DELL Technologies

MODULE 4 STORAGE EFFICIENCY

PARTICIPANT GUIDE

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Data Reduction

Data Reduction

General Data Reduction Overview

In general, Data Reduction reduces the amount of physical storage that is required to save a dataset. Data Reduction helps reduce the Total Cost of Ownership (TCO) of a Dell Unity XT storage system.

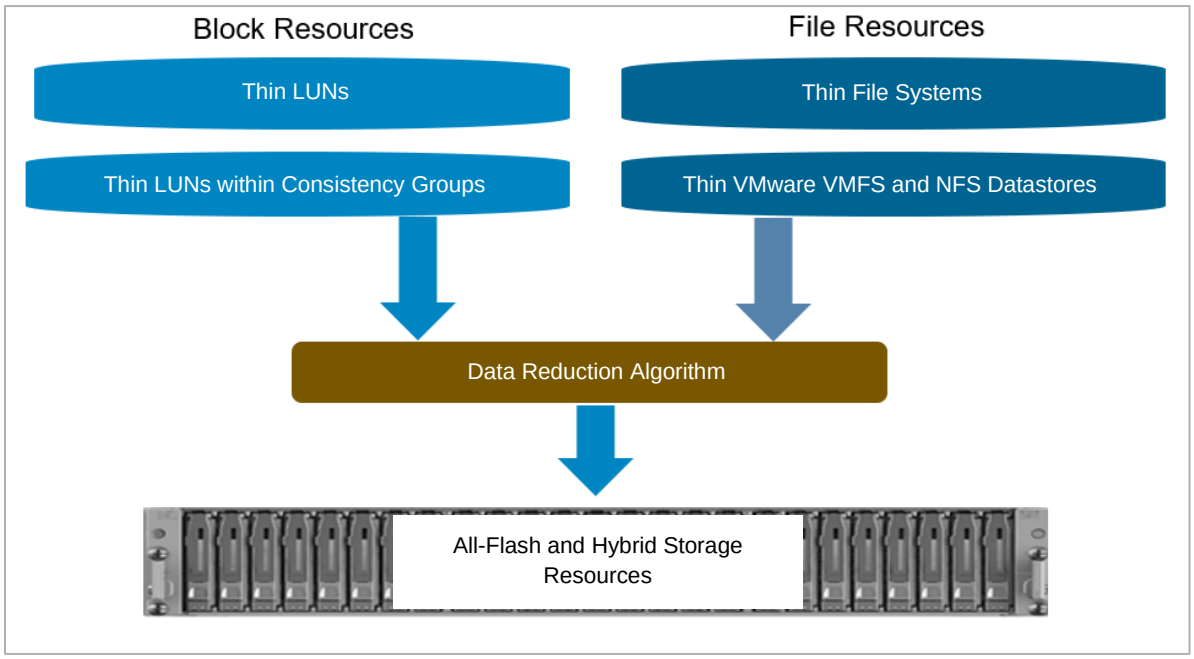
Data Reduction is achieved using the following methods:

- **Deduplication** uses algorithms to analyze, perform pattern detection, and attempts to store only a single instance of a data pattern.
- **Zero Detection** logically detects and discards consecutive zeros, saves only one instance, and uses pointers.
- **Compression** encodes data using fewer bits than the original representation.
- **Advanced Deduplication** deduplicates data blocks within a given storage resource that do not contain internally-defined data patterns.

When Data Reduction is selected on Dell Unity XT systems, it enables Deduplication, Zero Detection, and Compression.

Advanced Deduplication requires Data Reduction to be enabled on the resource but can be enabled or disabled independently of the Data Reduction setting.

Data Reduction Overview in Dell Unity XT



Dell Unity XT Data Reduction:

- Is licensed with all physical Dell Unity XT systems at no additional cost.
- Is easy to manage and is intelligently controlled by the storage system.
- Is configured through Unisphere, Unisphere CLI, or REST API.
- Is supported on All-Flash and Hybrid pools.
- Is supported on Thin LUNs, Thin LUNs within a Consistency Group, Thin File Systems, and Thin VMware VMFS and NFS Datastores.
- Provides Data Reduction savings on Snapshots and Thin Clones.
- Is not available on the Dell UnityVSA.

Data Reduction can also be enabled on Block and File storage resources participating in replication sessions. The source and destination storage resources in a replication session are independent. Data Reduction with or without the Advanced Deduplication option can be enabled or disabled separately on the source and destination resource.

Considerations

- Hybrid pools created on Unity XT model systems support Data Reduction with and without Advanced Deduplication enabled on Traditional or Dynamic pools.
- To support Data Reduction, the pool must contain a flash tier and the total usable capacity of the flash tier must meet or exceed 10% of the total pool capacity.
  - Data Reduction can be enabled on an existing resource if the flash capacity requirement is met.
- The Advanced Deduplication switch is available only on:
  - Dynamic or Traditional pools in Unity XT 380F, 480F, 680F, and 880F systems
  - Dynamic pools in Unity All-Flash 450F, 550F, and 650F systems.
  - All-Flash and Hybrid pools in Unity Hybrid 380, 480, 680, and 880 systems.

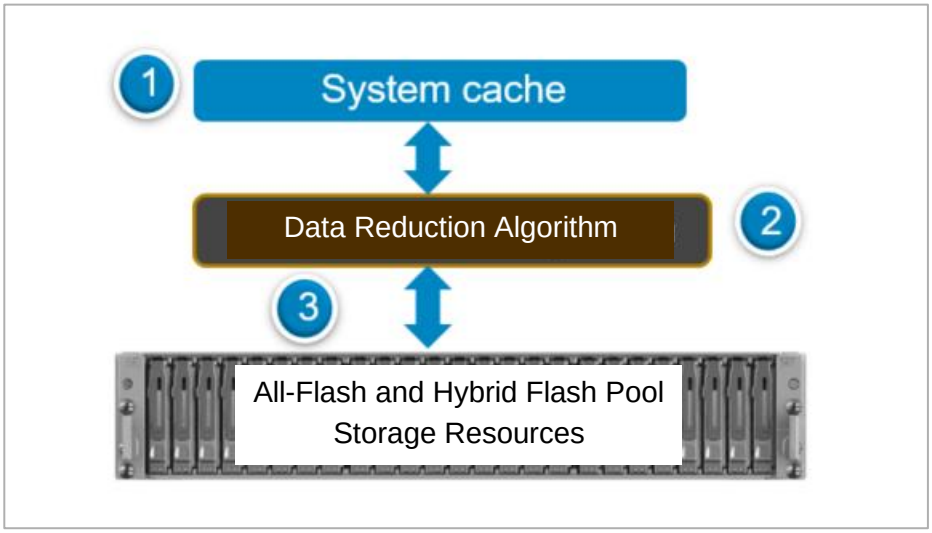
Go to: The About Data Reduction and Advanced Deduplication section of the *Dell Unity XT Family Configuring Pools* documentation.

For a deeper dive, review the Dell Unity XT: Data Reduction whitepaper.

Data Reduction Theory of Operation

For Data Reduction enabled storage resources, the Data Reduction process occurs during the System Cache proactive cleaning operations or when System Cache is flushing cache pages to the drives within a Pool. The data in this scenario may be new to the storage resource, or the data may be an update to existing blocks of data currently residing on disk.

In either case, the Data Reduction algorithm occurs before the data is written to the drives within the Pool. During the Data Reduction process, multiple blocks are aggregated together and sent through the algorithm. After determining if savings can be achieved or data must be written to disk, space within the Pool is allocated if needed, and the data is written to the drives.



Data Reduction process

Process:

1. System write cache sends data to the Data Reduction algorithm during proactive cleaning or flushing.
2. Data Reduction logic determines any savings.
3. Space is allocated in the storage resource for the dataset if needed, and the data is sent to the disk.

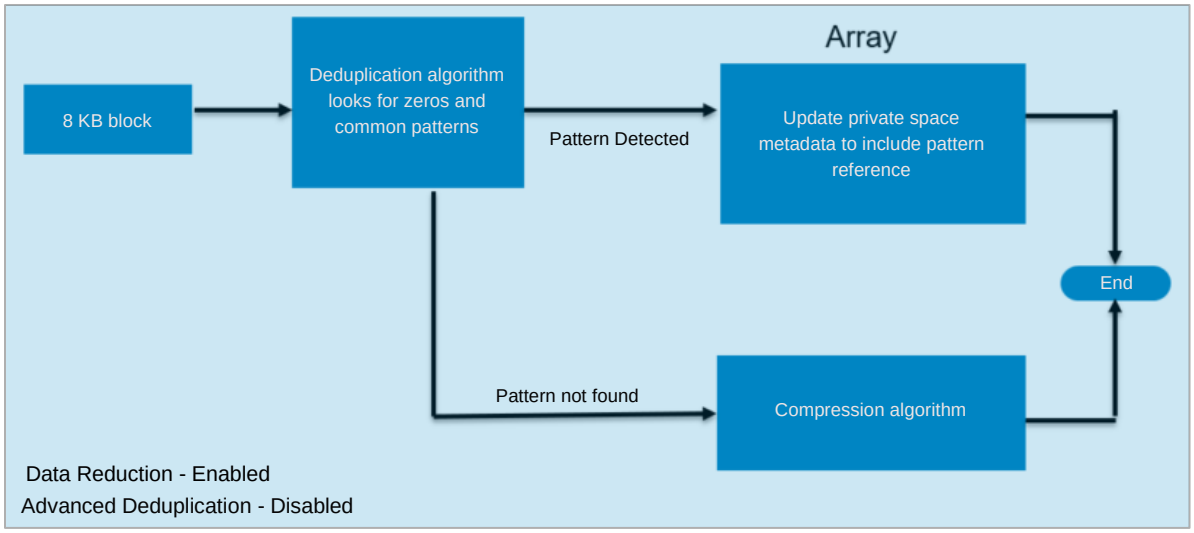
Data Reduction - Deduplication

Data is sent to the Data Reduction algorithm during proactive cleaning or flushing of write path data.

In the example, an 8 KB block enters the Data Reduction algorithm and Advanced Deduplication is disabled.

- The 8 KB block is first passed through the deduplication algorithm. Within this algorithm, the system determines if the block consists entirely of zeros, or matches a known pattern within the system.
- If a pattern is detected, the private space metadata of the storage resource is updated to include information about the pattern, along with information about how to re-create the data block if it is accessed in the future.
- Also, when deduplication finds a pattern match, the remainder of the Data Reduction feature is skipped for those blocks which saves system resources. None of the 8 KB block of data is written to the Pool at this time.
- If a block was allocated previously, then the block can be freed for reuse. When a read for the block of data is received, the metadata is reviewed, and the block will be re-created and sent to the host.
- If a pattern is not found, the data is passed through the Compression Algorithm. If savings are achieved, space is allocated on the Pool to accommodate the data.
- If the data is an overwrite, it may be written to the original location if it is the same size as before.

The example displays the behavior of the Data Reduction algorithm when Advanced Deduplication is disabled.



Data Reduction algorithm behavior when Advanced Deduplication is disabled

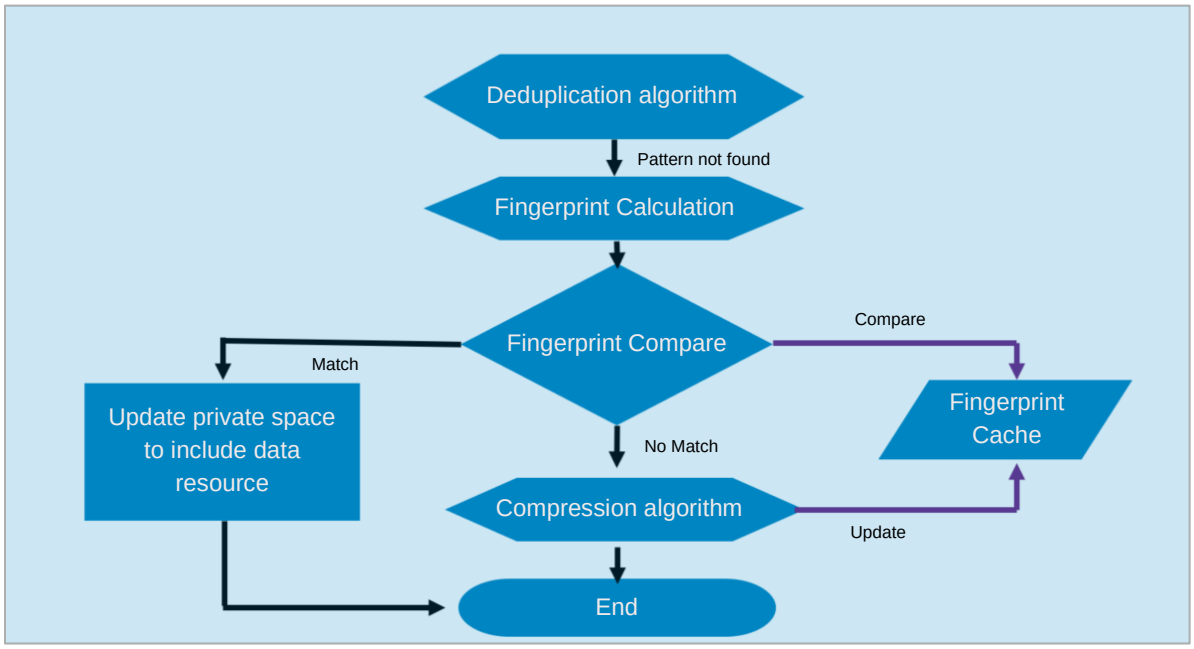
Data Reduction - Advanced Deduplication

If an 8 KB block is not deduplicated by the zero and common pattern deduplication algorithm, the data is passed into the Advanced Deduplication algorithm.

Each 8 KB block receives a fingerprint, which is compared to the fingerprints for the storage resource. If a matching fingerprint is found, deduplication occurs. The private space within the resource is updated to include a reference to the block of data residing on disk. No data is written to disk at this time.

Storage resource savings are compounded as deduplication can reference compressed blocks on disk. If a match is not found, the data is passed to the compression algorithm. Advanced Deduplication only compares and detects duplicate data that is found within a single storage resource, such as a LUN or File System.

The fingerprint cache is a component of the Advanced Deduplication algorithm. The fingerprint cache is a region in system memory that is reserved for storing fingerprints for each storage resource with Advanced Deduplication enabled. There is one fingerprint cache per storage processor, and it contains the fingerprints for storage resources residing on that SP.



Data Reduction algorithm behavior when Advanced Deduplication is enabled

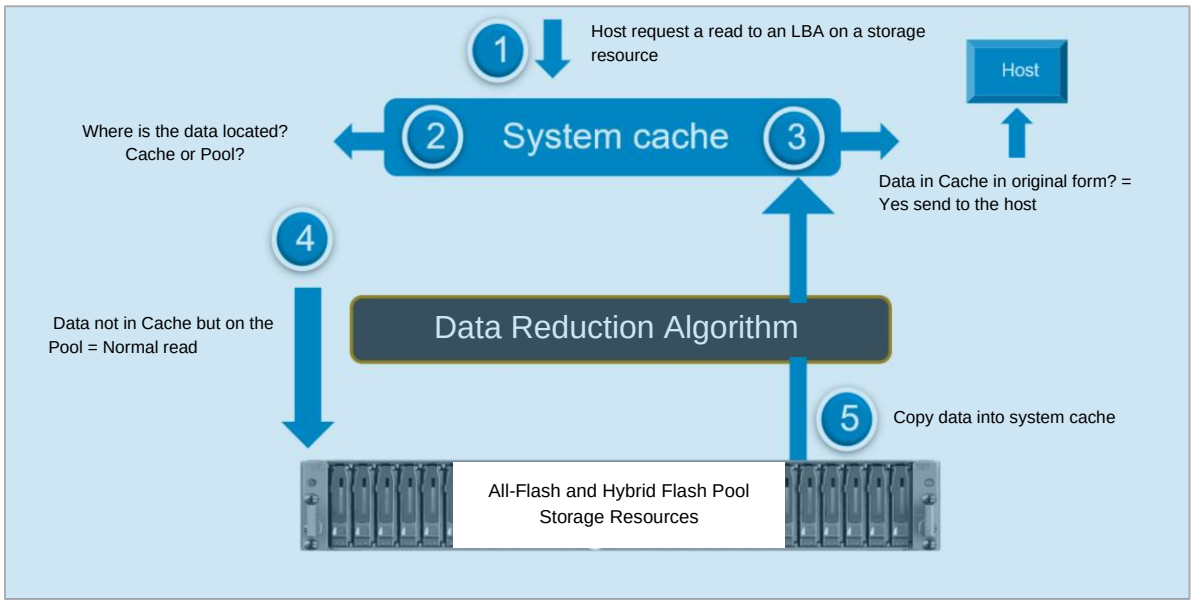
Through machine learning and statistics, the fingerprint cache determines which fingerprints to keep, and which ones to replace with new fingerprints. The fingerprint cache algorithm learns which resources have high deduplication rates and allows those resources to consume more fingerprint locations.

