (the container disk and the two partitions) collectively owned by the HA pair.

The container disk and the two partitions do not all need to be owned by the same node in the HA pair as long as they are all owned by one of the nodes in the HA pair. However, when you use a partition in a local tier (aggregate), it must be owned by the same node that owns the local tier.

Steps

- 1. Use the CLI to display the current ownership for the partitioned disk:

```
storage disk show -disk disk_name -partition-ownership
```

- 2. Set the CLI privilege level to advanced:

```
set -privilege advanced
```

- 3. Enter the appropriate command, depending on which ownership entity you want to assign ownership for:

If you want to assign ownership for the...	Use this command...
Container disk	<code>storage disk assign -disk disk_name -owner owner_name</code>
Data partition	<code>storage disk assign -disk disk_name -owner owner_name -data true</code>
Root partition	<code>storage disk assign -disk disk_name -owner owner_name -root true</code>

If any of the ownership entities are already owned, then you must include the “-force” option.

Manually assign disks with root-data-data partitioning

For root-data-data partitioning, there are four owned entities (the container disk and the three partitions) collectively owned by the HA pair.

Root-data-data partitioning creates one small partition as the root partition and two larger, equally sized partitions for data.

About this task

Parameters must be used with the `disk assign` command to assign the proper partition of a root-data-data partitioned disk. You cannot use these parameters with disks that are part of a storage pool. The default value is “false”.

- The `-data1 true` parameter assigns the “data1” partition of a root-data1-data2 partitioned disk.
- The `-data2 true` parameter assigns the “data2” partition of a root-data1-data2 partitioned disk.

Steps

1. Use the CLI to display the current ownership for the partitioned disk:

```
storage disk show -disk disk_name -partition-ownership
```

2. Set the CLI privilege level to advanced:

```
set -privilege advanced
```

3. Enter the appropriate command, depending on which ownership entity you want to assign ownership for:

If you want to assign ownership for the...	Use this command...
Container disk	<code>storage disk assign -disk <i>disk_name</i> -owner <i>owner_name</i></code>
Data1 partition	<code>storage disk assign -disk <i>disk_name</i> -owner <i>owner_name</i> -data1 true</code>
Data2 partition	<code>storage disk assign -disk <i>disk_name</i> -owner <i>owner_name</i> -data2 true</code>
Root partition	<code>storage disk assign -disk <i>disk_name</i> -owner <i>owner_name</i> -root true</code>

If any of the ownership entities are already owned, then you must include the “-force” option.

Set up an active-passive configuration on nodes using root-data partitioning

When an HA pair is configured to use root-data partitioning by the factory, ownership of the data partitions is split between both nodes in the pair for use in an active-active

configuration. If you want to use the HA pair in an active-passive configuration, you must update partition ownership before creating your data local tier (aggregate).

What you'll need

- You should have decided which node will be the active node and which node will be the passive node.
- Storage failover must be configured on the HA pair.

About this task

This task is performed on two nodes: Node A and Node B.

This procedure is designed for nodes for which no data local tier (aggregate) has been created from the partitioned disks.

Learn about [advanced disk partitioning](#).

Steps

All commands are inputted at the cluster shell.

1. View the current ownership of the data partitions:

```
storage aggregate show-spare-disks
```

The output shows that half of the data partitions are owned by one node and half are owned by the other node. All of the data partitions should be spare.

```
cluster1::> storage aggregate show-spare-disks

Original Owner: cluster1-01
Pool0
Partitioned Spares

Local
Local
Data
Root Physical
Disk
Usable      Size      Type      RPM Checksum      Usable
-----
-----
1.0.0      BSAS      7200 block      753.8GB
0B 828.0GB
1.0.1      BSAS      7200 block      753.8GB
73.89GB 828.0GB
1.0.5      BSAS      7200 block      753.8GB
0B 828.0GB
1.0.6      BSAS      7200 block      753.8GB
0B 828.0GB
1.0.10     BSAS      7200 block      753.8GB
0B 828.0GB
```

```

1.0.11          BSAS      7200 block      753.8GB
0B  828.0GB

Original Owner: cluster1-02
Pool0
Partitioned Spares

Local
Local
Data
Root Physical
Disk            Type      RPM Checksum      Usable
Usable      Size
-----
1.0.2          BSAS      7200 block      753.8GB
0B  828.0GB
1.0.3          BSAS      7200 block      753.8GB
0B  828.0GB
1.0.4          BSAS      7200 block      753.8GB
0B  828.0GB
1.0.7          BSAS      7200 block      753.8GB
0B  828.0GB
1.0.8          BSAS      7200 block      753.8GB
73.89GB  828.0GB
1.0.9          BSAS      7200 block      753.8GB
0B  828.0GB
12 entries were displayed.

```

2. Enter the advanced privilege level:

```
set advanced
```

3. For each data partition owned by the node that will be the passive node, assign it to the active node:

```
storage disk assign -force -data true -owner active_node_name -disk disk_name
```

You do not need to include the partition as part of the disk name.

You would enter a command similar to the following example for each data partition you need to reassign:

```
storage disk assign -force -data true -owner cluster1-01 -disk 1.0.3
```

4. Confirm that all of the partitions are assigned to the active node.

```

cluster1::*> storage aggregate show-spare-disks

Original Owner: cluster1-01
Pool0

```

Partitioned Spares

				Local
Local				
				Data
Root Physical				
Disk		Type	RPM Checksum	Usable
Usable	Size			

1.0.0		BSAS	7200 block	753.8GB
0B 828.0GB				
1.0.1		BSAS	7200 block	753.8GB
73.89GB 828.0GB				
1.0.2		BSAS	7200 block	753.8GB
0B 828.0GB				
1.0.3		BSAS	7200 block	753.8GB
0B 828.0GB				
1.0.4		BSAS	7200 block	753.8GB
0B 828.0GB				
1.0.5		BSAS	7200 block	753.8GB
0B 828.0GB				
1.0.6		BSAS	7200 block	753.8GB
0B 828.0GB				
1.0.7		BSAS	7200 block	753.8GB
0B 828.0GB				
1.0.8		BSAS	7200 block	753.8GB
0B 828.0GB				
1.0.9		BSAS	7200 block	753.8GB
0B 828.0GB				
1.0.10		BSAS	7200 block	753.8GB
0B 828.0GB				
1.0.11		BSAS	7200 block	753.8GB
0B 828.0GB				

Original Owner: cluster1-02

Pool0

Partitioned Spares

				Local
Local				
				Data
Root Physical				
Disk		Type	RPM Checksum	Usable
Usable	Size			

1.0.8		BSAS	7200 block	0B

```
73.89GB  828.0GB
13 entries were displayed.
```

Note that cluster1-02 still owns a spare root partition.

5. Return to administrative privilege:

```
set admin
```

6. Create your data aggregate, leaving at least one data partition as spare:

```
storage aggregate create new_aggr_name -diskcount number_of_partitions -node
active_node_name
```

The data aggregate is created and is owned by the active node.

Set up an active-passive configuration on nodes using root-data-data partitioning

When an HA pair is configured to use root-data-data partitioning by the factory, ownership of the data partitions is split between both nodes in the pair for use in an active-active configuration. If you want to use the HA pair in an active-passive configuration, you must update partition ownership before creating your data local tier (aggregate).

What you'll need

- You should have decided which node will be the active node and which node will be the passive node.
- Storage failover must be configured on the HA pair.

About this task

This task is performed on two nodes: Node A and Node B.

This procedure is designed for nodes for which no data local tier (aggregate) has been created from the partitioned disks.

Learn about [advanced disk partitioning](#).

Steps

All commands are input at the cluster shell.

1. View the current ownership of the data partitions:

```
storage aggregate show-spare-disks -original-owner passive_node_name -fields
local-usable-data1-size, local-usable-data2-size
```

The output shows that half of the data partitions are owned by one node and half are owned by the other node. All of the data partitions should be spare.