- If no fingerprint match is detected, the blocks enter the compression algorithm.
- If savings can be achieved, space is allocated within the Pool which matches the compressed size of the data, the data is compressed, and the data is written to the Pool. When Advanced Deduplication is enabled, the fingerprint for the block of data is also stored with the compressed data on disk.
- The fingerprint cache is then updated to include the fingerprint for the new data.

Compression does not compress data if no savings can be achieved. In this instance, the original block of data will be written to the Pool. Waiting to allocate space within the resource until after the compression algorithm is complete helps to not over-allocate space within the storage resource.

Read Operation

The example shows the process for a host Read operation.



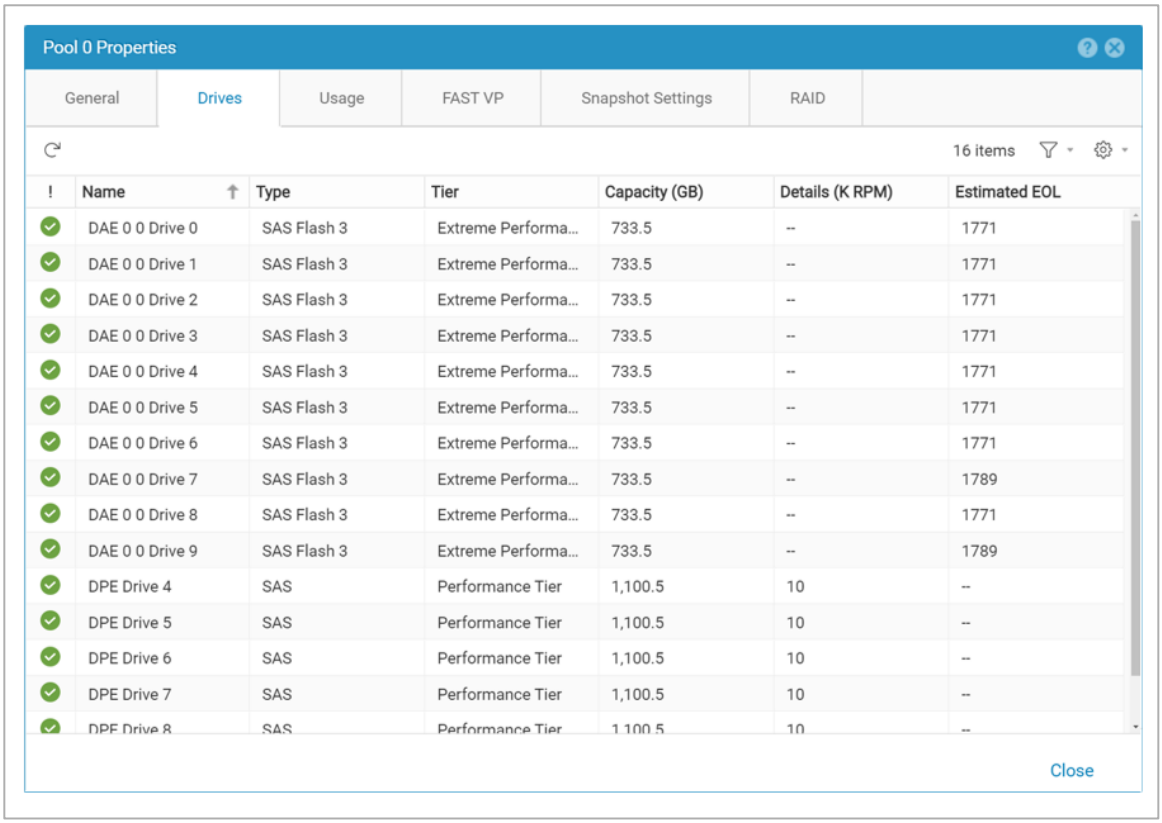
Read operation with Data Reduction enabled

Important: Logical Block Addressing (LBA) specifies the location of blocks of data that are stored on a storage resource.

Enable Data Reduction and Advanced Deduplication on Supported Storage Resources

Hybrid Flash Pools

Data Reduction can be enabled on resources that are built from hybrid flash pools within the Dell Unity XT 380, 480, 680 and 880 systems.

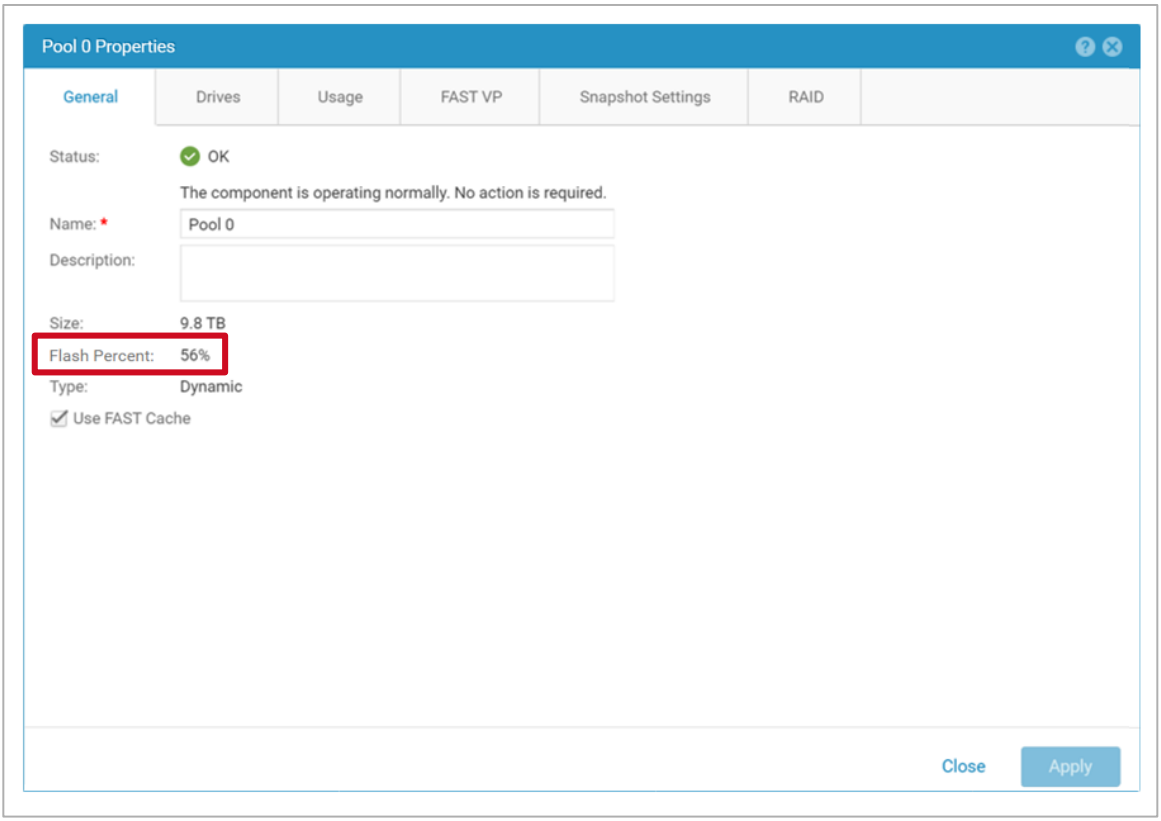


!	Name	Type	Tier	Capacity (GB)	Details (K RPM)	Estimated EOL
	DAE 0 0 Drive 0	SAS Flash 3	Extreme Performa...	733.5	--	1771
	DAE 0 0 Drive 1	SAS Flash 3	Extreme Performa...	733.5	--	1771
	DAE 0 0 Drive 2	SAS Flash 3	Extreme Performa...	733.5	--	1771
	DAE 0 0 Drive 3	SAS Flash 3	Extreme Performa...	733.5	--	1771
	DAE 0 0 Drive 4	SAS Flash 3	Extreme Performa...	733.5	--	1771
	DAE 0 0 Drive 5	SAS Flash 3	Extreme Performa...	733.5	--	1771
	DAE 0 0 Drive 6	SAS Flash 3	Extreme Performa...	733.5	--	1771
	DAE 0 0 Drive 7	SAS Flash 3	Extreme Performa...	733.5	--	1789
	DAE 0 0 Drive 8	SAS Flash 3	Extreme Performa...	733.5	--	1771
	DAE 0 0 Drive 9	SAS Flash 3	Extreme Performa...	733.5	--	1789
	DPE Drive 4	SAS	Performance Tier	1,100.5	10	--
	DPE Drive 5	SAS	Performance Tier	1,100.5	10	--
	DPE Drive 6	SAS	Performance Tier	1,100.5	10	--
	DPE Drive 7	SAS	Performance Tier	1,100.5	10	--
	DPE Drive 8	SAS	Performance Tier	1,100.5	10	--

The properties page of a multi-tiered pool that includes SAS Flash 3 and SAS drives

Flash Capacity

To support Data Reduction, the proportion of flash capacity on the pool must be equal to or exceed **10%** of the total capacity of the pool.

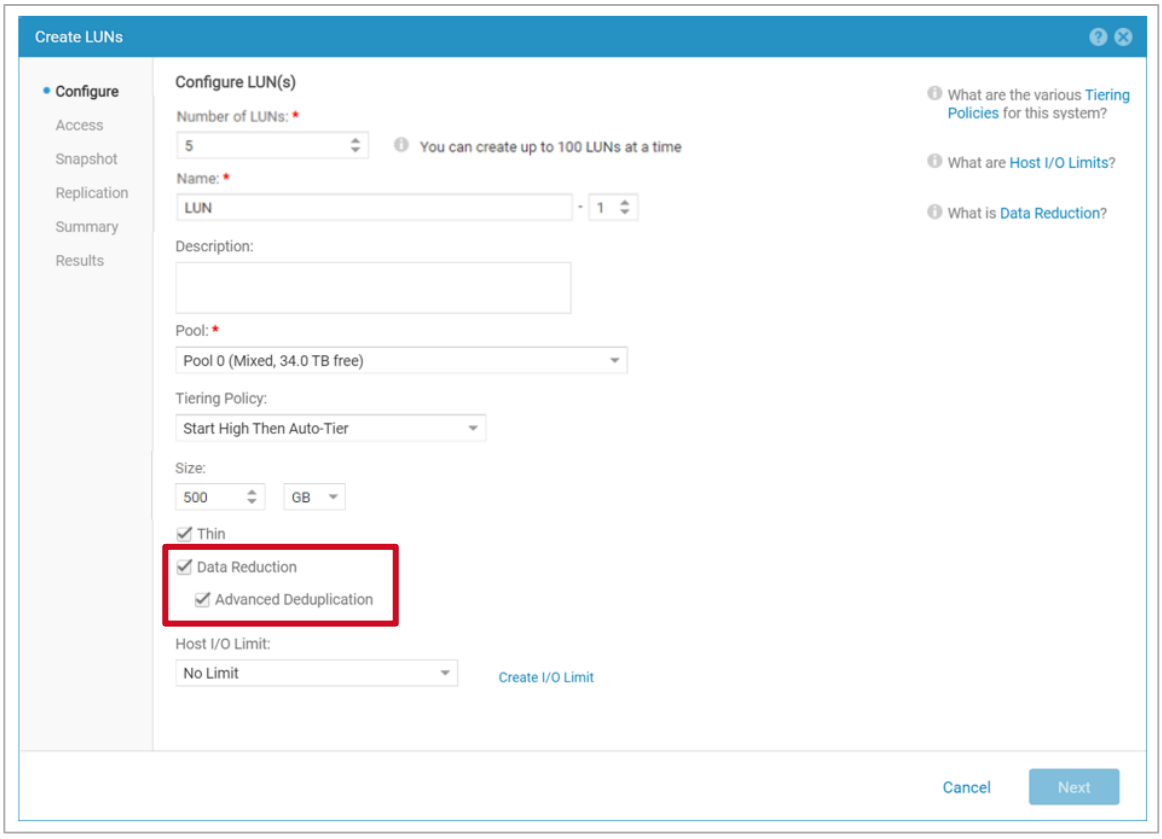


*This **Flash Percent (%)** value allows enabling data reduction for resources that are built from the pool*

Storage Resource

Enabling Data Reduction is only possible if the pool flash percent value requirements are met.

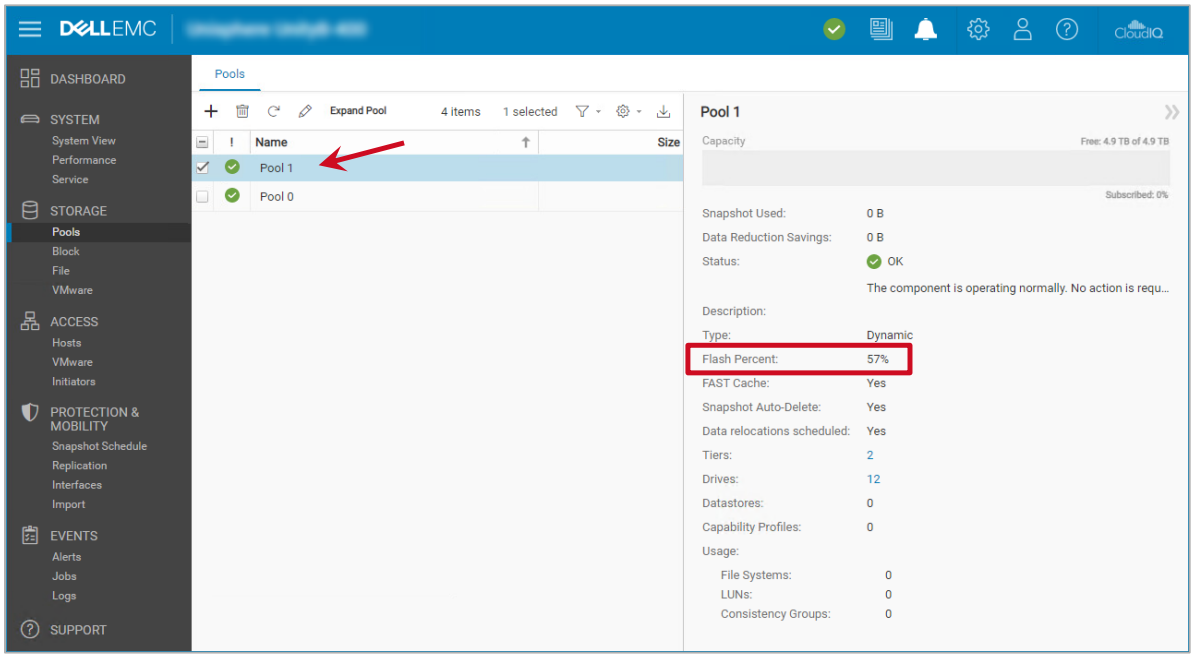
- For pools with a lower flash capacity, the feature is unavailable and a message is displayed. Go here to see an example.
- Advanced Deduplication is also supported for the data reduction enabled resources.



*Both Data Reduction and Advanced Deduplication can be enabled for a LUN built from **Pool 0***

Verify Pool Flash Capacity Utilization

The proportion of flash capacity utilization can also be verified from the **Details** pane of a selected pool.



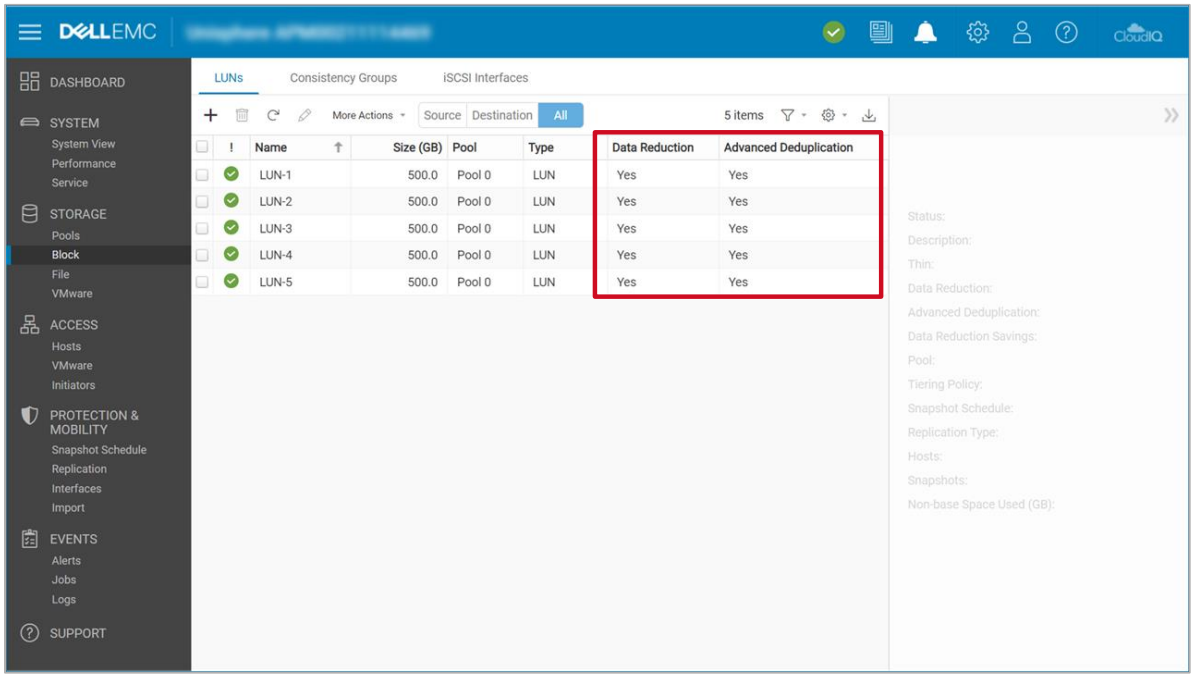
Pools page with selected pool showing the flash capacity utilization on the details pane

In the example, **Pool 1** is selected and the details pane shows that the pool has 57% of flash capacity utilization.

Identify Data Reduction Savings in Storage Resources

List of Storage Resources

Add the **Data Reduction** and **Advanced Deduplication** columns to the resources page, to verify which resources have the features enabled.

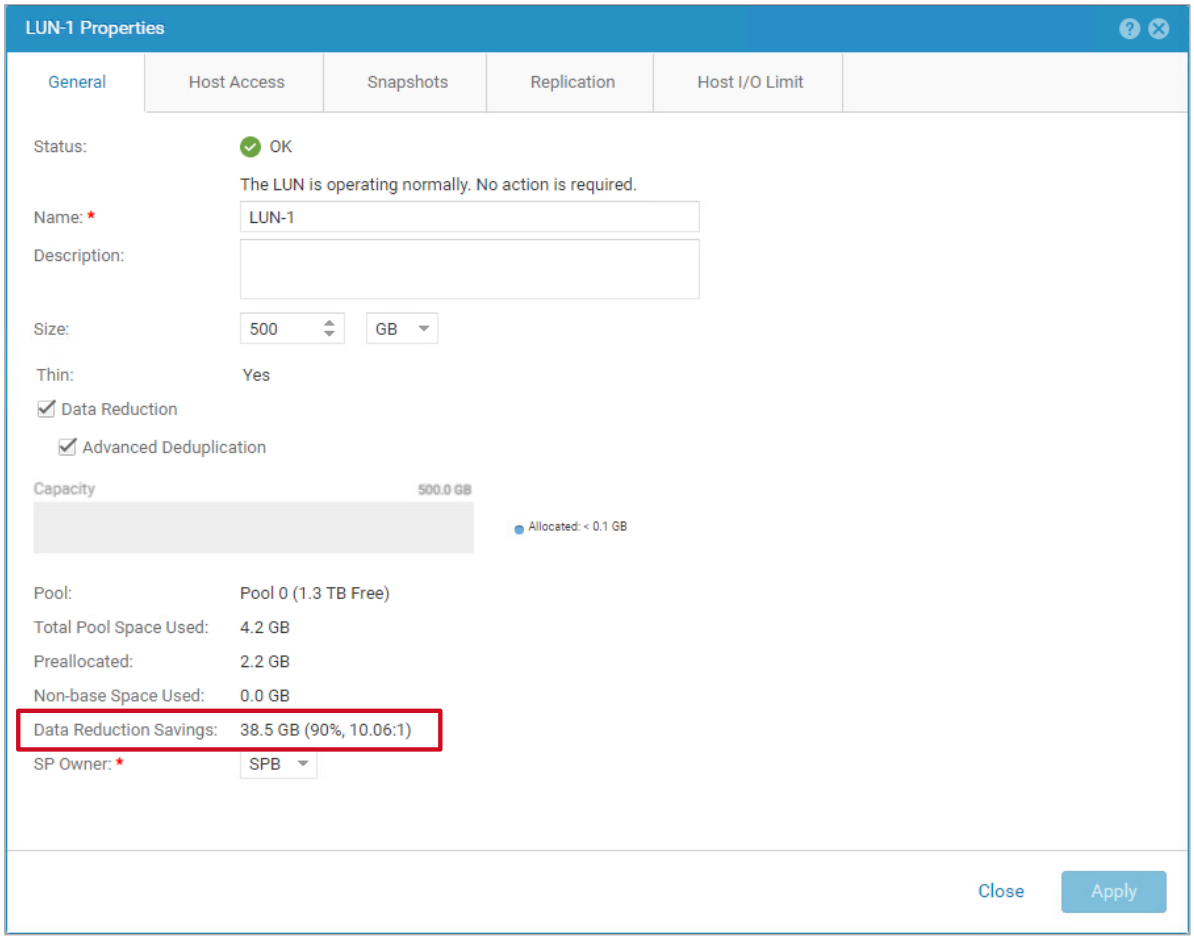


*LUNs page showing the **Data Reduction** and **Advanced Deduplication** columns*

In the example, all the LUNs created on the dynamic pool **Pool 0** are configured with data reduction and advanced deduplication.

Storage Resource Properties

To monitor the **Data Reduction Savings**, select the storage resource and open the properties page. The savings are reported in GBs, percent savings, and as a ratio on the General tab.



*LUN properties showing the **Data Reduction Savings** on the General tab*

In the example, the properties of LUN-1 show a data reduction savings of 38.5 GB. The percentage that is saved and ratio reflect the savings on the storage resource.

Configuring Data Reduction on an Existing Storage Resource

Data Reduction and Advanced Deduplication on a LUN can be enabled or disabled at any time. As noted earlier, Advanced Deduplication setting is only available once Data Reduction is enabled and the configuration supports it.

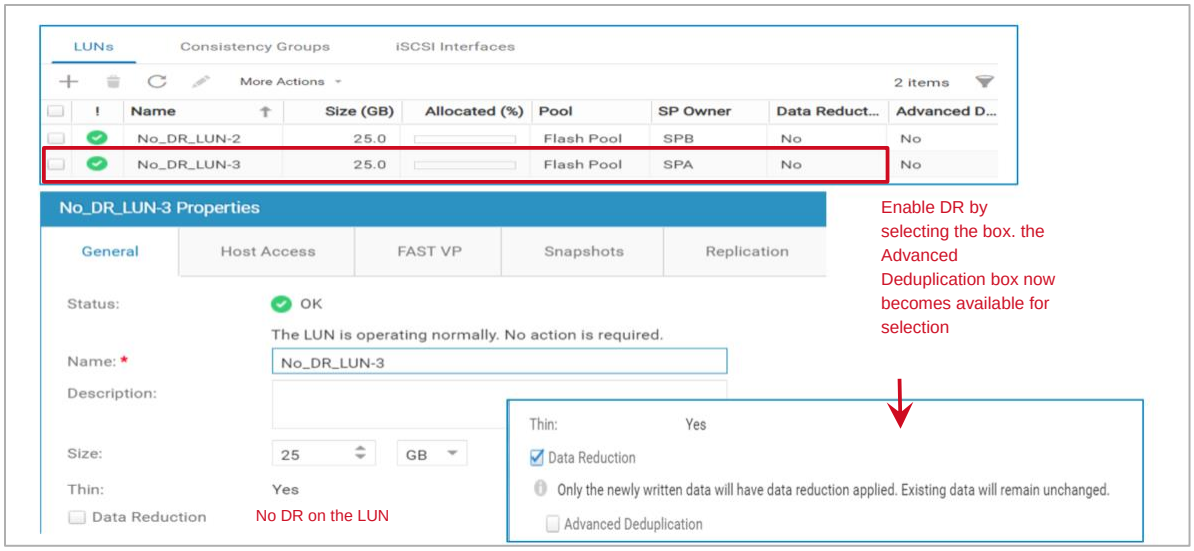
To enable and disable Data Reduction and Advanced Deduplication on an existing storage resource (LUN in the example), review the properties of the LUN from the Block page. Depending if Data Reduction and Advanced Deduplication are disabled or enabled on the storage resource, the respective boxes are either cleared or checked.

Advanced Deduplication can be enabled or disabled independently from the Data Reduction setting.

- When enabled on an existing LUN, all existing data is left in its current state and only incoming data is subject to Data Reduction. Existing data is subject to Data Reduction upon a rewrite of new data.
- If disabling Data Reduction, data is left in its current state on the disk until the data is overwritten or migrated.

To remove Data Reduction savings for block resources, use the Move operation. For file resources, since there is no Move operation, users can use host-based migration or replication. For example, you can asynchronously replicate a file system to another file system within the same pool using UEMCLI commands.

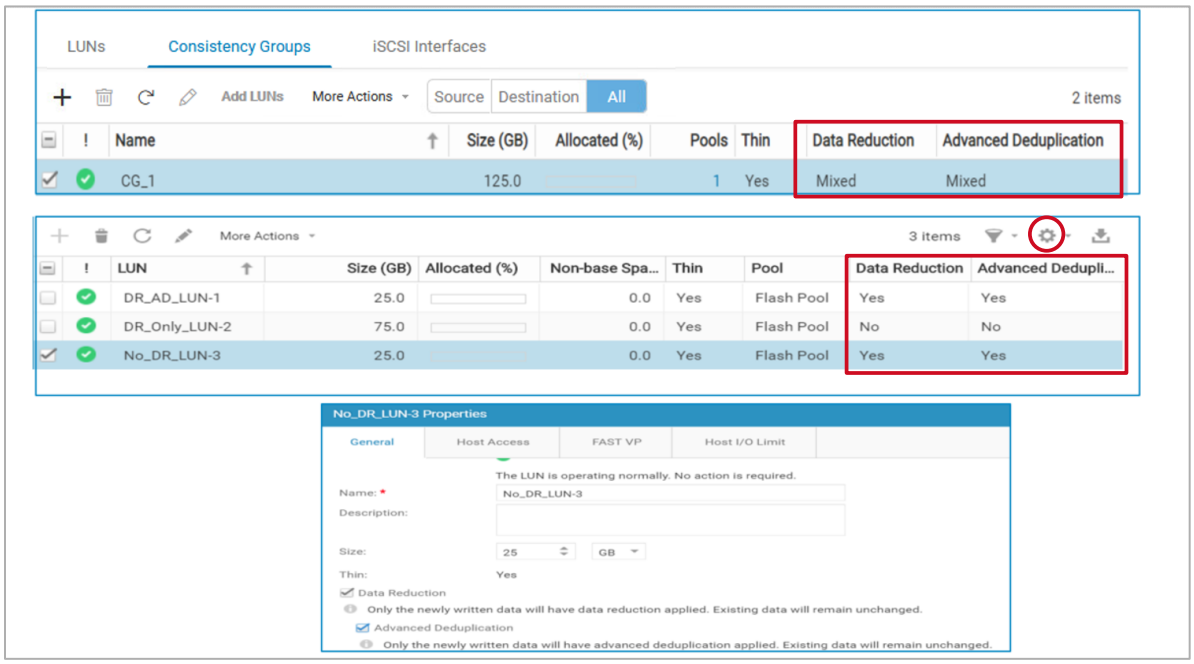
Data Reduction stops for new writes when sufficient resources are not available and resumes automatically after enough resources are available.



Configuring Data Reduction on an Existing Storage Resource

Data Reduction and Advanced Deduplication with Consistency Groups

To review which Consistency Groups contain Data Reduction enabled LUNs, select the **Consistency Group** tab, which is found on the Block page.

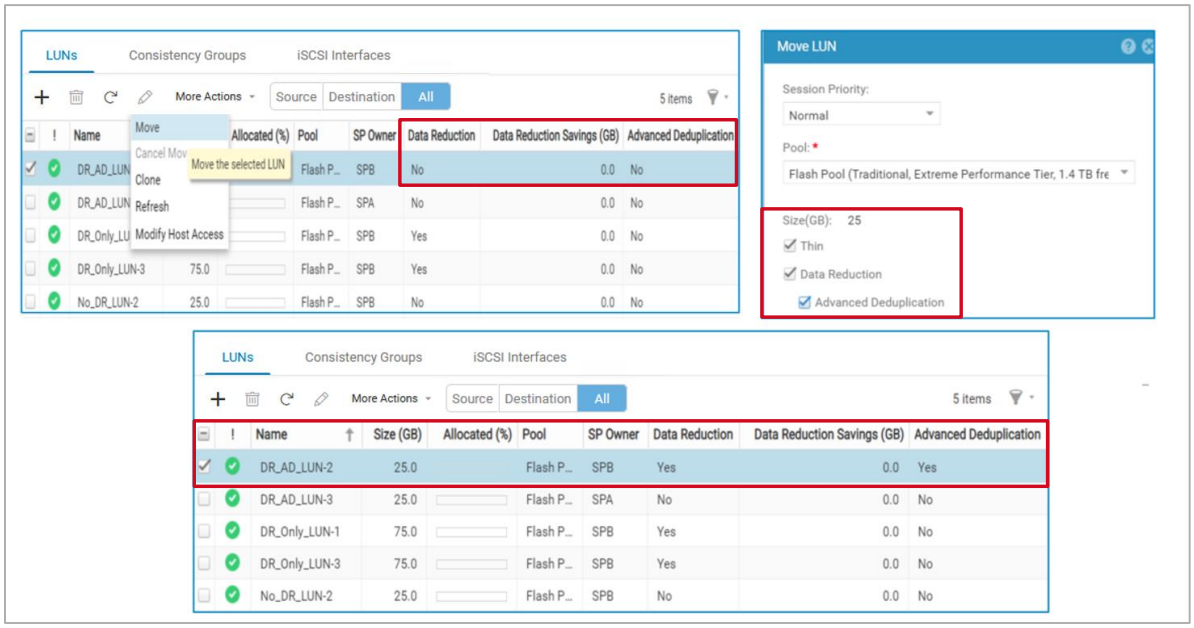


Data Reduction and Advanced Deduplication with Consistency Groups

On this page, columns that are named **Data Reduction** and **Advanced Deduplication** can be added to the current view.

- Click the Gear Icon and select **Data Reduction** or **Advanced Deduplication** under Column.
- The Data Reduction and Advanced Deduplication columns have three potential entries, **No**, **Yes**, and **Mixed**.
  - **No** is displayed if none of the LUNs within the Consistency Group has the option enabled.
  - **Yes** is displayed if all LUNs within the Consistency Group have the option enabled.
  - **Mixed** is displayed when the Consistency Group has some LUNs with Data Reduction enabled and other LUNs with Data Reduction disabled.

Data Reduction and Advanced Deduplication Using Local LUN Move



Data Reduction and Advanced Deduplication Using Local LUN Move

The Local LUN Move feature, also known as Move, provides native support for moving LUNs and VMFS Datastores online between pools or within the same pool. This ability allows for manual control over load balancing and rebalancing of data between pools.

Local LUN Move leverages Transparent Data Transfer (TDX) technology, a multi-threaded, data copy engine. Local LUN Move can also be leveraged to migrate a Block resource's data to or from a resource with Data Reduction or Advanced Deduplication enabled.

If Advanced Deduplication is supported and enabled, the data also passes through the Advanced Deduplication algorithm. This allows space savings to be achieved during the migration.

When migrating to a resource with Data Reduction disabled, all space savings that are achieved on the source are removed during the migration.