2. Enter the advanced privilege level:

```
set advanced
```

3. For each data1 partition owned by the node that will be the passive node, assign it to the active node:

```
storage disk assign -force -data1 -owner active_node_name -disk disk_name
```

You do not need to include the partition as part of the disk name

4. For each data2 partition owned by the node that will be the passive node, assign it to the active node:

```
storage disk assign -force -data2 -owner active_node_name -disk disk_name
```

You do not need to include the partition as part of the disk name

5. Confirm that all of the partitions are assigned to the active node:

```
storage aggregate show-spare-disks
```

```
cluster1::*> storage aggregate show-spare-disks
```

```
Original Owner: cluster1-01
```

```
Pool0
```

```
Partitioned Spares
```

Local		Local		Data	
Root Physical		Disk		Type	RPM Checksum Usable
Usable	Size				

1.0.0		BSAS	7200 block	753.8GB	
0B	828.0GB				
1.0.1		BSAS	7200 block	753.8GB	
73.89GB	828.0GB				
1.0.2		BSAS	7200 block	753.8GB	
0B	828.0GB				
1.0.3		BSAS	7200 block	753.8GB	
0B	828.0GB				
1.0.4		BSAS	7200 block	753.8GB	
0B	828.0GB				
1.0.5		BSAS	7200 block	753.8GB	
0B	828.0GB				
1.0.6		BSAS	7200 block	753.8GB	
0B	828.0GB				
1.0.7		BSAS	7200 block	753.8GB	
0B	828.0GB				
1.0.8		BSAS	7200 block	753.8GB	
0B	828.0GB				
1.0.9		BSAS	7200 block	753.8GB	
0B	828.0GB				
1.0.10		BSAS	7200 block	753.8GB	

```

0B 828.0GB
1.0.11 BSAS 7200 block 753.8GB
0B 828.0GB

Original Owner: cluster1-02
Pool0
Partitioned Spares

Local
Local
Data
Root Physical
Disk
Usable Size Type RPM Checksum Usable
-----
1.0.8 BSAS 7200 block 0B
73.89GB 828.0GB
13 entries were displayed.

```

Note that cluster1-02 still owns a spare root partition.

6. Return to administrative privilege:

```
set admin
```

7. Create your data aggregate, leaving at least one data partition as spare:

```
storage aggregate create new_aggr_name -diskcount number_of_partitions -node
active_node_name
```

The data aggregate is created and is owned by the active node.

8. Alternatively, you can use ONTAP's recommend aggregate layout which includes best practices for RAID group layout and spare counts:

```
storage aggregate auto-provision
```

Remove ownership from a disk

ONTAP writes disk ownership information to the disk. Before you remove a spare disk or its shelf from a node, you should remove its ownership information so that it can be properly integrated into another node.

What you'll need

The disk you want to remove ownership from must meet the following requirements:

- It must be a spare disk.

You cannot remove ownership from a disk that is being used in an local tier (aggregate).

- It cannot be in the maintenance center.
- It cannot be undergoing sanitization.
- It cannot have failed.

It is not necessary to remove ownership from a failed disk.

About this task

If you have automatic disk assignment enabled, ONTAP could automatically reassign ownership before you remove the disk from the node. For this reason, you disable the automatic ownership assignment until the disk is removed, and then you re-enable it.

Steps

1. If disk ownership automatic assignment is on, use the CLI to turn it off:

```
storage disk option modify -node node_name -autoassign off
```

2. If needed, repeat the previous step for the node's HA partner.
3. Remove the software ownership information from the disk:

```
storage disk removeowner disk_name
```

To remove ownership information from multiple disks, use a comma-separated list.

Example:

```
storage disk removeowner sys1:0a.23,sys1:0a.24,sys1:0a.25
```

4. If the disk is partitioned for root-data partitioning, remove ownership from the partitions:

- a. For ONTAP 9.10.1 and later, enter:

```
storage disk removeowner -disk disk_name
```

- b. For ONTAP 9.9.1 and earlier, enter both commands:

```
storage disk removeowner -disk disk_name -root true
```

```
storage disk removeowner -disk disk_name -data true
```

Both partitions are no longer owned by any node.

5. If you previously turned off automatic assignment of disk ownership, turn it on after the disk has been removed or reassigned:

```
storage disk option modify -node node_name -autoassign on
```

6. If needed, repeat the previous step for the node's HA partner.

Remove a failed disk

A disk that has completely failed is no longer counted by ONTAP as a usable disk, and you can immediately disconnect the disk from the disk shelf. However, you should leave a partially failed disk connected long enough for the Rapid RAID Recovery process to complete.

About this task

If you are removing a disk because it has failed or because it is producing excessive error messages, you should not use the disk again in this or any other storage system.

Steps

1. Use the CLI to find the disk ID of the failed disk:

```
storage disk show -broken
```

If the disk does not appear in the list of failed disks, it might have partially failed, with a Rapid RAID Recovery in process. In this case, you should wait until the disk is present in the list of failed disks (which means that the Rapid RAID Recovery process is complete) before removing the disk.

2. Determine the physical location of the disk you want to remove:

```
storage disk set-led -action on -disk disk_name 2
```

The fault LED on the face of the disk is lit.

3. Remove the disk from the disk shelf, following the instructions in the hardware guide for your disk shelf model.

Disk sanitization

Disk sanitization overview

Disk sanitization is the process of physically obliterating data by overwriting disks or SSDs with specified byte patterns or random data so that recovery of the original data becomes impossible. Using the sanitization process ensures that no one can recover the data on the disks.

This functionality is available through the nodeshell in all ONTAP 9 releases, and starting with ONTAP 9.6 in maintenance mode.

The disk sanitization process uses three successive default or user-specified byte overwrite patterns for up to seven cycles per operation. The random overwrite pattern is repeated for each cycle.

Depending on the disk capacity, the patterns, and the number of cycles, the process can take several hours. Sanitization runs in the background. You can start, stop, and display the status of the sanitization process. The sanitization process contains two phases: the "Formatting phase" and the "Pattern overwrite phase".

Formatting phase

The operation performed for the formatting phase depends on the class of disk being sanitized, as shown in the following table:

Disk class	Formatting phase operation
Capacity HDDs	Skipped
Performance HDDs	SCSI format operation
SSDs	SCSI sanitize operation

Pattern overwrite phase

The specified overwrite patterns are repeated for the specified number of cycles.

When the sanitization process is complete, the specified disks are in a sanitized state. They are not returned to spare status automatically. You must return the sanitized disks to the spare pool before the newly sanitized disks are available to be added to another aggregate.

When disk sanitization cannot be performed

Disk sanitization is not supported for all disk types. In addition, there are circumstances in which disk sanitization cannot be performed.

- It is not supported on all SSD part numbers.

For information about which SSD part numbers support disk sanitization, see the [Hardware Universe](#).

- It is not supported in takeover mode for systems in an HA pair.
- It cannot be performed on disks that were failed due to readability or writability problems.
- It does not perform its formatting phase on ATA drives.
- If you are using the random pattern, it cannot be performed on more than 100 disks at one time.
- It is not supported on array LUNs.
- If you sanitize both SES disks in the same ESH shelf at the same time, you see errors on the console about access to that shelf, and shelf warnings are not reported for the duration of the sanitization.

However, data access to that shelf is not interrupted.

What happens if disk sanitization is interrupted

If disk sanitization is interrupted by user intervention or an unexpected event such as a power outage, ONTAP takes action to return the disks that were being sanitized to a known state, but you must also take action before the sanitization process can finish.

Disk sanitization is a long-running operation. If the sanitization process is interrupted by power failure, system panic, or manual intervention, the sanitization process must be repeated from the beginning. The disk is not designated as sanitized.

If the formatting phase of disk sanitization is interrupted, ONTAP must recover any disks that were corrupted by the interruption. After a system reboot and once every hour, ONTAP checks for any sanitization target disk that did not complete the formatting phase of its sanitization. If any such disks are found, ONTAP recovers them. The recovery method depends on the type of the disk. After a disk is recovered, you can rerun the sanitization process on that disk; for HDDs, you can use the `-s` option to specify that the formatting phase is not repeated again.