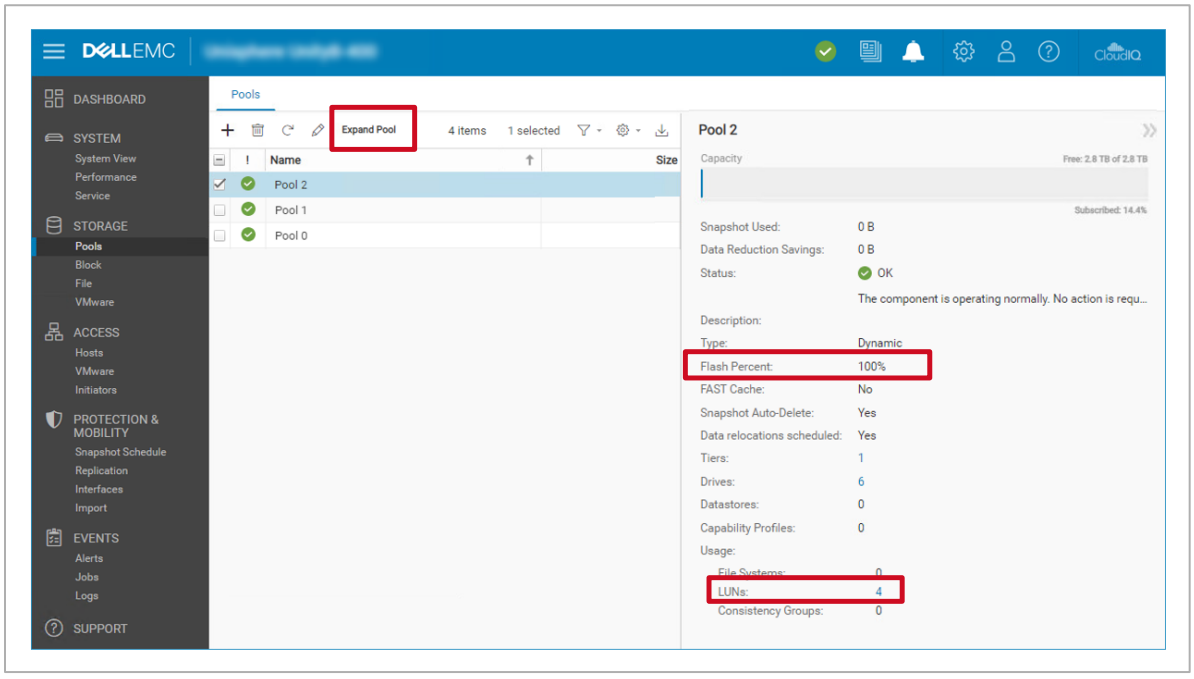
The example shows DR_AD_LUN-2 with no Data Reduction or Advanced Deduplication set, is being moved to a pool to pass the existing data on the LUN through the Data Reduction and Advanced Deduplication algorithms.

Expand an All-Flash Pool with Data Reduction Enabled Storage Resources

Launch Wizard

Dell Unity XT supports the expansion and conversion of an All-Flash pool to a Hybrid pool.

To add drives from different tiers to an All-Flash pool (with Data Reduction enabled resources), select the pool and **Expand Pool**.

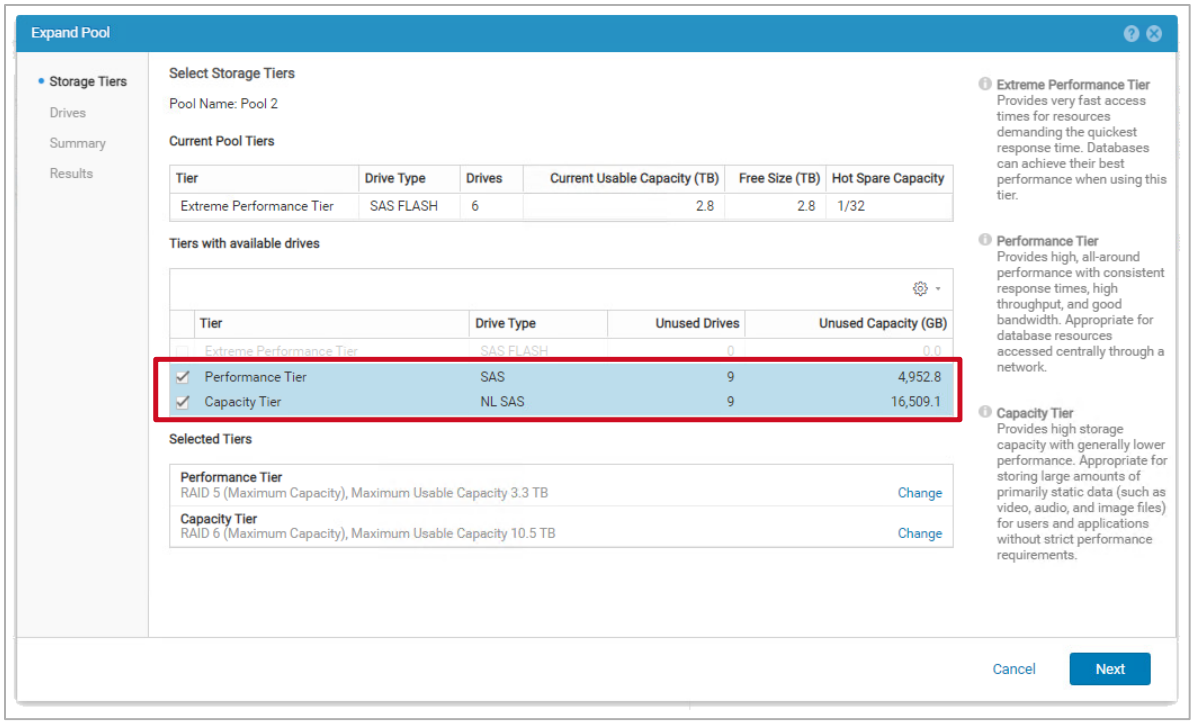


Details pane of a dynamic pool showing the Flash Percent, and number of storage resources built from it

In the example, the All-Flash pool **Pool 2** has four LUNs with Data Reduction and Advanced Deduplication enabled.

Select Tiers

Select the storage tiers with available drives to expand the pool, and optionally change the hot spare capacity for new added tiers.

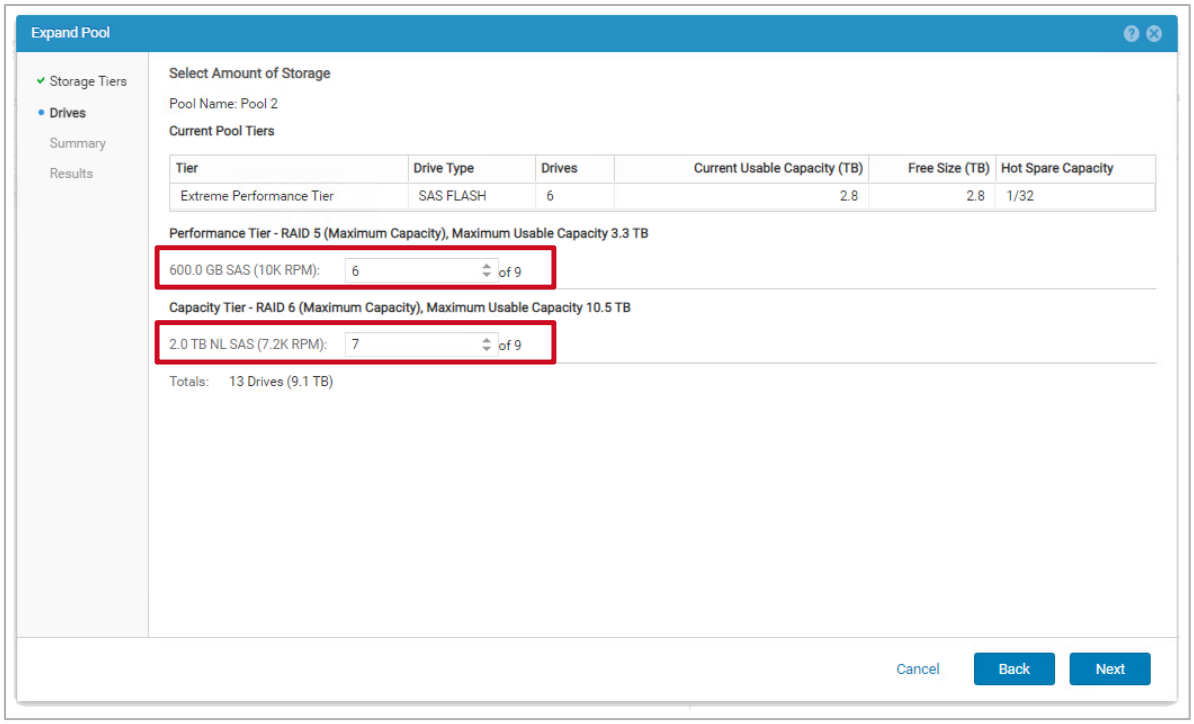


Expand Pool wizard with the selected tiers

The **Performance** and **Capacity** tiers are selected. The **Extreme Performance** tier cannot be selected since there are no unused drives.

Select Drives

Select the amount of storage from each tier to add to the All-Flash pool. The number of drives must comply with the RAID width plus the hot spare capacity that is defined for the tier.



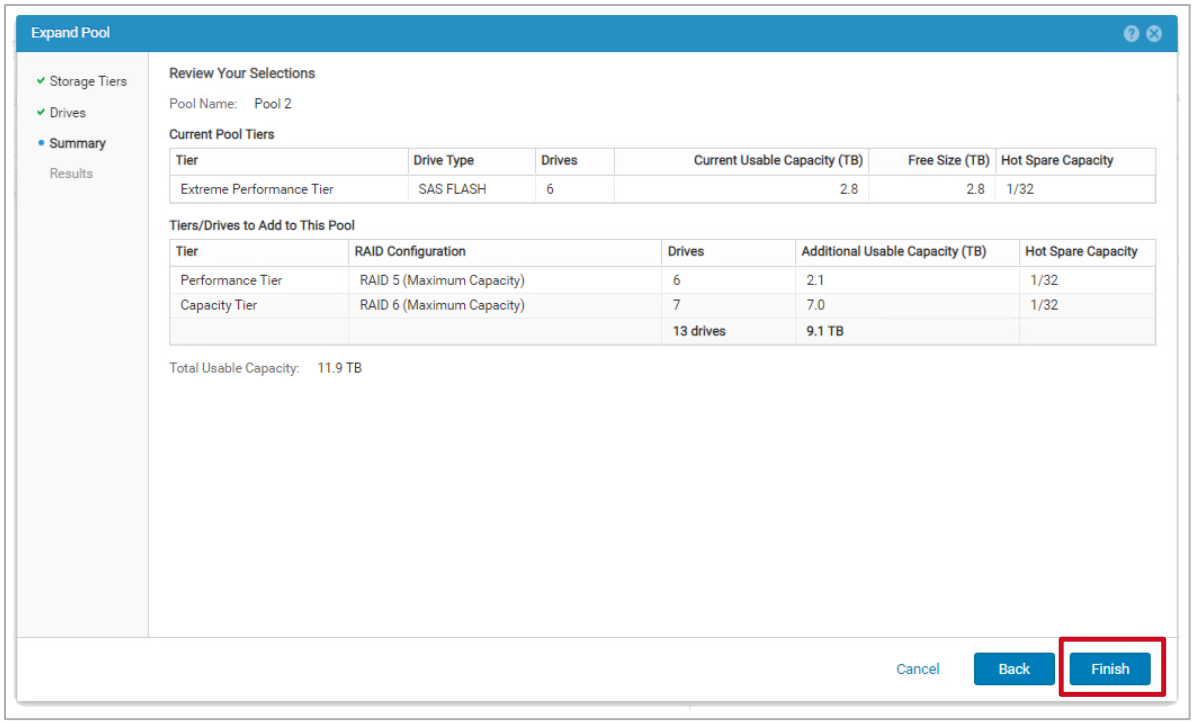
Expand Pool wizard selection of drives from selected tiers

In the example, six SAS drives comply with the RAID 5 (4+1) plus one hot spare requirement. Seven NL-SAS drives comply with the RAID 6 (4+2) plus one hot spare requirement.

If the expansion does not cause an increase in the spare space the pool requires, the new free space is made available for use. When extra drives increase the spare space requirement, a portion of the space being added is reserved. The reserved space is equal to the size of one or two drives per 32.

Summary

Verify the proposed configuration with the expanded drives. Select **Finish** to start the expansion process.

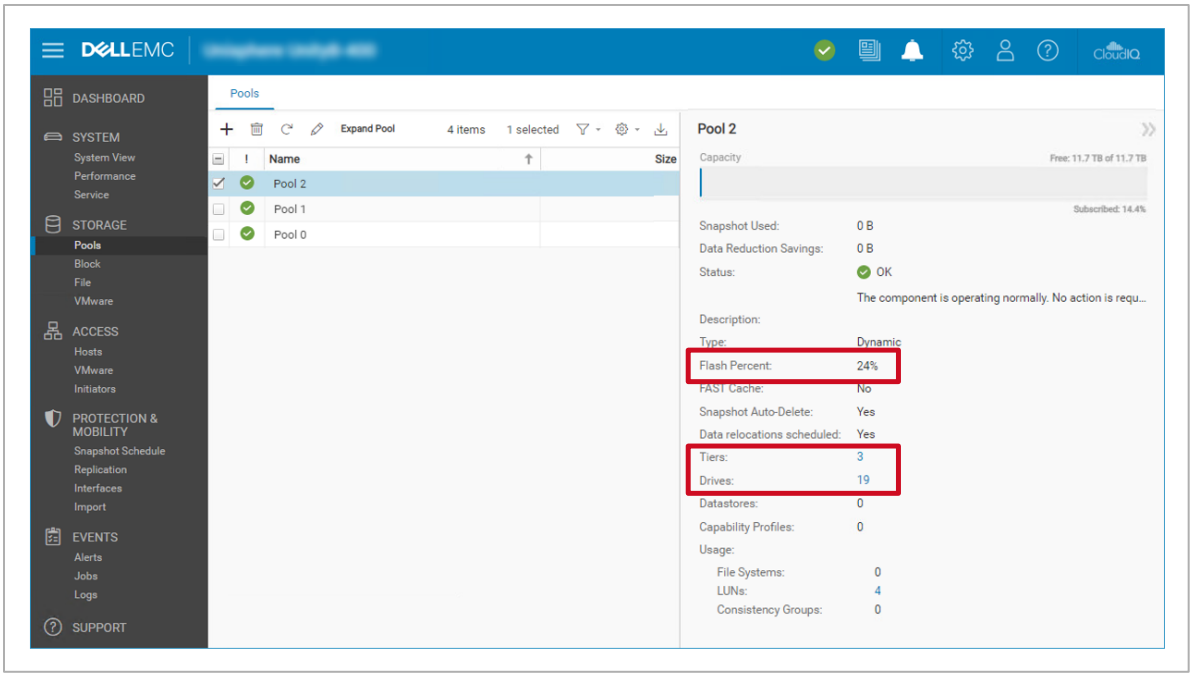


Expand Pool wizard summary

In the example, the expansion process adds 13 drives to the All-Flash pool and converts it to a multi-tiered pool.

Pool Expanded

Verify the pool conversion on the details pane. The number of tiers and drives increased. Observe that the flash percent supports the Data Reduction.



Details pane of a selected pool showing the Flash Percent, number of tiers and drives

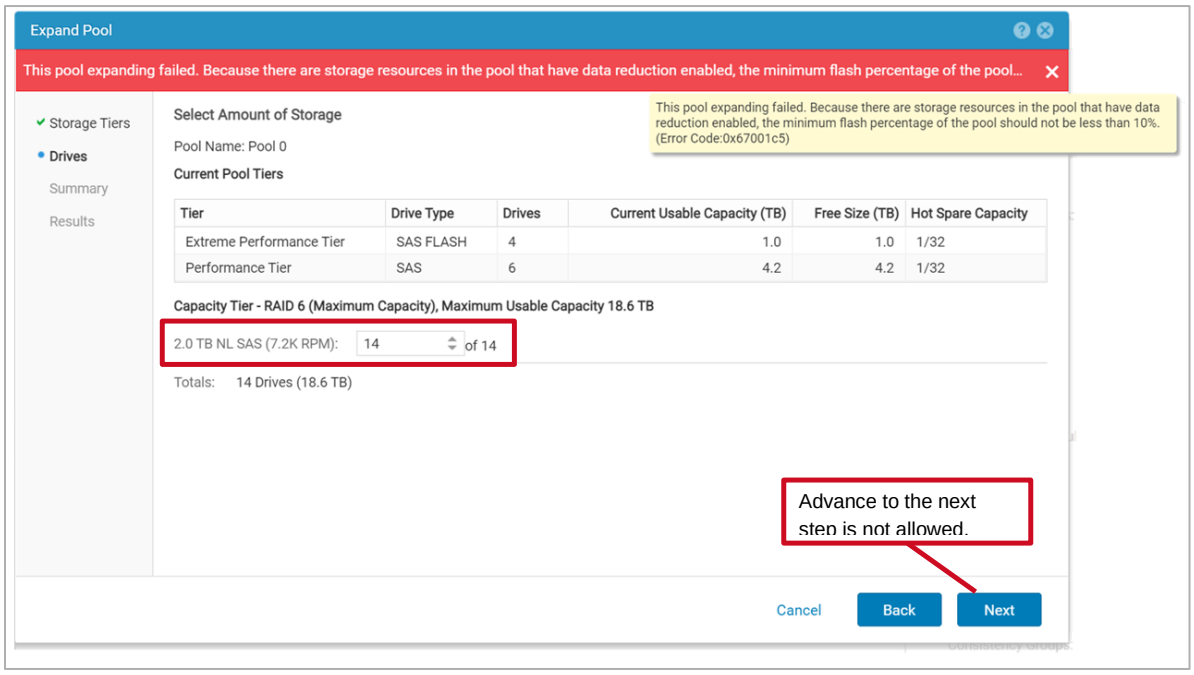
In the example, the expansion included two new tiers and added 13 new drives to the pool. The flash percent is over 10% which ensures that Data Reduction is supported.

If the pool contains Data Reduction enabled resources and the resulting flash percent would be below 10%, the expansion would not be allowed.

Considerations About Expansion of Dynamic Pools with Data Reduction Enabled Resources

If the additional capacity drops the **Flash Percent** value below 10%, the expansion of a dynamic pool with Data Reduction enabled resources is blocked.

- To support Data Reduction, the proportion of flash capacity must be equal to or exceed 10% of the total capacity of the pool.
- If the requirement is not met, the wizard displays a warning message when trying to advance to the next step.



Expand Pool wizard with warning message

In the example, the Flash Percent capacity utilization of **Pool 0** is 19%, and the addition of 14 NL-SAS drives reduces the value below the 10% requirement.

To conclude the expansion, select a number of drives that keep the flash percent capacity utilization within the Data Reduction requirements.

Identify Flash Tier Free Space Considerations

Each resource that is created on the system uses metadata.

- The Data Reduction algorithm creates additional metadata on a resource for tracking purposes.
- Data Reduction and Advanced Deduplication generates metadata with additional space consumption.

In Hybrid pools, the metadata has priority over user data for placement on the fastest drives.

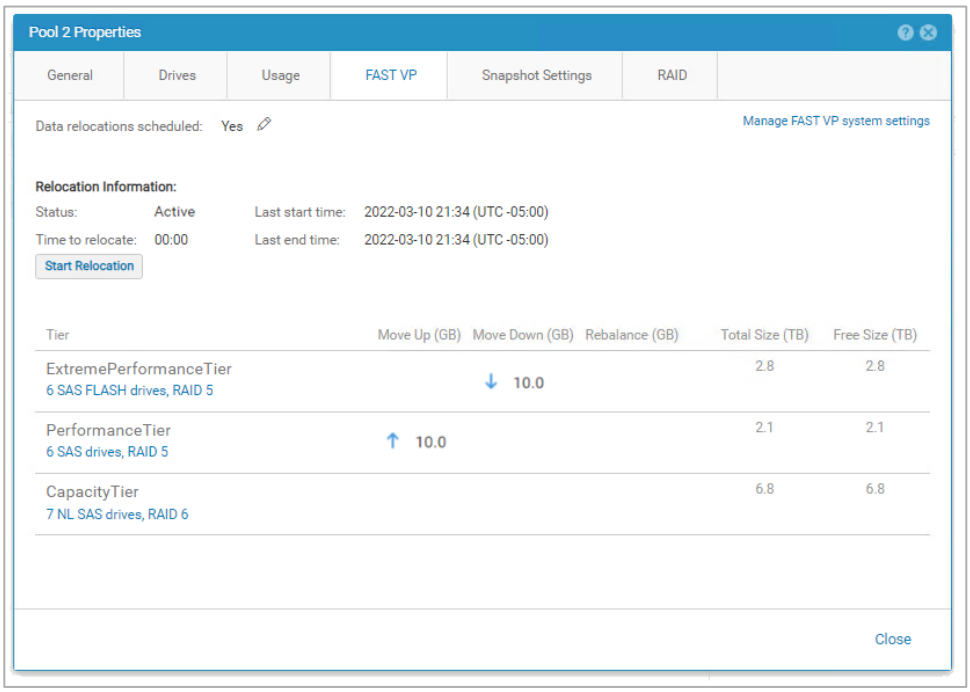
- Algorithms ensure that metadata go to the tier that provides the fastest access. Usually this is the Extreme Performance (SAS Flash) tier.
- If necessary, user data is moved to the next available tier (Performance or Capacity), to give space to metadata created on the pool.

The system monitors how much metadata is created as the resources grow, and the pool space is consumed.

- The system automatically estimates how much metadata can be created based on the free capacity.
  - The estimate considers the amount of metadata that is generated, the pool usable capacity, and the free space within each tier.

Flash Tier Free Space Considerations - Metadata Relocation

FAST VP tries to relocate user data out of the Flash tier to free space for metadata.



FAST VP tab showing the relocation of data blocks

In extreme cases, when FAST VP cannot evacuate enough space, performance issues may be seen. When the amount of metadata on the pool exceeds the capacity of the Flash tier, the metadata is placed on the next available tier. The metadata is moved to spinning media.

There is a significant impact to the performance of the Data Reduction algorithm with the access of metadata blocks from SAS or NL-SAS drives. The process takes CPU cycles away from user I/O.

In this situation, the pool status changes to **OK, Needs Attention** (seen from the Pools page, and the pool properties General tab). A warning informs the administrator to increase the amount of flash capacity within the pool to address the issue.

In the example, the system identifies metadata blocks to move from the Performance to the Extreme Performance tier.

Note: The access to metadata blocks that are written on spinning media is slow in comparison to Flash drives. There is a noticeable performance difference with the metadata paging into memory.

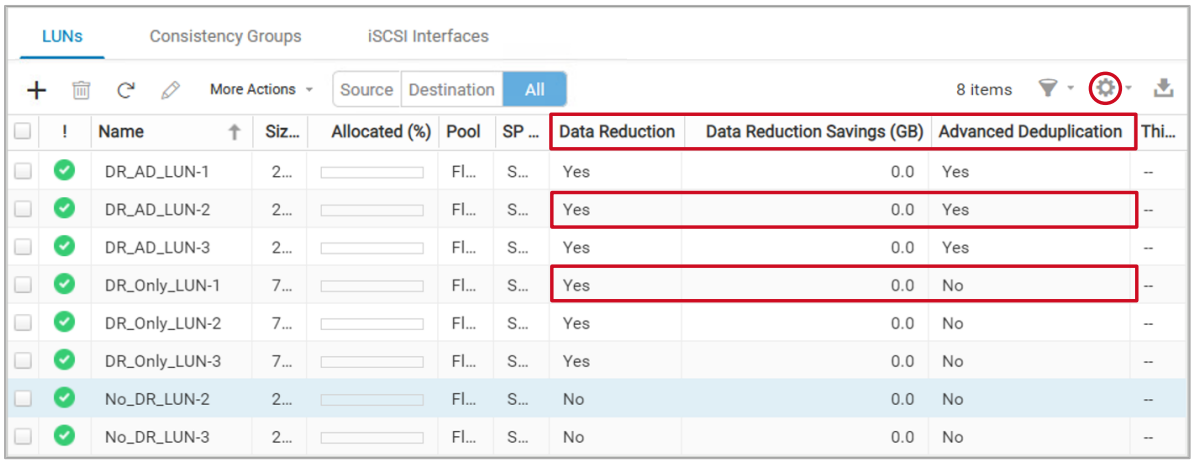
Viewing Storage Resource Properties - LUN

To review the status of Data Reduction and Advanced Deduplication on each of the LUNs created on the system, go to the **Block** page in Unisphere. The page can be accessed by selecting **Block** under Storage in the left pane.

The page contains three columns specific for Data Reduction.

- The Data Reduction column, which shows if Data Reduction is enabled or not on the resource.
- The **Advanced Deduplication** column, which shows if Advanced Deduplication is enabled.
- The **Data Reduction Savings (GB)** column, which shows the amount of savings in GBs for the resource.

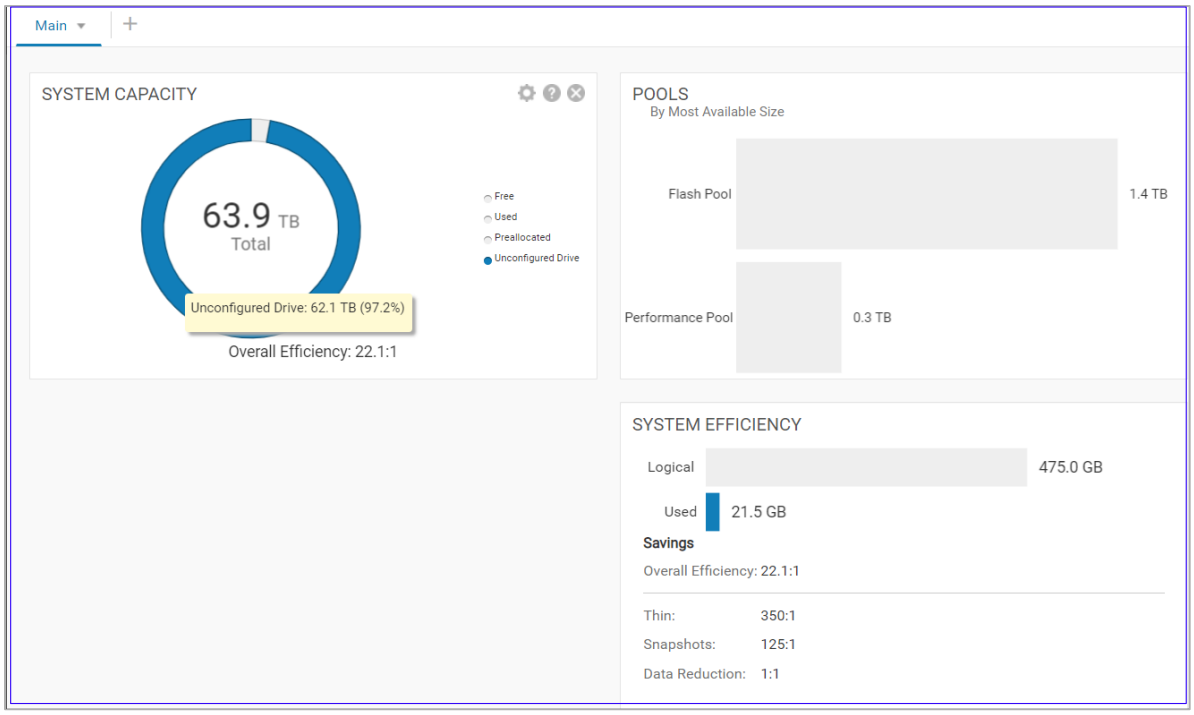
To add these and other columns to the view, click the **Gear** Icon in the upper right portion of the LUNs tab and select the columns to add under the Columns option.



!	Name	Siz...	Allocated (%)	Pool	SP ...	Data Reduction	Data Reduction Savings (GB)	Advanced Deduplication	Thi...
	DR_AD_LUN-1	2...		Fl...	S...	Yes	0.0	Yes	--
	DR_AD_LUN-2	2...		Fl...	S...	Yes	0.0	Yes	--
	DR_AD_LUN-3	2...		Fl...	S...	Yes	0.0	Yes	--
	DR_Only_LUN-1	7...		Fl...	S...	Yes	0.0	No	--
	DR_Only_LUN-2	7...		Fl...	S...	Yes	0.0	No	--
	DR_Only_LUN-3	7...		Fl...	S...	Yes	0.0	No	--
	No_DR_LUN-2	2...		Fl...	S...	No	0.0	No	--
	No_DR_LUN-3	2...		Fl...	S...	No	0.0	No	--

*View LUN Data Reduction properties on **LUNs** page*

Understanding Savings Reporting



*View Data Reduction saving on **Main** tab*

Data Reduction provides savings information at many different levels within the system, and in many different formats.

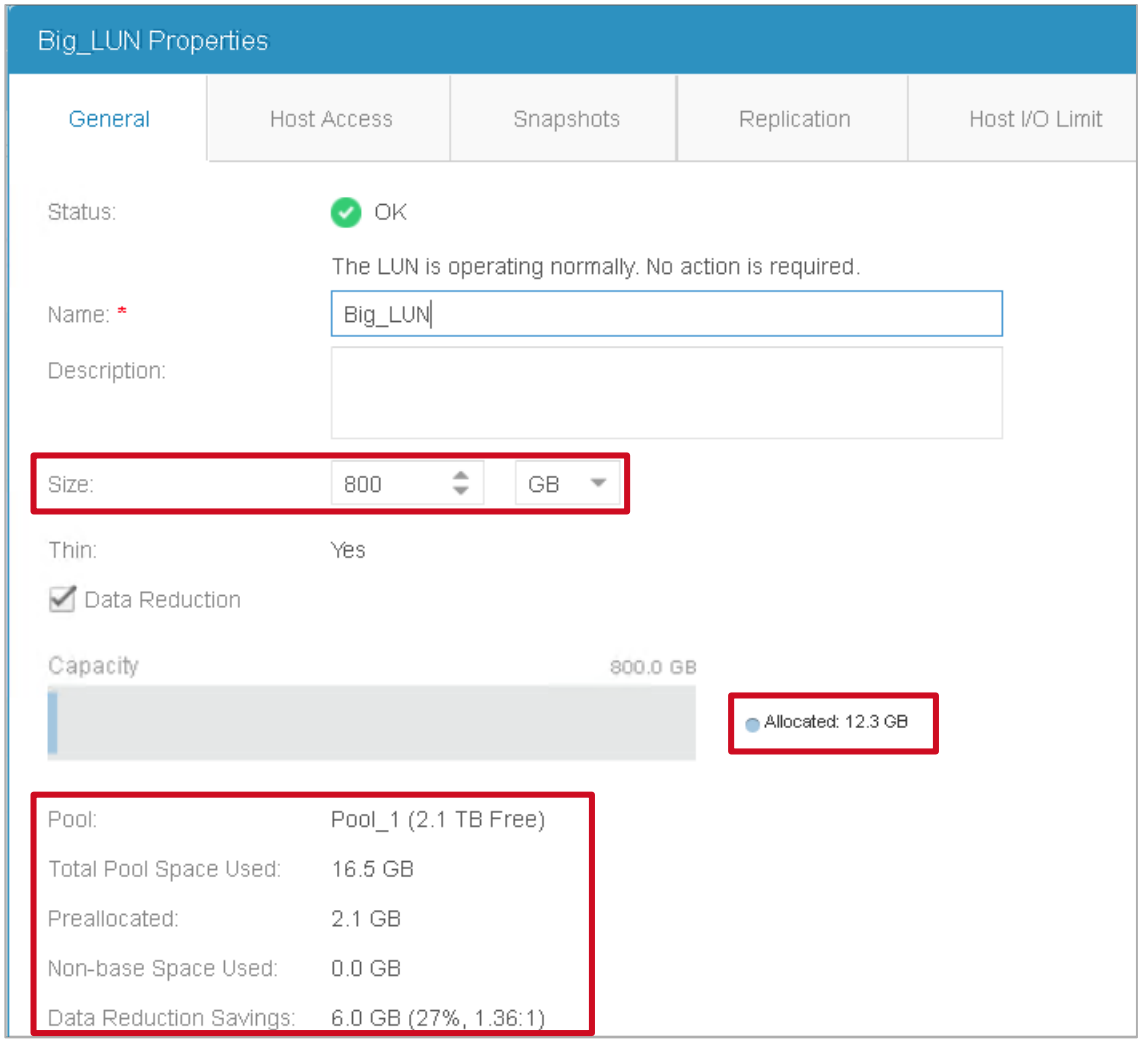
- Savings information is provided at the individual storage resource, pool, and system levels.
- Savings information is reported in GBs, percent savings, and as a ratio.
- Total GBs saved includes the savings due to Data Reduction on the storage resource, Advanced Deduplication savings, and savings which are realized on any Snapshots and Thin Clones taken of the resource.
- The percentage that is saved and the ratio reflect the savings within the storage resource itself. All savings information is aggregated and then displayed at the Pool level and System level.