Tips for creating and backing up local tiers (aggregates) containing data to be sanitized

If you are creating or backing up local tiers (aggregates) to contain data that might need to be sanitized, following some simple guidelines will reduce the time it takes to sanitize your data.

- Make sure your local tiers containing sensitive data are not larger than they need to be.

If they are larger than needed, sanitization requires more time, disk space, and bandwidth.

- When you back up local tiers containing sensitive data, avoid backing them up to local tier that also contain large amounts of nonsensitive data.

This reduces the resources required to move nonsensitive data before sanitizing sensitive data.

Sanitize a disk

Sanitizing a disk allows you to remove data from a disk or a set of disks on decommissioned or inoperable systems so that the data can never be recovered.

Two methods are available to sanitize disks using the CLI:

Sanitize a disk with “maintenance mode” commands (ONTAP 9.6 and later releases)

Beginning with ONTAP 9.6, you can perform disk sanitization in maintenance mode.

Before you begin

- The disks cannot be self-encrypting disks (SED).

You must use the `storage encryption disk sanitize` command to sanitize an SED.

[Encryption of data at rest](#)

Steps

1. Boot into maintenance mode.

- a. Exit the current shell by entering `halt`.

The LOADER prompt is displayed.

- b. Enter maintenance mode by entering `boot_ontap maint`.

After some information is displayed, the maintenance mode prompt is displayed.

2. If the disks you want to sanitize are partitioned, unpartition each disk:



The command to unpartition a disk is only available at the diag level and should be performed only under NetApp Support supervision. It is highly recommended that you contact NetApp Support before you proceed. You can also refer to the Knowledge Base article [How to unpartition a spare drive in ONTAP](#)

```
disk unpartition disk_name
```

3. Sanitize the specified disks:

```
disk sanitize start [-p pattern1|-r [-p pattern2|-r [-p pattern3|-r]]] [-c cycle_count] disk_list
```



Do not turn off power to the node, disrupt the storage connectivity, or remove target disks while sanitizing. If sanitizing is interrupted during the formatting phase, the formatting phase must be restarted and allowed to finish before the disks are sanitized and ready to be returned to the spare pool. If you need to abort the sanitization process, you can do so by using the `disk sanitize abort` command. If the specified disks are undergoing the formatting phase of sanitization, the abort does not occur until the phase is complete.

`-p pattern1 -p pattern2 -p pattern3` specifies a cycle of one to three user-defined hex byte overwrite patterns that can be applied in succession to the disks being sanitized. The default pattern is three passes, using 0x55 for the first pass, 0xaa for the second pass, and 0x3c for the third pass.

`-r` replaces a patterned overwrite with a random overwrite for any or all of the passes.

`-c cycle_count` specifies the number of times that the specified overwrite patterns are applied. The

default value is one cycle. The maximum value is seven cycles.

disk_list specifies a space-separated list of the IDs of the spare disks to be sanitized.

4. If desired, check the status of the disk sanitization process:

```
disk sanitize status [disk_list]
```

5. After the sanitization process is complete, return the disks to spare status for each disk:

```
disk sanitize release disk_name
```

6. Exit maintenance mode.

Sanitize a disk with “nodeshell” commands (all ONTAP 9 releases)

For all versions of ONTAP 9, when disk sanitization is enabled using nodeshell commands, some low-level ONTAP commands are disabled. After disk sanitization is enabled on a node, it cannot be disabled.

Before you begin

- The disks must be spare disks; they must be owned by a node, but not used in a local tier (aggregate).

If the disks are partitioned, neither partition can be in use in a local tier (aggregate).

- The disks cannot be self-encrypting disks (SED).

You must use the `storage encryption disk sanitize` command to sanitize an SED.

Encryption of data at rest

- The disks cannot be part of a storage pool.

Steps

1. If the disks you want to sanitize are partitioned, unpartition each disk:



The command to unpartition a disk is only available at the diag level and should be performed only under NetApp Support supervision. **It is highly recommended that you contact NetApp Support before you proceed.** You can also refer to the Knowledge Base article [How to unpartition a spare drive in ONTAP](#).

```
disk unpartition disk_name
```

2. Enter the nodeshell for the node that owns the disks you want to sanitize:

```
system node run -node node_name
```

3. Enable disk sanitization:

```
options licensed_feature.disk_sanitization.enable on
```

You are asked to confirm the command because it is irreversible.

4. Switch to the nodeshell advanced privilege level:

```
priv set advanced
```

5. Sanitize the specified disks:

```
disk sanitize start [-p pattern1|-r [-p pattern2|-r [-p pattern3|-r]]] [-c  
cycle_count] disk_list
```



Do not turn off power to the node, disrupt the storage connectivity, or remove target disks while sanitizing. If sanitizing is interrupted during the formatting phase, the formatting phase must be restarted and allowed to finish before the disks are sanitized and ready to be returned to the spare pool. If you need to abort the sanitization process, you can do so by using the `disk sanitize abort` command. If the specified disks are undergoing the formatting phase of sanitization, the abort does not occur until the phase is complete.

`-p pattern1 -p pattern2 -p pattern3` specifies a cycle of one to three user-defined hex byte overwrite patterns that can be applied in succession to the disks being sanitized. The default pattern is three passes, using 0x55 for the first pass, 0xaa for the second pass, and 0x3c for the third pass.

`-r` replaces a patterned overwrite with a random overwrite for any or all of the passes.

`-c cycle_count` specifies the number of times that the specified overwrite patterns are applied.

The default value is one cycle. The maximum value is seven cycles.

`disk_list` specifies a space-separated list of the IDs of the spare disks to be sanitized.

6. If you want to check the status of the disk sanitization process:

```
disk sanitize status [disk_list]
```

7. After the sanitization process is complete, return the disks to spare status:

```
disk sanitize release disk_name
```

8. Return to the nodeshell admin privilege level:

```
priv set admin
```

9. Return to the ONTAP CLI:

```
exit
```

10. Determine whether all of the disks were returned to spare status:

```
storage aggregate show-spare-disks
```

If...	Then...
All of the sanitized disks are listed as spares	You are done. The disks are sanitized and in spare status.

Some of the sanitized disks are not listed as spares

Complete the following steps:

a. Enter advanced privilege mode:

```
set -privilege advanced
```

b. Assign the unassigned sanitized disks to the appropriate node for each disk:

```
storage disk assign -disk disk_name -owner  
node_name
```

c. Return the disks to spare status for each disk:

```
storage disk unfail -disk disk_name -s -q
```

d. Return to administrative mode:

```
set -privilege admin
```

Result

The specified disks are sanitized and designated as hot spares. The serial numbers of the sanitized disks are written to `/etc/log/sanitized_disks`.

The specified disks' sanitization logs, which show what was completed on each disk, are written to `/mroot/etc/log/sanitization.log`.

Commands for managing disks

You can use the `storage disk` and `storage aggregate` commands to manage your disks.

If you want to...	Use this command...
Display a list of spare disks, including partitioned disks, by owner	<code>storage aggregate show-spare-disks</code>
Display the disk RAID type, current usage, and RAID group by aggregate	<code>storage aggregate show-status</code>
Display the RAID type, current usage, aggregate, and RAID group, including spares, for physical disks	<code>storage disk show -raid</code>
Display a list of failed disks	<code>storage disk show -broken</code>
Display the pre-cluster (nodescope) drive name for a disk	<code>storage disk show -primary-paths</code> (advanced)

Illuminate the LED for a particular disk or shelf	<code>storage disk set-led</code>
Display the checksum type for a specific disk	<code>storage disk show -fields checksum-compatibility</code>
Display the checksum type for all spare disks	<code>storage disk show -fields checksum-compatibility -container-type spare</code>
Display disk connectivity and placement information	<code>storage disk show -fields disk,primary-port,secondary-name,secondary-port,shelf,bay</code>
Display the pre-cluster disk names for specific disks	<code>storage disk show -disk diskname -fields diskpathnames</code>
Display the list of disks in the maintenance center	<code>storage disk show -maintenance</code>
Display SSD wear life	<code>storage disk show -ssd-wear</code>
Unpartition a shared disk	<code>storage disk unpartition</code> (available at diagnostic level)
Zero all non-zeroed disks	<code>storage disk zerospares</code>
Stop an ongoing sanitization process on one or more specified disks	<code>system node run -node nodename -command disk sanitize</code>
Display storage encryption disk information	<code>storage encryption disk show</code>
Retrieve authentication keys from all linked key management servers	<code>security key-manager restore</code>

Related information

[ONTAP 9 Commands](#)

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	<code>storage aggregate show</code> <code>storage aggregate show-space -fields snap-size-total,used-including-snapshot-reserve</code>
How disks and RAID groups are used in an aggregate, and RAID status	<code>storage aggregate show-status</code>
The amount of disk space that would be reclaimed if you deleted a specific Snapshot copy	<code>volume snapshot compute-reclaimable</code>
The amount of space used by a volume	<code>volume show -fields size,used,available,percent-used</code> <code>volume show-space</code>
The amount of space used by a volume in the containing aggregate	<code>volume show-footprint</code>

Related information

[ONTAP 9 Commands](#)

Commands for displaying information about storage shelves

You use the `storage shelf show` command to display configuration and error information for your disk shelves.