Storage Resource Level - Block

Space savings information in the three formats is available within the Properties window of the storage resource.

For LUNs, you must either access the Properties page from the Block page, or on the LUN tab from within the Consistency Group Properties window.

Shown is the total GBs saved, which includes savings within data used by Snapshots and Thin Clones of the storage resource. Also shown is the % saved and the Data Reduction ratio, which both reflect the savings within the storage resource. File System and VMware VMFS Datastores display the same parameters.



*View Data Reduction properties on **General** tab within **LUN Properties***

Data Reduction savings are shown on the General tab within the LUN Properties Window.

The storage resource properties terms are described below.

- Size/Capacity – The client visible size of a storage resource
- Allocated – The amount of storage that has been allocated to host data
- Total Pool Space Used – Space that is used by the resource on disk, including space for Snapshots, Thin Clones, and overhead (metadata)
- Preallocated – Space that is reserved but not yet used by the resource and non-reclaimed (freeable) space

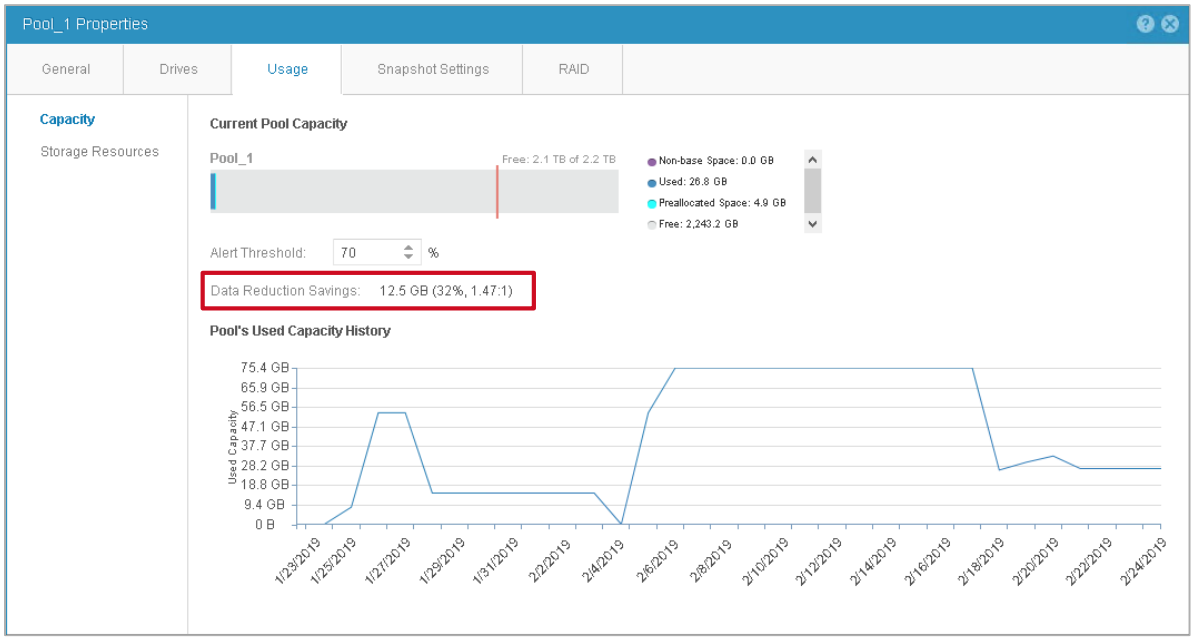
- Non-base Space used – Space that is consumed by Snapshots and Thin Clones
- Data Reduction Savings - The % saved and the Ratio reflect the average space that is saved across all Data Reduction enabled storage resources

Data Reduction Savings - Pool Level

Data Reduction information is also aggregated at the Pool level on the **Usage** tab.

Savings are reported in the three formats, including the GBs saved, % savings, and ratio.

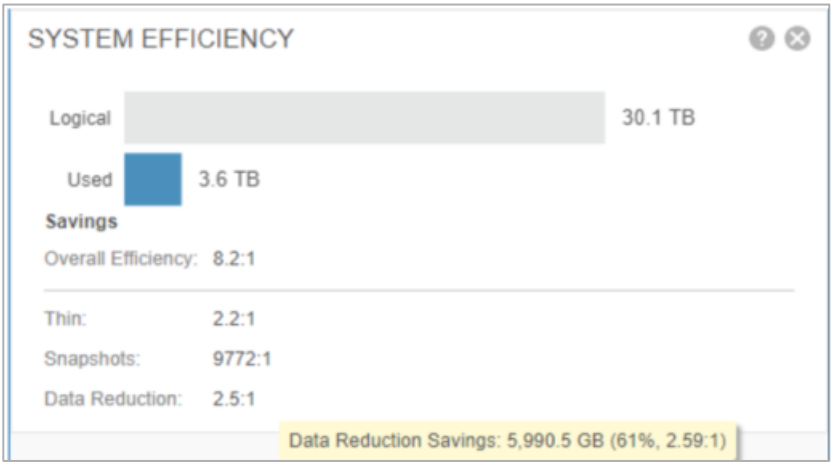
- The GBs savings reflect the total amount of space saved due to Data Reduction on storage resources and their Snapshots and Thin Clones.
- The % saved and the Ratio reflect the average space that is saved across all Data Reduction enabled storage resources.



*View Data Reduction Savings on **Usage** tab of **Pool Properties***

Data Reduction Savings - System Level

Data Reduction Savings information is also available at the System Level.



Data Reduction Savings at the system level

System level Data Reduction Savings information is displayed within the **System Efficiency** view block that is found on the system Dashboard page. If the view block is not shown on your system, you can add it by selecting the **Main** tab, clicking **Customize**, and adding the view block.

The system level aggregates all savings across the entire system and displays them in the three formats available, GBs saved, % saved, and ratio.

- For the GBs saved, this value is the total amount of space saved due to Data Reduction, along with savings achieved by Snapshots and Thin Clones of Data Reduction enabled storage resources.
- The % savings and ratio are the average savings that are achieved across all data reduction enabled storage resources.

Calculating Data Reduction Savings

Overview

The space reporting updates affect the System, Pool, and Storage Resource values. Users can use the formulas, displayed here to calculate, and verify the Data Reduction Savings percentage and ratio for the System, Pools, and Storage Resources.

The system level aggregates all savings across the entire system and displays them in the three formats available, GBs saved, % saved, and ratio.

- For the GBs saved, this value is the total amount of space saved due to Data Reduction, along with savings achieved by Snapshots and Thin Clones of Data Reduction enabled storage resources.
- The % savings and ratio are the average savings that are achieved across all Data Reduction enabled storage resources.

$$\text{Savings Ratio} = \frac{(\text{Total Pool Space Used} + \text{Data Reduction Savings})}{\text{Total Pool Space Used}} : 1$$

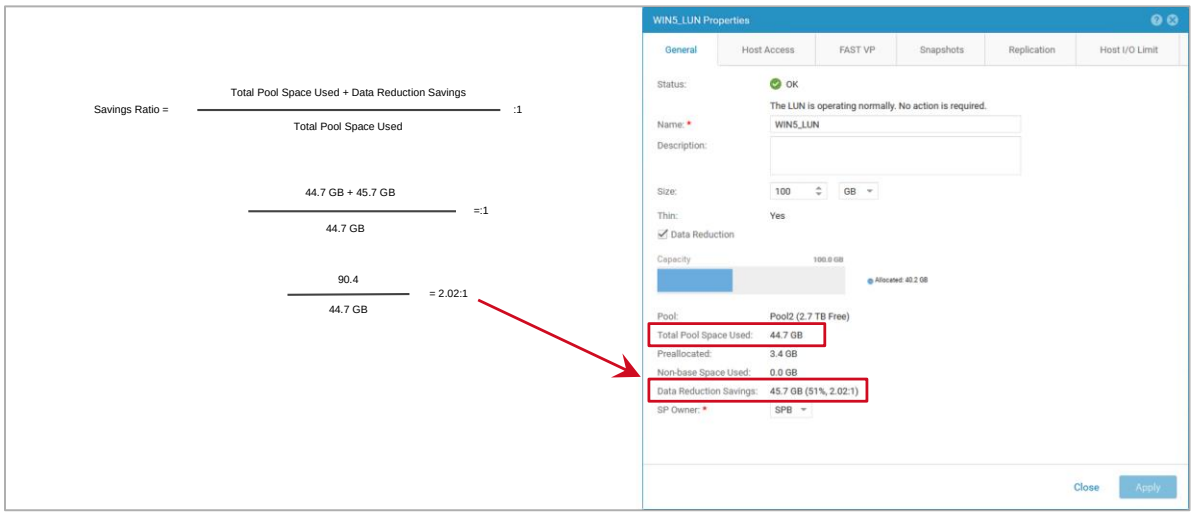
$$\text{Savings Percentage} = \frac{\text{Data Reduction Savings}}{(\text{Data Reduction Savings} + \text{Total Pool Space Used})} * 100$$

Calculating Data Reduction savings

Data Reduction Savings - Savings Ratio

Example

The example shows the calculation for Data Reduction savings ratio on a LUN.

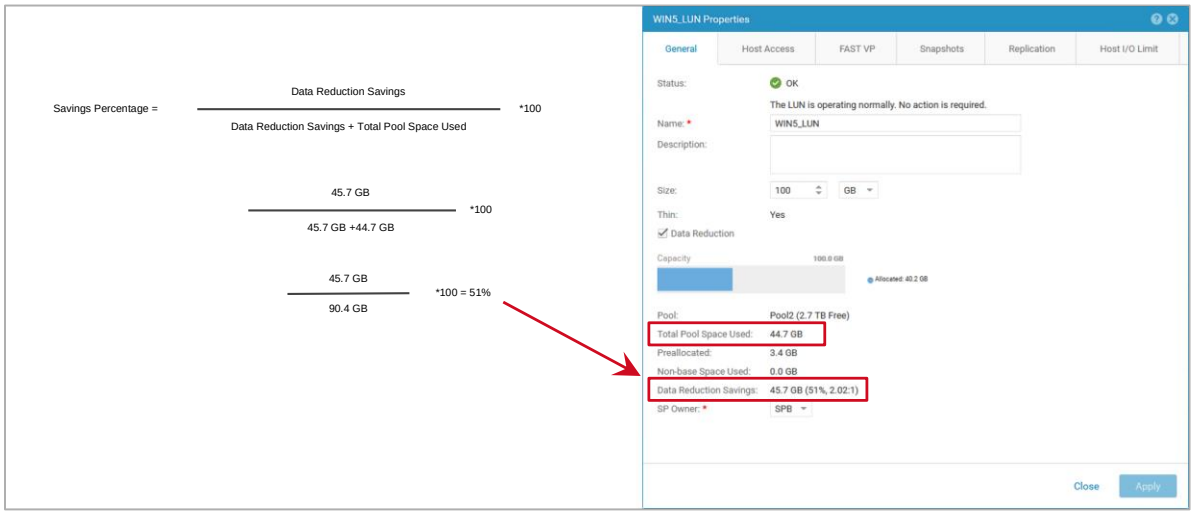


Calculating savings ratio example

Data Reduction Savings - Saving Percentage

Example

The example displays the formula for calculating the Data Reduction percentage savings.



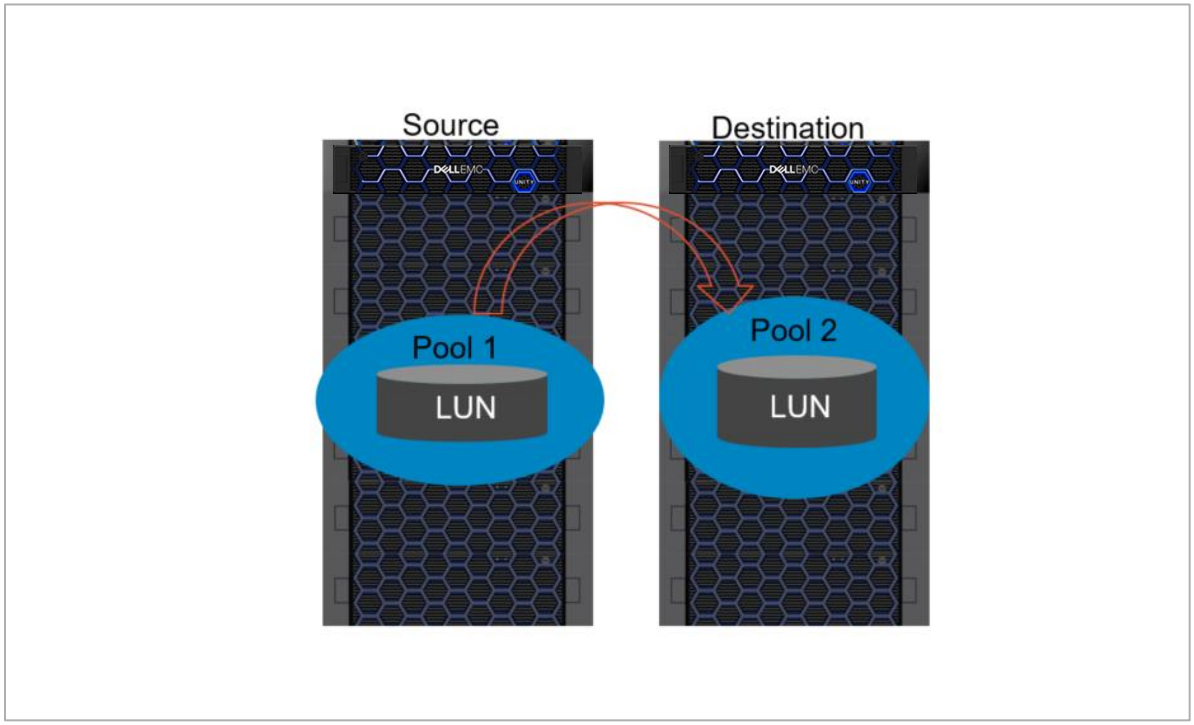
Calculating savings percentage example

Data Reduction and Advanced Deduplication with Replication

Overview

Storage resources using Data Reduction can be replicated using any supported replication software. Native Synchronous Block Replication or Native Asynchronous Replication to any supported destination is supported.

All data replicated, local, or remote, is first re-hydrated (deduplicated data is reconstructed, compressed data is uncompressed), and then replicated to the destination. This method of replicating Data Reduction enabled storage resources ensures that all replication topologies are supported as if Data Reduction is not enabled on the resource.



Replication considerations with Data Reduction and Advanced Deduplication

Some considerations when using Replication are listed below.

- Replication is supported on resources which support Data Reduction and/or Advanced Deduplication.
- If replicating to a destination storage system with no efficiencies applied, the data is not deduplicated or compressed.

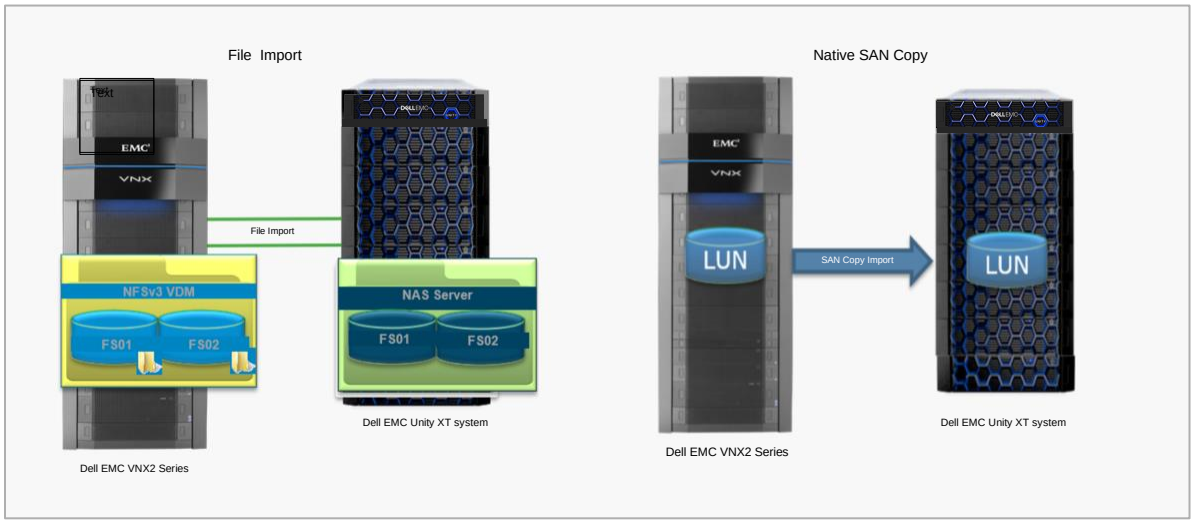
- Replication can occur to or from a Dell Unity XT that does not support Data Reduction.
- Data Reduction can be enabled or disabled on source or destination independently.

Data Reduction and Advanced Deduplication with Native File and Block Import

When configuring an Import Session, Data Reduction and Advanced Deduplication are supported on the destination as long as the destination system and Pool configuration supports it.

When creating an Import Session, if the destination resource supports Data Reduction, a checkbox is available to enable it on the destination resource. An option for Advanced Deduplication is also shown for configurations which support it.

As data is migrated from the source VNX system to the Dell Unity XT system, it passes through the Data Reduction algorithm as it is written to the Pool.



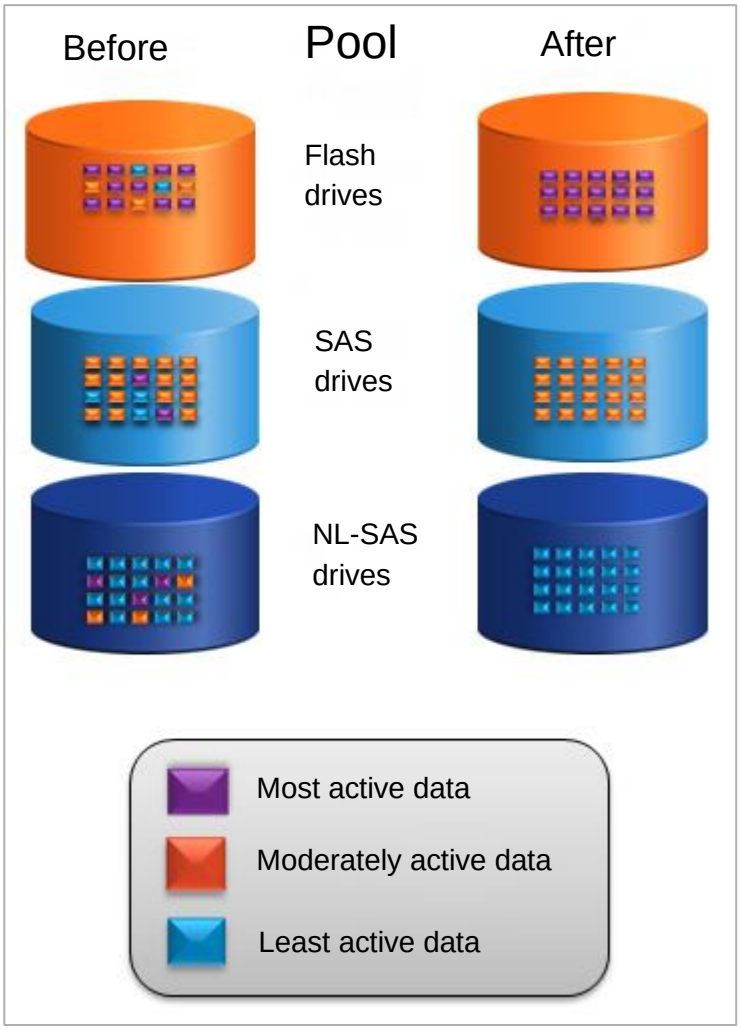
Data Reduction and Advanced Deduplication with Native File and Block Import

FAST VP

FAST VP Overview

When reviewing the access patterns for data within a system, most access patterns show a basic trend. Typically, the data is most heavily accessed near the time it was created, and the activity level decreases as the data ages. This trending is also seen as the lifecycle of the data. Dell EMC Unity Fully Automated Storage Tiering for Virtual Pools - FAST VP monitors the data access patterns within pools on the system.

FAST VP dynamically matches the performance requirements to sets of drives.



FAST VP classifies drives into three categories, called tiers. These tiers are:

- Extreme Performance Tier – Comprised of Flash drives

- Performance Tier – Comprised of Serial Attached SCSI - SAS drives
- Capacity Tier - Comprised of Near-Line SAS - NL-SAS drives

FAST VP helps to reduce the Total Cost of Ownership - TCO by maintaining performance and efficiently using the configuration of a pool. Users can create pools with a mix of Flash, SAS, and NL-SAS drives. Creating mixed pools reduces the cost of a configuration by reducing drive counts and using larger capacity drives. Data requiring the highest level of performance is tiered to Flash, while data with less activity resides on SAS or NL-SAS drives.

Dell EMC Unity has a unified approach to create storage resources on the system. Block LUNs, file systems, and the VMware datastores can all exist within a single pool, and can all benefit from using FAST VP. In system configurations with minimal amounts of Flash, FAST VP uses the Flash drives for active data, regardless of the resource type. For efficiency, FAST VP uses low cost spinning drives for less active data. Access patterns for all data within a pool are compared against each other. The most active data is placed on the highest performing drives according to the storage resource’s tiering policy. Tiering policies are explained later in this document.

Tiering Policies

FAST VP Tiering policies determine how the data relocation takes place within the storage pool. The available FAST VP policies are displayed here.

The Tier label is used to describe the various categories of media used within a pool. In a physical system, the tier directly relates to the drive types used within the pool. The available tiers are Extreme Performance Tier using Flash drives, the Performance Tier using SAS drives, and the Capacity Tier using NL-SAS drives.

On a Dell EMC UnityVSA system, a storage tier of the virtual drives must be created manually. The drives should match the underlying characteristics of the virtual disk.

The table shows the available tiering policies with its description, and the initial tier placement which corresponds to a selected policy.

Tiering Policy	Corresponding Initial Tier Placement	Description
Highest Available Tier	Highest Available Tier	Initial data placement and subsequent data relocations set to the highest performing tier of drives with available space
Auto-Tier	Optimized for pool Performance	Initial data placement optimizes the pool capacity, then relocates slices to different tiers based on the activity levels of the slices

Start High then Auto-Tier [Default]	Highest Available Tier	Initial data placed on slices from the highest tier with available space, then relocates data based on performance statistics and slice activity
Lowest Available Tier	Lowest Available Tier	Initial data placement and subsequent relocations preferred on the lowest tier with available space.

There are four Tiering Policies:

- Use the **Highest Available Tier** policy when quick response times are a priority.
- The **Auto-Tier** policy automatically relocates data to the most appropriate tier based on the activity level of each data slice.
- The **Start High, then Auto-Tier** is the recommended policy for each newly created pool. The tier takes advantage of the Highest Available Tier and Auto-Tier policies.
- Use the **Lowest Available Tier** policy when cost effectiveness is the highest priority. With this policy, data is initially placed on the lowest available tier with capacity.

Supported RAID Types and Drive Configurations

Users can select the RAID protection for each one of the tiers being configured when creating a pool. A single RAID protection is selected for each tier, and after the RAID configuration is selected, and the pool is created, it cannot be changed. Only when you expand the pool with a new drive type, you can select a RAID protection.

This table shows the supported RAID types and drive configurations.

Remember to consider the performance, capacity and protection levels these configurations provide, when deciding on the RAID configuration to adopt.

- RAID 1/0 is suggested for applications with large amounts of random writes, as there is no parity write penalty in this RAID type.
- RAID 5 is preferred when cost and performance are a concern.
- RAID 6 provides the maximum level of protection against drive faults of all the supported RAID types.

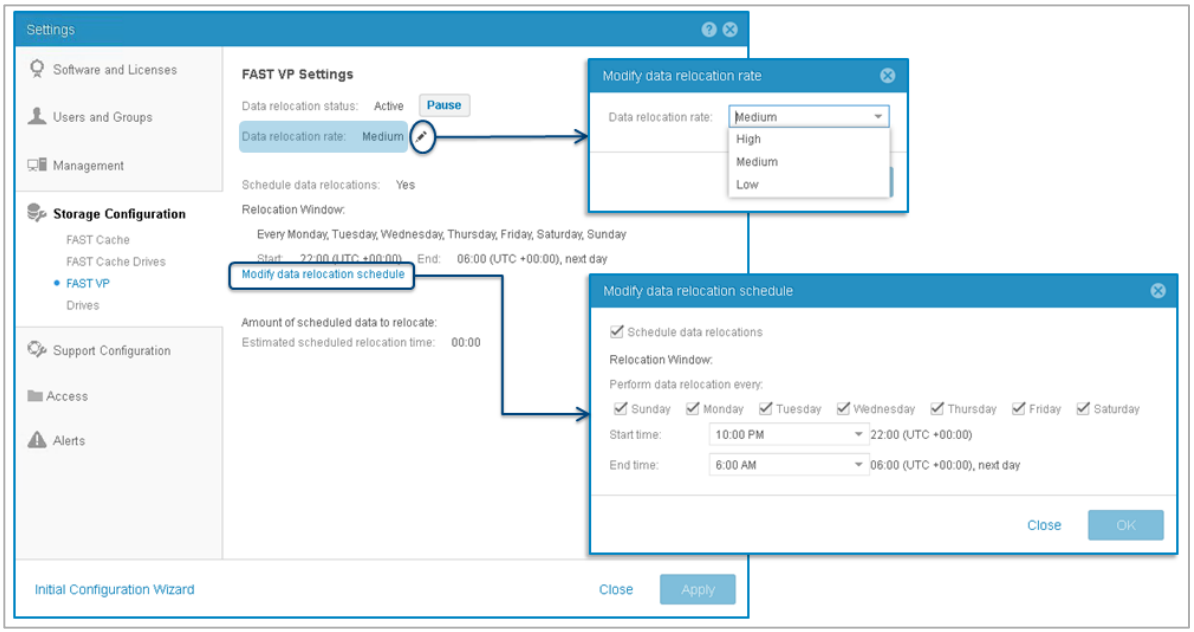
When considering a RAID configuration which includes many drives - 12+1, 12+2, 14+2, consider the tradeoffs that the larger drive counts contain. Using larger drive sizes can lead to longer rebuild times and possible faulted domains.

RAID Type	Default Configuration	Supported Configurations
RAID 1/0	4+4	1+1*, 2+2, 3+3, 4+4
RAID 5	4+1	4+1, 8+1, 12+1
RAID 6	6+2	4+2, 6+2, 8+2, 10+2, 12+2, 14+2

FAST VP Management

System Global Settings

The user can change the system-level data relocation configuration using the Global settings window.



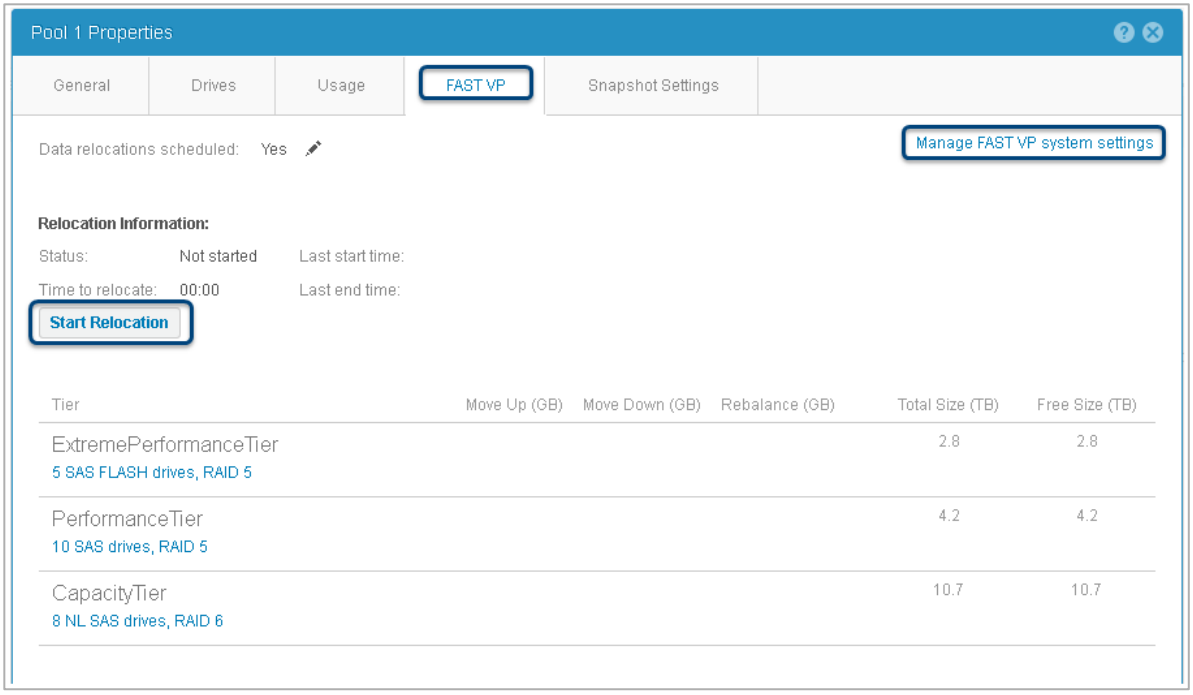
Select the **Settings** option on the top of the Unisphere page to open the Settings window.

Users have the option to:

- Manually pause and resume the scheduled data relocations
- Change the data relocation rate
- Disable and re-enable scheduled data relocations
- Modify the data relocation schedule.

Storage Pool

FAST VP relocation at the pool level can be also verified from the pool properties window.



In Unisphere, select a pool and click the edit icon to open its properties window. Then select the **FAST VP** tab.

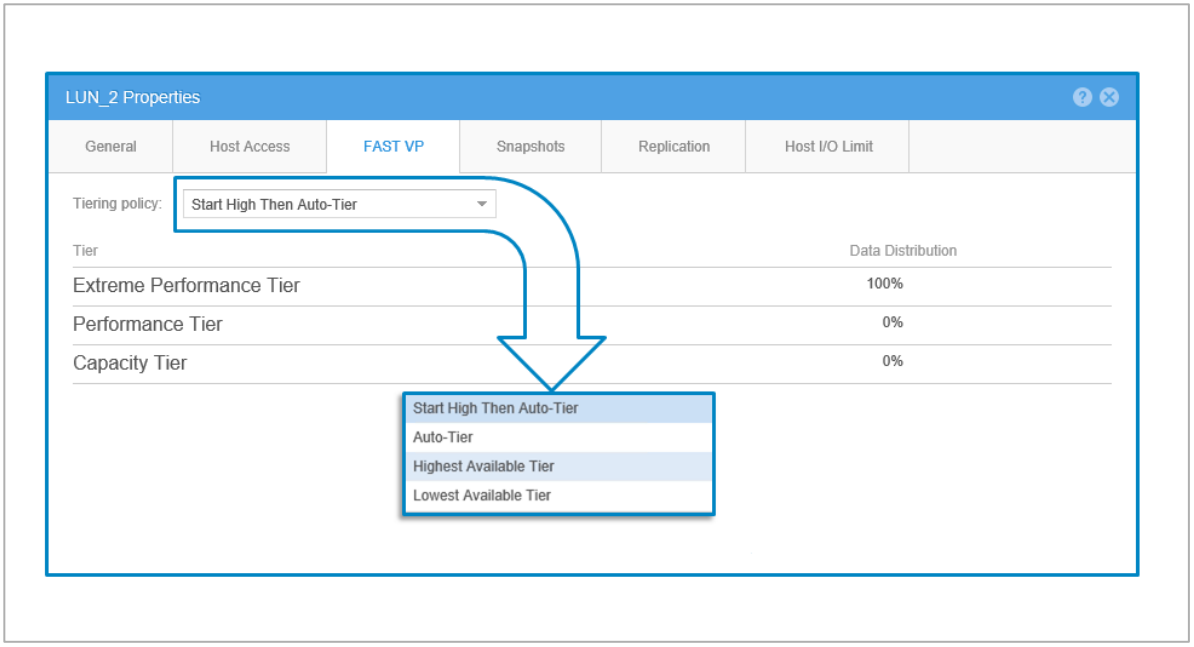
Users can view the following information for a pool:

- Pool participation in scheduled data relocations
- Estimated time needed for scheduled data relocations
- Start and end time for the most recent data relocation
- Number and type of disks in each tier
- Amount of data in the pool scheduled to move to higher and lower tiers
- Amount of data in the pool scheduled to be rebalanced within a tier

You also have the option to manually start a data relocation by clicking the **Start Relocation** button. To modify the FAST VP settings, click the **Manage FAST VP system settings** link in the upper right side of the window.