If you want to display...	Use this command...
General information about shelf configuration and hardware status	<code>storage shelf show</code>
Detailed information for a specific shelf, including stack ID	<code>storage shelf show -shelf</code>
Unresolved, customer actionable, errors by shelf	<code>storage shelf show -errors</code>
Bay information	<code>storage shelf show -bay</code>
Connectivity information	<code>storage shelf show -connectivity</code>
Cooling information, including temperature sensors and cooling fans	<code>storage shelf show -cooling</code>
Information about I/O modules	<code>storage shelf show -module</code>

If you want to display...	Use this command...
Port information	<code>storage shelf show -port</code>
Power information, including PSUs (power supply units), current sensors, and voltage sensors	<code>storage shelf show -power</code>

Related information

[ONTAP 9 Commands](#)

Manage RAID configurations

Overview of managing RAID configurations

You can perform various procedures to manage RAID configurations in your system.

- **Aspects of managing RAID configurations:**
 - [Default RAID policies for local tiers \(aggregates\)](#)
 - [RAID protection levels for disks](#)
- **Drive and RAID group information for a local tier (aggregate)**
 - [Determine drive and RAID group information for a local tier \(aggregate\)](#)
- **RAID configuration conversions**
 - [Convert from RAID-DP to RAID-TEC](#)
 - [Convert from RAID-TEC to RAID-DP](#)
- **RAID group sizing**
 - [Considerations for sizing RAID groups](#)
 - [Customize the size of your RAID group](#)

Default RAID policies for local tiers (aggregates)

Either RAID-DP or RAID-TEC is the default RAID policy for all new local tiers (aggregates). The RAID policy determines the parity protection you have in the event of a disk failure.

RAID-DP provides double-parity protection in the event of a single or double disk failure. RAID-DP is the default RAID policy for the following local tier (aggregate) types:

- All Flash local tiers
- Flash Pool local tiers
- Performance hard disk drive (HDD) local tiers

RAID-TEC is supported on all disk types and all platforms, including AFF. Local tiers that contain larger disks have a higher possibility of concurrent disk failures. RAID-TEC helps to mitigate this risk by providing triple-parity protection so that your data can survive up to three simultaneous disk failures. RAID-TEC is the default RAID policy for capacity HDD local tiers with disks that are 6 TB or larger.

Each RAID policy type requires a minimum number of disks:

- RAID-DP: minimum of 5 disks
- RAID-TEC: minimum of 7 disks

RAID protection levels for disks

ONTAP supports three levels of RAID protection for local tiers (aggregates). The level of RAID protection determines the number of parity disks available for data recovery in the event of disk failures.

With RAID protection, if there is a data disk failure in a RAID group, ONTAP can replace the failed disk with a spare disk and use parity data to reconstruct the data of the failed disk.

- **RAID4**

With RAID4 protection, ONTAP can use one spare disk to replace and reconstruct the data from one failed disk within the RAID group.

- **RAID-DP**

With RAID-DP protection, ONTAP can use up to two spare disks to replace and reconstruct the data from up to two simultaneously failed disks within the RAID group.

- **RAID-TEC**

With RAID-TEC protection, ONTAP can use up to three spare disks to replace and reconstruct the data from up to three simultaneously failed disks within the RAID group.

Drive and RAID group information for a local tier (aggregate)

Some local tier (aggregate) administration tasks require that you know what types of drives compose the local tier, their size, checksum, and status, whether they are shared with other local tiers, and the size and composition of the RAID groups.

Step

1. Show the drives for the aggregate, by RAID group:

```
storage aggregate show-status aggr_name
```

The drives are displayed for each RAID group in the aggregate.

You can see the RAID type of the drive (data, parity, dparity) in the `Position` column. If the `Position` column displays `shared`, then the drive is shared: if it is an HDD, it is a partitioned disk; if it is an SSD, it is part of a storage pool.

Example: A Flash Pool aggregate using an SSD storage pool and data partitions

```
cluster1::> storage aggregate show-status nodeA_fp_1
```

Owner Node: cluster1-a

Aggregate: nodeA_fp_1 (online, mixed_raid_type, hybrid) (block checksums)

Plex: /nodeA_fp_1/plex0 (online, normal, active, pool0)

RAID Group /nodeA_fp_1/plex0/rg0 (normal, block checksums, raid_dp)

Position	Disk	Pool	Type	RPM	Usable Size	Physical Size	Status
shared	2.0.1	0	SAS	10000	472.9GB	547.1GB	(normal)
shared	2.0.3	0	SAS	10000	472.9GB	547.1GB	(normal)
shared	2.0.5	0	SAS	10000	472.9GB	547.1GB	(normal)
shared	2.0.7	0	SAS	10000	472.9GB	547.1GB	(normal)
shared	2.0.9	0	SAS	10000	472.9GB	547.1GB	(normal)
shared	2.0.11	0	SAS	10000	472.9GB	547.1GB	(normal)

RAID Group /nodeA_flashpool_1/plex0/rg1

(normal, block checksums, raid4) (Storage Pool: SmallSP)

Position	Disk	Pool	Type	RPM	Usable Size	Physical Size	Status
shared	2.0.13	0	SSD	-	186.2GB	745.2GB	(normal)
shared	2.0.12	0	SSD	-	186.2GB	745.2GB	(normal)

8 entries were displayed.

Convert from RAID-DP to RAID-TEC

If you want the added protection of triple-parity, you can convert from RAID-DP to RAID-TEC. RAID-TEC is recommended if the size of the disks used in your local tier (aggregate) is greater than 4 TiB.

What you'll need

The local tier (aggregate) that is to be converted must have a minimum of seven disks.

About this task

Hard disk drive (HDD) local tiers can be converted from RAID-DP to RAID-TEC. This includes HDD tiers in Flash Pool local tiers.

Steps

1. Verify that the aggregate is online and has a minimum of six disks:

```
storage aggregate show-status -aggregate aggregate_name
```

2. Convert the aggregate from RAID-DP to RAID-TEC:

```
storage aggregate modify -aggregate aggregate_name -raidtype raid_tec
```

3. Verify that the aggregate RAID policy is RAID-TEC:

```
storage aggregate show aggregate_name
```

Convert from RAID-TEC to RAID-DP

If you reduce the size of your local tier (aggregate) and no longer need triple parity, you can convert your RAID policy from RAID-TEC to RAID-DP and reduce the number of disks you need for RAID parity.

What you'll need

The maximum RAID group size for RAID-TEC is larger than the maximum RAID group size for RAID-DP. If the largest RAID-TEC group size is not within the RAID-DP limits, you cannot convert to RAID-DP.

Steps

1. Verify that the aggregate is online and has a minimum of six disks:

```
storage aggregate show-status -aggregate aggregate_name
```

2. Convert the aggregate from RAID-TEC to RAID-DP:

```
storage aggregate modify -aggregate aggregate_name -raidtype raid_dp
```

3. Verify that the aggregate RAID policy is RAID-DP:

```
storage aggregate show aggregate_name
```

Considerations for sizing RAID groups

Configuring an optimum RAID group size requires a trade-off of factors. You must decide which factors—speed of RAID rebuild, assurance against risk of data loss due to drive failure, optimizing I/O performance, and maximizing data storage space—are most important for the (local tier) aggregate that you are configuring.

When you create larger RAID groups, you maximize the space available for data storage for the same amount of storage used for parity (also known as the “parity tax”). On the other hand, when a disk fails in a larger RAID group, reconstruction time is increased, impacting performance for a longer period of time. In addition, having more disks in a RAID group increases the probability of a multiple disk failure within the same RAID group.

HDD or array LUN RAID groups

You should follow these guidelines when sizing your RAID groups composed of HDDs or array LUNs:

- All RAID groups in an local tier (aggregate) should have the same number of disks.

While you can have up to 50% less or more than the number of disks in different raid groups on one local tier, this might lead to performance bottlenecks in some cases, so it is best avoided.

- The recommended range of RAID group disk numbers is between 12 and 20.

The reliability of performance disks can support a RAID group size of up to 28, if needed.

- If you can satisfy the first two guidelines with multiple RAID group disk numbers, you should choose the larger number of disks.

SSD RAID groups in Flash Pool local tiers (aggregates)

The SSD RAID group size can be different from the RAID group size for the HDD RAID groups in a Flash Pool local tier (aggregate). Usually, you should ensure that you have only one SSD RAID group for a Flash Pool local tier, to minimize the number of SSDs required for parity.

SSD RAID groups in SSD local tiers (aggregates)

You should follow these guidelines when sizing your RAID groups composed of SSDs:

- All RAID groups in a local tier (aggregate) should have a similar number of drives.

The RAID groups do not have to be exactly the same size, but you should avoid having any RAID group that is less than one half the size of other RAID groups in the same local tier when possible.

- For RAID-DP, the recommended range of RAID group size is between 20 and 28.

Customize the size of your RAID groups

You can customize the size of your RAID groups to ensure that your RAID group sizes are appropriate for the amount of storage you plan to include for a local tier (aggregate).

About this task

For standard local tiers (aggregates), you change the size of RAID groups for each local tier separately. For Flash Pool local tiers, you can change the RAID group size for the SSD RAID groups and the HDD RAID groups independently.

The following list outlines some facts about changing the RAID group size:

- By default, if the number of disks or array LUNs in the most recently created RAID group is less than the new RAID group size, disks or array LUNs will be added to the most recently created RAID group until it reaches the new size.
- All other existing RAID groups in that local tier remain the same size, unless you explicitly add disks to them.
- You can never cause a RAID group to become larger than the current maximum RAID group size for the local tier.
- You cannot decrease the size of already created RAID groups.
- The new size applies to all RAID groups in that local tier (or, in the case of a Flash Pool local tier, all RAID groups for the affected RAID group type—SSD or HDD).

Steps

1. Use the applicable command:

If you want to...	Enter the following command...

Change the maximum RAID group size for the SSD RAID groups of a Flash Pool aggregate	<code>storage aggregate modify -aggregate aggr_name -cache-raid-group-size size</code>
Change the maximum size of any other RAID groups	<code>storage aggregate modify -aggregate aggr_name -maxraidsz size</code>

Examples

The following command changes the maximum RAID group size of the aggregate n1_a4 to 20 disks or array LUNs:

```
storage aggregate modify -aggregate n1_a4 -maxraidsz 20
```

The following command changes the maximum RAID group size of the SSD cache RAID groups of the Flash Pool aggregate n1_cache_a2 to 24:

```
storage aggregate modify -aggregate n1_cache_a2 -cache-raid-group-size 24
```

Manage Flash Pool local tiers (aggregates)

Manage Flash Pool tiers (aggregates)

You can perform various procedures to manage Flash Pool tiers (aggregates) in your system.

- **Caching policies**
 - [Flash Pool local tier \(aggregate\) caching policies](#)
 - [Manage Flash Pool caching policies](#)
- **SSD partitioning**
 - [Flash Pool SSD partitioning for Flash Pool local tiers \(aggregates\) using storage pools](#)
- **Candidacy and cache size**
 - [Determine Flash Pool candidacy and optimal cache size](#)
- **Flash Pool creation**
 - [Create a Flash Pool local tier \(aggregate\) using physical SSDs](#)
 - [Create a Flash Pool local tier \(aggregate\) using SSD storage pools](#)

Flash Pool local tier (aggregate) caching policies

Caching policies for the volumes in a Flash Pool local tier (aggregate) let you deploy Flash as a high performance cache for your working data set while using lower-cost HDDs for less frequently accessed data. If you are providing cache to two or more Flash Pool local tiers, you should use Flash Pool SSD partitioning to share SSDs across the local tiers in the Flash Pool.

Caching policies are applied to volumes that reside in Flash Pool local tiers. You should understand how caching policies work before changing them.

In most cases, the default caching policy of “auto” is the best caching policy to use. The caching policy should be changed only if a different policy provides better performance for your workload. Configuring the wrong caching policy can severely degrade volume performance; the performance degradation could increase gradually over time.

Caching policies combine a read caching policy and a write caching policy. The policy name concatenates the names of the read caching policy and the write caching policy, separated by a hyphen. If there is no hyphen in the policy name, the write caching policy is “none”, except for the “auto” policy.

Read caching policies optimize for future read performance by placing a copy of the data in the cache in addition to the stored data on HDDs. For read caching policies that insert data into the cache for write operations, the cache operates as a *write-through* cache.

Data inserted into the cache by using the write caching policy exists only in cache; there is no copy in HDDs. Flash Pool cache is RAID protected. Enabling write caching makes data from write operations available for reads from cache immediately, while deferring writing the data to HDDs until it ages out of the cache.

If you move a volume from a Flash Pool local tier to a single-tier local tier, it loses its caching policy; if you later move it back to a Flash Pool local tier, it is assigned the default caching policy of “auto”. If you move a volume between two Flash Pool local tier, the caching policy is preserved.

Change a caching policy

You can use the CLI to change the caching policy for a volume that resides on a Flash Pool local tier by using the `-caching-policy` parameter with the `volume create` command.

When you create a volume on a Flash Pool local tier, by default, the “auto” caching policy is assigned to the volume.

Manage Flash Pool caching policies

Overview of managing Flash Pool caching policies

Using the CLI, you can perform various procedures to manage Flash Pool caching policies in your system.

- **Preparation**
 - [Determine whether to modify the caching policy of Flash Pool local tiers \(aggregates\)](#)
- **Caching policies modification**
 - [Modify caching policies of Flash Pool local tiers \(aggregates\)](#)
 - [Set the cache-retention policy for Flash Pool local tiers \(aggregates\)](#)

Determine whether to modify the caching policy of Flash Pool local tiers (aggregates)

You can assign cache-retention policies to volumes in Flash Pool local tiers (aggregates) to determine how long the volume data remains in the Flash Pool cache. However, in some cases changing the cache-retention policy might not impact the amount of time the volume’s data remains in the cache.

About this task

If your data meets any of the following conditions, changing your cache-retention policy might not have an

impact:

- Your workload is sequential.
- Your workload does not reread the random blocks cached in the solid state drives (SSDs).
- The cache size of the volume is too small.

Steps

The following steps check for the conditions that must be met by the data. The task must be done using the CLI in advanced privilege mode.

1. Use the CLI to view the workload volume:

```
statistics start -object workload_volume
```

2. Determine the workload pattern of the volume:

```
statistics show -object workload_volume -instance volume-workload -counter sequential_reads
```

3. Determine the hit rate of the volume:

```
statistics show -object waf1_hya_vvol -instance volume -counter read_ops_replaced_ppercent|wc_write_blks_overwritten_percent
```

4. Determine the Cacheable Read and Project Cache Alloc of the volume:

```
system node run -node node_name waf1 awa start aggr_name
```

5. Display the AWA summary:

```
system node run -node node_name waf1 awa print aggr_name
```

6. Compare the volume's hit rate to the Cacheable Read.

If the hit rate of the volume is greater than the Cacheable Read, then your workload does not reread random blocks cached in the SSDs.

7. Compare the volume's current cache size to the Project Cache Alloc.

If the current cache size of the volume is greater than the Project Cache Alloc, then the size of your volume cache is too small.

Modify caching policies of Flash Pool local tiers (aggregates)

You should modify the caching policy of a volume only if a different caching policy is expected to provide better performance. You can modify the caching policy of a volume on a Flash Pool local tier (aggregate).

What you'll need

You must determine whether you want to modify your caching policy.

About this task

In most cases, the default caching policy of “auto” is the best caching policy that you can use. The caching policy should be changed only if a different policy provides better performance for your workload. Configuring the wrong caching policy can severely degrade volume performance; the performance degradation could increase gradually over time. You should use caution when modifying caching policies. If you experience performance issues with a volume for which the caching policy has been changed, you should return the caching policy to “auto”.

Step

- 1. Use the CLI to modify the volume’s caching policy:

```
volume modify -volume volume_name -caching-policy policy_name
```

Example

The following example modifies the caching policy of a volume named “vol2” to the policy “none”:

```
volume modify -volume vol2 -caching-policy none
```

Set the cache-retention policy for Flash Pool local tiers (aggregates)

You can assign cache-retention policies to volumes in Flash Pool local tiers (aggregates). Data in volumes with a high cache-retention policy remains in cache longer and data in volumes with a low cache-retention policy is removed sooner. This increases performance of your critical workloads by making high priority information accessible at a faster rate for a longer period of time.

What you’ll need

You should know whether your system has any conditions that might prevent the cache-retention policy from having an impact on how long your data remains in cache.

Steps

Use the CLI in advanced privilege mode to perform the following steps:

- 1. Change the privilege setting to advanced:

```
set -privilege advanced
```

- 2. Verify the volume’s cache-retention policy:

By default the cache retention policy is “normal”.

- 3. Set the cache-retention policy:

ONTAP Version	Command
---------------	---------

ONTAP 9.0, 9.1	<pre>priority hybrid-cache set volume_name read-cache=read_cache_value write- cache=write_cache_value cache- retention- priority=cache_retention_policy</pre> <p>Set <code>cache_retention_policy</code> to <code>high</code> for data that you want to remain in cache longer. Set <code>cache_retention_policy</code> to <code>low</code> for data that you want to remove from cache sooner.</p>
ONTAP 9.2 or later	<pre>volume modify -volume volume_name -vserver vservers_name -caching-policy policy_name.</pre>

4. Verify that the volume's cache-retention policy is changed to the option you selected.
5. Return the privilege setting to admin:

```
set -privilege admin
```

Flash Pool SSD partitioning for Flash Pool local tiers (aggregates) using storage pools

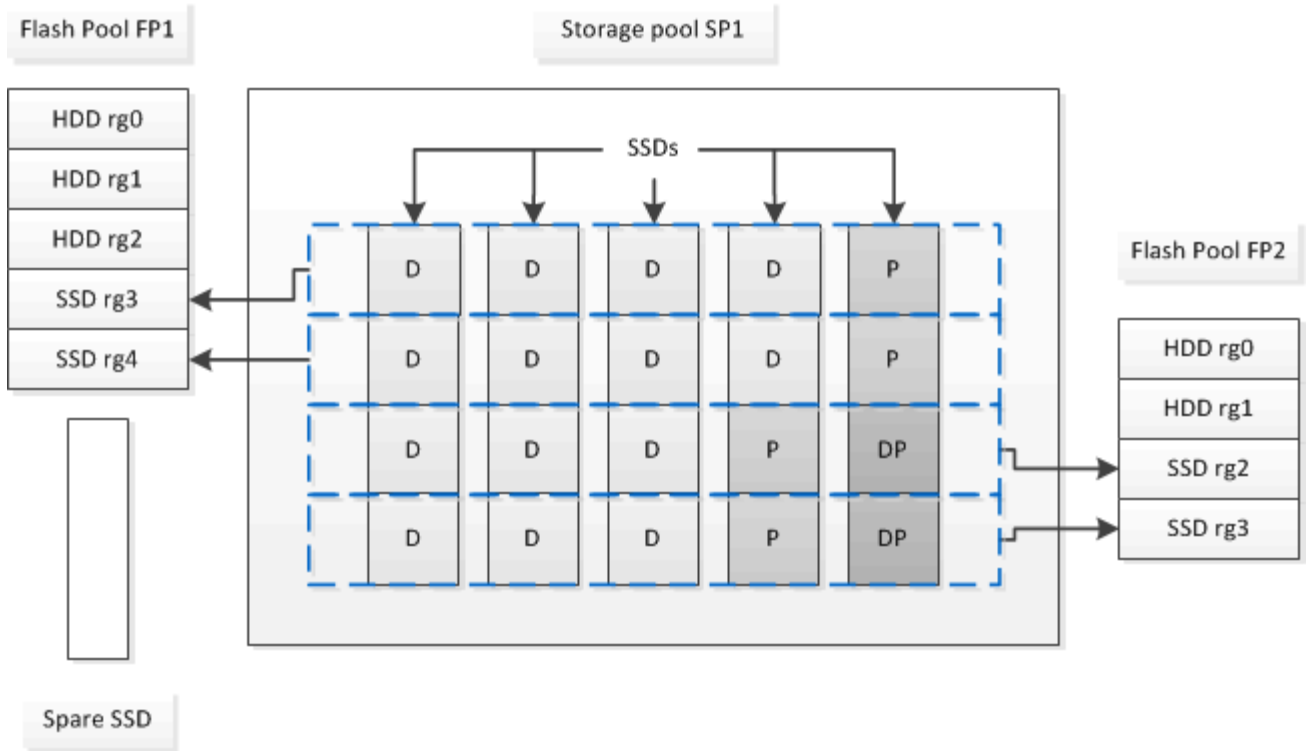
If you are providing cache to two or more Flash Pool local tiers (aggregates), you should use Flash Pool Solid-State Drive (SSD) partitioning. Flash Pool SSD partitioning allows SSDs to be shared by all the local tiers that use the Flash Pool. This spreads the cost of parity over multiple local tiers, increases SSD cache allocation flexibility, and maximizes SSD performance.

For an SSD to be used in a Flash Pool local tier, the SSD must be placed in a storage pool. You cannot use SSDs that have been partitioned for root-data partitioning in a storage pool. After the SSD is placed in the storage pool, the SSD can no longer be managed as a stand-alone disk and cannot be removed from the storage pool unless you destroy the local tiers associated with the Flash Pool and you destroy the storage pool.

SSD storage pools are divided into four equal allocation units. SSDs added to the storage pool are divided into four partitions and one partition is assigned to each of the four allocation units. The SSDs in the storage pool must be owned by the same HA pair. By default, two allocation units are assigned to each node in the HA pair. Allocation units must be owned by the node that owns the local tier it is serving. If more Flash cache is required for local tiers on one of the nodes, the default number of allocation units can be shifted to decrease the number on one node and increase the number on the partner node.

You use spare SSDs to add to an SSD storage pool. If the storage pool provides allocation units to Flash Pool local tiers owned by both nodes in the HA pair, then the spare SSDs can be owned by either node. However, if the storage pool provides allocation units only to Flash Pool local tiers owned by one of the nodes in the HA pair, then the SSD spares must be owned by that same node.

The following illustration is an example of Flash Pool SSD partitioning. The SSD storage pool provides cache to two Flash Pool local tiers:



Storage pool SP1 is composed of five SSDs and a hot spare SSD. Two of the storage pool's allocation units are allocated to Flash Pool FP1, and two are allocated to Flash Pool FP2. FP1 has a cache RAID type of RAID4. Therefore, the allocation units provided to FP1 contain only one partition designated for parity. FP2 has a cache RAID type of RAID-DP. Therefore, the allocation units provided to FP2 include a parity partition and a double-parity partition.

In this example, two allocation units are allocated to each Flash Pool local tier. However, if one Flash Pool local tier required a larger cache, you could allocate three of the allocation units to that Flash Pool local tier, and only one to the other.

Determine Flash Pool candidacy and optimal cache size

Before converting an existing local tier (aggregate) to a Flash Pool local tier, you can determine whether the local tier is I/O bound and the best Flash Pool cache size for your workload and budget. You can also check whether the cache of an existing Flash Pool local tier is sized correctly.

What you'll need

You should know approximately when the local tier you are analyzing experiences its peak load.

Steps

1. Enter advanced mode:

```
set advanced
```

2. If you need to determine whether an existing local tier (aggregate) would be a good candidate for conversion to a Flash Pool aggregate, determine how busy the disks in the aggregate are during a period of peak load, and how that is affecting latency:

```
statistics show-periodic -object disk:raid_group -instance raid_group_name
```

```
-counter disk_busy|user_read_latency -interval 1 -iterations 60
```

You can decide whether reducing latency by adding Flash Pool cache makes sense for this aggregate.

The following command shows the statistics for the first RAID group of the aggregate “aggr1”:

```
statistics show-periodic -object disk:raid_group -instance /aggr1/plex0/rg0  
-counter disk_busy|user_read_latency -interval 1 -iterations 60
```

3. Start Automated Workload Analyzer (AWA):

```
storage automated-working-set-analyzer start -node node_name -aggregate  
aggr_name
```

AWA begins collecting workload data for the volumes associated with the specified aggregate.

4. Exit advanced mode:

```
set admin
```

Allow AWA to run until one or more intervals of peak load have occurred. AWA collects workload statistics for the volumes associated with the specified aggregate, and analyzes data for up to one rolling week in duration. Running AWA for more than one week will report only on data collected from the most recent week. Cache size estimates are based on the highest loads seen during the data collection period; the load does not need to be high for the entire data collection period.

5. Enter advanced mode:

```
set advanced
```

6. Display the workload analysis:

```
storage automated-working-set-analyzer show -node node_name -instance
```

7. Stop AWA:

```
storage automated-working-set-analyzer stop node_name
```

All workload data is flushed and is no longer available for analysis.

8. Exit advanced mode:

```
set admin
```

Create a Flash Pool local tier (aggregate) using physical SSDs

You create a Flash Pool local tier (aggregate) by enabling the feature on an existing local tier composed of HDD RAID groups, and then adding one or more SSD RAID groups to that local tier. This results in two sets of RAID groups for that local tier: SSD RAID groups (the SSD cache) and HDD RAID groups.

About this task

After you add an SSD cache to an local tier to create a Flash Pool local tier, you cannot remove the SSD cache

to convert the local tier back to its original configuration.

By default, the RAID level of the SSD cache is the same as the RAID level of the HDD RAID groups. You can override this default selection by specifying the “raidtype” option when you add the first SSD RAID groups.

Before you begin

- You must have identified a valid local tier composed of HDDs to convert to a Flash Pool local tier.
- You must have determined write-caching eligibility of the volumes associated with the local tier, and completed any required steps to resolve eligibility issues.
- You must have determined the SSDs you will be adding, and these SSDs must be owned by the node on which you are creating the Flash Pool local tier.
- You must have determined the checksum types of both the SSDs you are adding and the HDDs already in the local tier.
- You must have determined the number of SSDs you are adding and the optimal RAID group size for the SSD RAID groups.

Using fewer RAID groups in the SSD cache reduces the number of parity disks required, but larger RAID groups require RAID-DP.

- You must have determined the RAID level you want to use for the SSD cache.
- You must have determined the maximum cache size for your system and determined that adding SSD cache to your local tier will not cause you to exceed it.
- You must have familiarized yourself with the configuration requirements for Flash Pool local tiers.



Steps

You can create a FlashPool aggregate using System Manager or the ONTAP CLI.

System Manager

Beginning with ONTAP 9.12.1, you can use System Manager to create a Flash Pool local tier using physical SSDs.

Steps

1. Select **Storage > Tiers** then select an existing local HDD storage tier.
2. Select  then **Add Flash Pool Cache**.
3. Select **Use dedicated SSDs as cache**.
4. Select a disk type and the number of disks.
5. Choose a RAID type.
6. Select **Save**.
7. Locate the storage tier then select .
8. Select **More Details**. Verify that Flash Pool shows as **Enabled**.

CLI

Steps

1. Mark the local tier (aggregate) as eligible to become a Flash Pool aggregate:

```
storage aggregate modify -aggregate aggr_name -hybrid-enabled true
```

If this step does not succeed, determine write-caching eligibility for the target aggregate.

2. Add the SSDs to the aggregate by using the `storage aggregate add` command.
 - You can specify the SSDs by ID or by using the `diskcount` and `disktype` parameters.
 - If the HDDs and the SSDs do not have the same checksum type, or if the aggregate is a mixed-checksum aggregate, then you must use the `checksumstyle` parameter to specify the checksum type of the disks you are adding to the aggregate.
 - You can specify a different RAID type for the SSD cache by using the `raidtype` parameter.
 - If you want the cache RAID group size to be different from the default for the RAID type you are using, you should change it now, by using the `-cache-raid-group-size` parameter.

Create a Flash Pool local tier (aggregate) using SSD storage pools

Overview of creating a Flash Pool local tier (aggregate) using SSD storage pools

You can perform various procedures to create a Flash Pool local tier (aggregate) using SSD storage pools:

- **Preparation**
 - [Determine whether a Flash Pool local tier \(aggregate\) is using an SSD storage pool](#)
- **SSD storage pool creation**
 - [Create an SSD storage pool](#)
 - [Add SSDs to an SSD storage pool](#)

- **Flash Pool creation using SSD storage pools**

- Create a Flash Pool local tier (aggregate) using SSD storage pool allocation units
- Determine the impact to cache size of adding SSDs to an SSD storage pool

Determine whether a Flash Pool local tier (aggregate) is using an SSD storage pool

You can configure a Flash Pool (local tier) aggregate by adding one or more allocation units from an SSD storage pool to an existing HDD local tier.

You manage Flash Pool local tiers differently when they use SSD storage pools to provide their cache than when they use discrete SSDs.

Step

1. Display the aggregate's drives by RAID group:

```
storage aggregate show-status aggr_name
```

If the aggregate is using one or more SSD storage pools, the value for the `Position` column for the SSD RAID groups is displayed as `Shared`, and the name of the storage pool is displayed next to the RAID group name.

Add cache to a local tier (aggregate) by creating an SSD storage pool

You can provision cache by converting an existing local tier (aggregate) to a Flash Pool local tier (aggregate) by adding solid state drives (SSDs).

You can create solid state drive (SSD) storage pools to provide SSD cache for two to four Flash Pool local tiers (aggregates). Flash Pool aggregates enable you to deploy flash as high performance cache for your working data set while using lower-cost HDDs for less frequently accessed data.

About this task

- You must supply a disk list when creating or adding disks to a storage pool.

Storage pools do not support a `diskcount` parameter.

- The SSDs used in the storage pool should be the same size.

System Manager

Use System Manager to add an SSD cache (ONTAP 9.12.1 and later)

Beginning with ONTAP 9.12.1, you can use System Manager to add an SSD cache.



Storage pool options are not available on AFF systems.

Steps

1. Click **Cluster > Disks** and then click **Show/Hide**.
2. Select **Type** and verify that spare SSDs exist on the cluster.
3. Click to **Storage > Tiers** and click **Add Storage Pool**.
4. Select the disk type.
5. Enter a disk size.
6. Select the number of disks to add to the storage pool.
7. Review the estimated cache size.

Use System Manager to add an SSD cache (ONTAP 9.7 only)



Use the CLI procedure if you are using an ONTAP version later than ONTAP 9.7 or earlier than ONTAP 9.12.1.

Steps

1. Click **(Return to classic version)**.
2. Click **Storage > Aggregates & Disks > Aggregates**.
3. Select the local tier (aggregate), and then click **Actions > Add Cache**.
4. Select the cache source as "storage pools" or "dedicated SSDs".
5. Click **(Switch to the new experience)**.
6. Click **Storage > Tiers** to verify the size of the new aggregate.

CLI

Use the CLI to create an SSD storage pool

Steps

1. Determine the names of the available spare SSDs:

```
storage aggregate show-spare-disks -disk-type SSD
```

The SSDs used in a storage pool can be owned by either node of an HA pair.

2. Create the storage pool:

```
storage pool create -storage-pool sp_name -disk-list disk1,disk2,...
```

3. **Optional:** Verify the newly created storage pool:

```
storage pool show -storage-pool sp_name
```

Results

After the SSDs are placed into the storage pool, they no longer appear as spares on the cluster, even though the storage provided by the storage pool has not yet been allocated to any Flash Pool caches. You cannot add SSDs to a RAID group as discrete drives; their storage can be provisioned only by using the allocation units of the storage pool to which they belong.

Create a Flash Pool local tier (aggregate) using SSD storage pool allocation units

You can configure a Flash Pool local tier (aggregate) by adding one or more allocation units from an SSD storage pool to an existing HDD local tier.

Beginning with ONTAP 9.12.1, you can use the redesigned System Manager to create a Flash Pool local tier using storage pool allocation units.

What you'll need

- You must have identified a valid local tier composed of HDDs to convert to a Flash Pool local tier.
- You must have determined write-caching eligibility of the volumes associated with the local tier, and completed any required steps to resolve eligibility issues.
- You must have created an SSD storage pool to provide the SSD cache to this Flash Pool local tier.

Any allocation unit from the storage pool that you want to use must be owned by the same node that owns the Flash Pool local tier.

- You must have determined how much cache you want to add to the local tier.

You add cache to the local tier by allocation units. You can increase the size of the allocation units later by adding SSDs to the storage pool if there is room.

- You must have determined the RAID type you want to use for the SSD cache.

After you add a cache to the local tier from SSD storage pools, you cannot change the RAID type of the cache RAID groups.

- You must have determined the maximum cache size for your system and determined that adding SSD cache to your local tier will not cause you to exceed it.

You can see the amount of cache that will be added to the total cache size by using the `storage pool show` command.

- You must have familiarized yourself with the configuration requirements for Flash Pool local tier.

About this task



If you want the RAID type of the cache to be different from that of the HDD RAID groups, you must specify the cache RAID type when you add the SSD capacity. After you add the SSD capacity to the local tier, you can no longer change the RAID type of the cache.

After you add an SSD cache to a local tier to create a Flash Pool local tier, you cannot remove the SSD cache to convert the local tier back to its original configuration.

System Manager

Beginning with ONTAP 9.12.1, you can use System Manager to add SSDs to an SSD storage pool.

Steps

1. Click **Storage > Tiers** and select an existing local HDD storage tier.
2. Click  and select **Add Flash Pool Cache**.
3. Select **Use Storage Pools**.
4. Select a storage pool.
5. Select a cache size and RAID configuration.
6. Click **Save**.
7. Locate the storage tier again and click .
8. Select **More Details** and verify that the Flash Pool shows as **Enabled**.

CLI

Steps

1. Mark the aggregate as eligible to become a Flash Pool aggregate:

```
storage aggregate modify -aggregate aggr_name -hybrid-enabled true
```

If this step does not succeed, determine write-caching eligibility for the target aggregate.

2. Show the available SSD storage pool allocation units:

```
storage pool show-available-capacity
```

3. Add the SSD capacity to the aggregate:

```
storage aggregate add aggr_name -storage-pool sp_name -allocation-units  
number_of_units
```

If you want the RAID type of the cache to be different from that of the HDD RAID groups, you must change it when you enter this command by using the `raidtype` parameter.

You do not need to specify a new RAID group; ONTAP automatically puts the SSD cache into separate RAID groups from the HDD RAID groups.

You cannot set the RAID group size of the cache; it is determined by the number of SSDs in the storage pool.

The cache is added to the aggregate and the aggregate is now a Flash Pool aggregate. Each allocation unit added to the aggregate becomes its own RAID group.

4. Confirm the presence and size of the SSD cache:

```
storage aggregate show aggregate_name
```

The size of the cache is listed under `Total Hybrid Cache Size`.

Related information

[NetApp Technical Report 4070: Flash Pool Design and Implementation Guide](#)

Determine the impact to cache size of adding SSDs to an SSD storage pool

If adding SSDs to a storage pool causes your platform model's cache limit to be exceeded, ONTAP does not allocate the newly added capacity to any Flash Pool local tiers (aggregates). This can result in some or all of the newly added capacity being unavailable for use.

About this task

When you add SSDs to an SSD storage pool that has allocation units already allocated to Flash Pool local tiers (aggregates), you increase the cache size of each of those local tiers and the total cache on the system. If none of the storage pool's allocation units have been allocated, adding SSDs to that storage pool does not affect the SSD cache size until one or more allocation units are allocated to a cache.

Steps

1. Determine the usable size of the SSDs you are adding to the storage pool:

```
storage disk show disk_name -fields usable-size
```

2. Determine how many allocation units remain unallocated for the storage pool:

```
storage pool show-available-capacity sp_name
```

All unallocated allocation units in the storage pool are displayed.

3. Calculate the amount of cache that will be added by applying the following formula:

$$(4 - \text{number of unallocated allocation units}) \times 25\% \times \text{usable size} \times \text{number of SSDs}$$

Add SSDs to an SSD storage pool

When you add solid state drives (SSDs) to an SSD storage pool, you increase the storage pool's physical and usable sizes and allocation unit size. The larger allocation unit size also affects allocation units that have already been allocated to local tiers (aggregates).

What you'll need

You must have determined that this operation will not cause you to exceed the cache limit for your HA pair. ONTAP does not prevent you from exceeding the cache limit when you add SSDs to an SSD storage pool, and doing so can render the newly added storage capacity unavailable for use.

About this task


When you add SSDs to an existing SSD storage pool, the SSDs must be owned by one node or the other of the same HA pair that already owned the existing SSDs in the storage pool. You can add SSDs that are owned by either node of the HA pair.

The SSD you add to the storage pool must be the same size as disk currently used in the storage pool.

System Manager

Beginning with ONTAP 9.12.1, you can use System Manager to add SSDs to an SSD storage pool.

Steps

1. Click **Storage > Tiers** and locate the **Storage Pools** section.
2. Locate the storage pool, click , and select **Add Disks**.
3. Choose the disk type and select the number of disks.
4. Review the estimate cache size.

CLI

Steps

1. **Optional:** View the current allocation unit size and available storage for the storage pool:

```
storage pool show -instance sp_name
```

2. Find available SSDs:

```
storage disk show -container-type spare -type SSD
```

3. Add the SSDs to the storage pool:

```
storage pool add -storage-pool sp_name -disk-list disk1,disk2...
```

The system displays which Flash Pool aggregates will have their size increased by this operation and by how much, and prompts you to confirm the operation.

Commands for managing SSD storage pools

ONTAP provides the `storage pool` command for managing SSD storage pools.

If you want to...	Use this command...
Display how much storage a storage pool is providing to which aggregates	<code>storage pool show-aggregate</code>
Display how much cache would be added to the overall cache capacity for both RAID types (allocation unit data size)	<code>storage pool show -instance</code>
Display the disks in a storage pool	<code>storage pool show-disks</code>
Display the unallocated allocation units for a storage pool	<code>storage pool show-available-capacity</code>
Change the ownership of one or more allocation units of a storage pool from one HA partner to the other	<code>storage pool reassign</code>

Related information

[ONTAP 9 Commands](#)

Copyright information

Copyright © 2024 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.

LIMITED RIGHTS LEGEND: Use, duplication, or disclosure by the government is subject to restrictions as set forth in subparagraph (b)(3) of the Rights in Technical Data -Noncommercial Items at DFARS 252.227-7013 (FEB 2014) and FAR 52.227-19 (DEC 2007).

Data contained herein pertains to a commercial product and/or commercial service (as defined in FAR 2.101) and is proprietary to NetApp, Inc. All NetApp technical data and computer software provided under this Agreement is commercial in nature and developed solely at private expense. The U.S. Government has a non-exclusive, non-transferrable, nonsublicensable, 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) (FEB 2014).

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.