Block or File Resource

At the storage resource level, the user can change the tiering policy for the data relocation.



In Unisphere, select the block or file resource and click the pencil icon to open its properties window. Then select the **FAST VP** tab.

From this page, it is possible to edit the tiering policy for the data relocation.

The example shows the properties for LUN_2. The FAST VP page displays the information of the tiers that are used for data distribution.

Thin Clones

Thin Clones Overview

A Thin Clone is a read/write copy of a thin block storage resource that shares blocks with the parent resource. Thin Clones created from a thin LUN, Consistency Group, or the VMware VMFS datastore form a hierarchy.

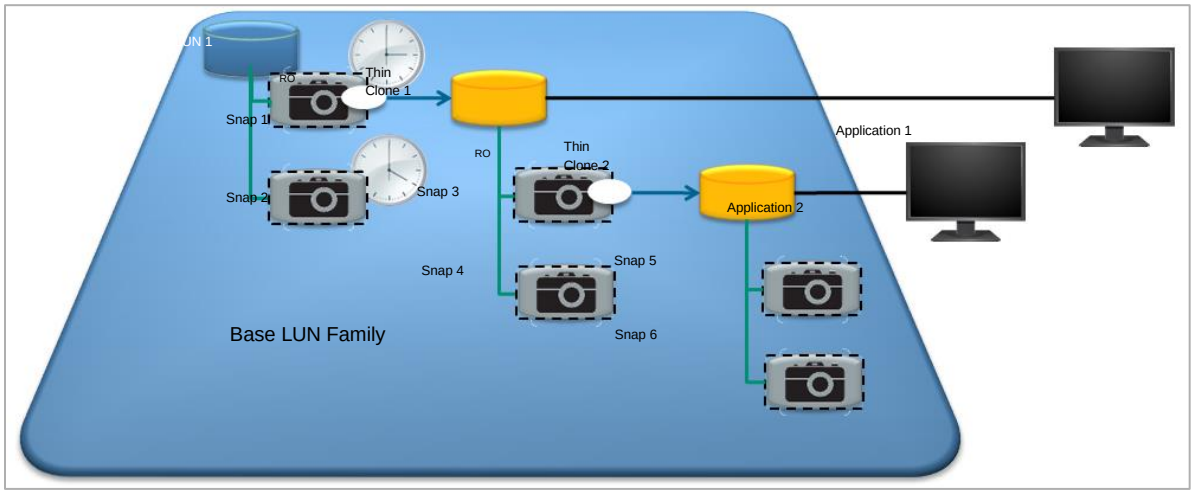
A Base LUN family is the combination of the Base LUN, and all its derivative Thin Clones and snapshots. The original or production LUN for a set of derivative snapshots, and Thin Clones is called a Base LUN. The Base LUN family includes snapshots and Thin Clones based on child snapshots of the storage resource or its Thin Clones.

Data available on the source snapshot is immediately available to the Thin Clone. The Thin Clone references the source snapshot for this data. Data resulting from changes to the Thin Clone after its creation is stored on the Thin Clone.

A snapshot of the LUN, Consistency Group, or VMFS datastore that is used for the Thin Clone create and refresh operations is called a source snapshot. The original parent resource is the original parent datastore or Thin Clone for the snapshot on which the Thin Clone is based.

Thin Clones are created from attached read-only or unattached snapshots with no auto-deletion policy and no expiration policy set. Thin Clones are supported on all Dell Unity models including Dell UnityVSA.

In the example, the Base LUN family for LUN1 includes all the snapshots and Thin Clones that are displayed in the diagram.



Thin Clone Capabilities

A thin clone is displayed in the LUNs page. The page shows the details and properties for the clone.

You can expand a thin clone by selecting the clone, then selecting the View/Edit option. If a thin clone is created from a 100 GB Base LUN, the size of the thin clone can be later expanded.

All data services remain available on the parent resource after the creation of the thin clone. Changes to the thin clone do not affect the source snapshot, because the source snapshot is read-only.

With thin clones, users can make space-efficient copies of the production environment. Thin clones are based on pointer-based technology, which means a thin clone does not consume much space from the storage pool. The thin clones share the space with the base resource, rather than allocate a copy of the source data for itself, which provide benefits to the user.

Users can also apply data services to thin clones. Data services include; host I/O limits, host access configuration, manual or scheduled snapshots, and replication. With the thin clone replication, a full clone is created on the target side which is an independent copy of the source LUN.

A maximum of 16 thin clones per Base LUN can be created. The combination of snapshots and thin clones cannot exceed 256.

Thin Clone Capabilities

Thin Clone operations	Users can create, refresh, view, modify, expand, and delete a thin clone.
Data Services	All data services remain available on the parent resource after the thin clone creation.
Space Savings	Only changed data consumes space.
Data Services	Most LUN data services can be applied to thin clones: host I/O limits, host access configuration, manual/scheduled snapshots, replication.

Thin Clones

Maximum number of thin clones per Base LUN	16 thin clones per Base LUN
Snapshots per LUN	256 snapshot per LUN
Snapshots + Thin Clones per LUN	256 snapshots + thin clones per LUN

Recommended Uses for Thin Clones

The use of Thin Clones is beneficial for the types of activities that are explained here.

Thin Clones allow development and test personnel to work with real workloads and use all data services that are associated with production storage resources without interfering with production.

For parallel processing applications which span multiple servers the user can use multiple Thin Clones of a single production dataset to achieve results more quickly.

An administrator can meet defined SLAs by using Thin Clones to maintain hot backup copies of production systems. If there is corruption of the production dataset, the user can immediately resume the read/write workload by using the Thin Clones.

Thin Clones can also be used to build and deploy templates for identical or near-identical environments.

Recommended Uses for Thin Clones

Development and test environments	Work with real workloads and all data services that are associated with production storage with no effect to production.
Parallel Processing	Parallel processing applications which span multiple servers can use multiple Thin Clones of a single production dataset to achieve results more quickly.
Online backup	Maintain hot backup copies of production systems; if there is production data corruption, immediately resume the read/write workload by using Thin Clones.
System deployments	Build and deploy templates for identical or near-identical environments.

Technical Comparison – Snapshots and Thin Clones

Description	Snapshots	Thin Clones
Space-Efficient Data	Yes	Yes
Creation Time	Instantaneous	Instantaneous
Delete Limitations	Automatic deletion of source snapshot of a Thin Clone not allowed	Any copy in the tree can be deleted. Base LUN cannot be deleted.
Topology	Snap-of-snap	Nested hierarchy of snap and Thin Clones
Any-Any Refresh	From base LUN only	Yes, any Thin Clone can be refreshed from any snapshot.
Restore	Yes, Snap to base LUN	Yes, must create a snap first, then restore primary.
Use Cases	Data Protection	Test/Dev

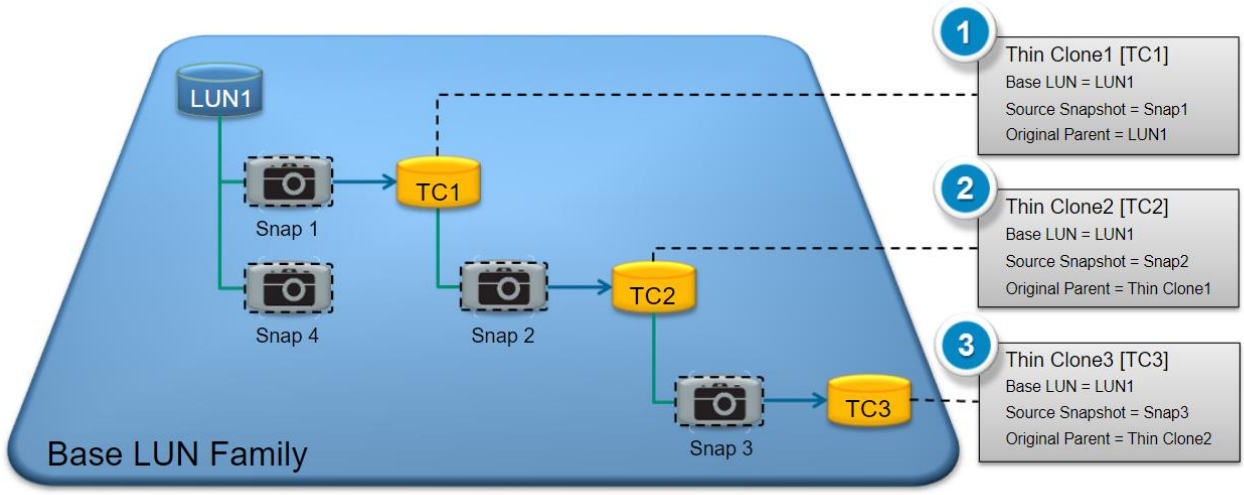
Theory of Operations: Create Thin Clones

The Create operation uses a Base LUN to build the set of derivative snapshots, and Thin Clones.

In this example, LUN1 is the Base LUN.

1. The first snapshot - Snap1 is created with read-only access. Snap1 is going to be the source snapshot to create Thin Clone1 [TC1]. The original parent resource is the original parent datastore or Thin Clone for the snapshot on which the Thin Clone is based. For Thin Clone1, the original parent is LUN1.
2. To create another Thin Clone, snapshot [Snap2] is created from Thin Clone1 [TC1]. Snap2 is the source snapshot for the creation of Thin Clone2 [TC2]. Observe that for this Thin Clone the original parent is Thin Clone1.
3. To create the third Thin Clone, another snapshot is created. Snap3 is created from Thin Clone2, and is used as the source snapshot for creating Thin Clone3 [TC3]. Observe that the original parent for this Thin Clone is Thin Clone2.

The creation of snapshots of the production LUN works independently of Thin Clones and the snapshots of Thin Clones creation.

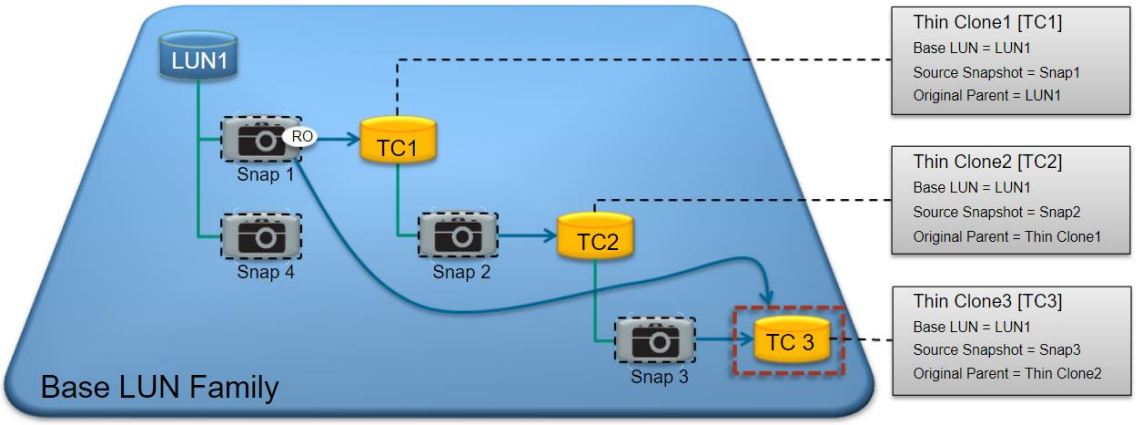


Theory of Operations: Refresh Thin Clones - 1 of 2

Refreshing a Thin Clone updates the Thin Clone's data with data from a different source snapshot. The new source snapshot must be related to the base LUN for the existing Thin Clone. In addition, the snapshot must be read-only, and it must have expiration policy or automatic deletion disabled.

This example shows that the user is refreshing Thin Clone3 with the contents of source Snap1.

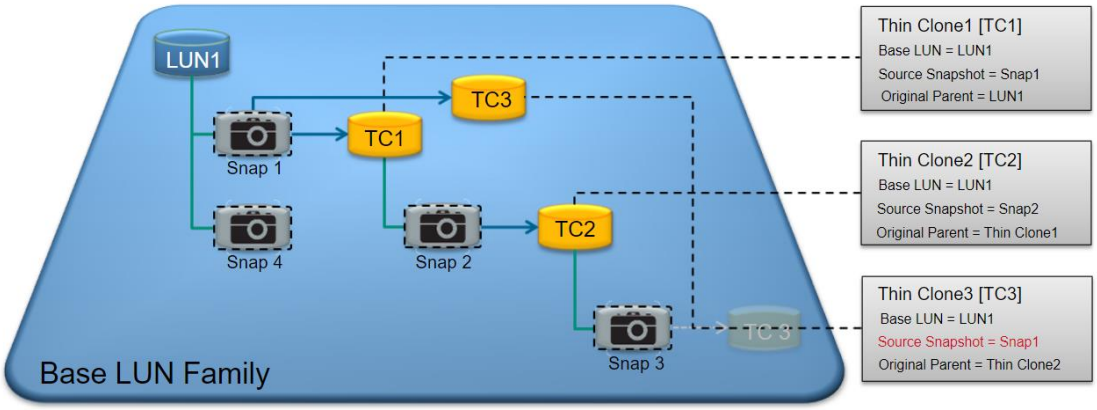
After the Thin Clone is refreshed, the existing data is removed and replaced with the Snap1 data. There are no changes to the data services configured in the Thin Clone, and if the Thin Clone has derivative snapshots they remain unchanged.



Theory of Operations: Refresh Thin Clones - 2 of 2

In this example, the source snapshot of the Thin Clone changes. So instead of being Snap3, the source snapshot is now Snap1.

Observe that the original parent resource does not change when a Thin Clone is refreshed to a different source snapshot. The new source snapshot comes from the same base LUN.

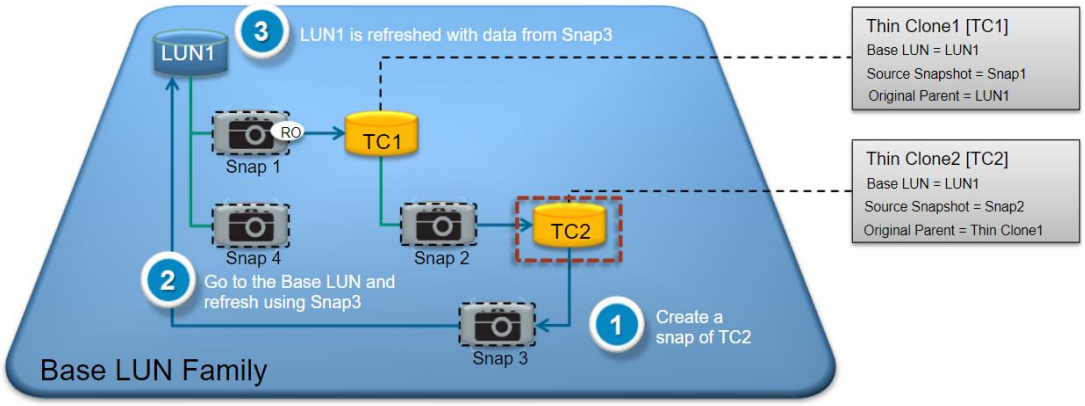


Theory of Operations: Refresh Base LUN

Refreshing a Base LUN updates the LUNs data with data from any eligible snapshot in the Base LUN family including a snapshot of a Thin Clone. The new source snapshot must be related to the Base LUN family for the existing Thin Clone. In addition, the snapshot must be read-only, and the retention policy must be set to no automatic deletion.

This example shows the user refreshing LUN1 with the data from Snap3. When the LUN is refreshed, the existing data is removed from LUN1 and replaced with the data from Snap3.

There are no changes to the data services configured on the Thin Clone. If the Thin Clone has derivative snapshots, the snapshots remain unchanged.



Thin Clone Considerations

Thin Clone Considerations

- Certain properties cannot be changed at the Thin Clone level and are dependent upon the Base LUN. If a user changes these properties on the Base LUN, then the changes are reflected on the Thin Clone. These properties are:
  - SP ownership
  - FAST VP
  - Data reduction settings
- Thin Clones are not supported for snapshots of thick LUNs. A Thin Clone is a read/write copy of a thin block storage resource and cannot be created using thick LUNs.
- At the time of the Thin Clone creation:
  - The source snapshot must be read-only and expiration policy / automatic deletion must be disabled.
  - After the Thin Clone is created, the source snapshot can be deleted.
- A Thin Clone of a Thin Clone cannot be created before an intermediate snapshot is created.
- A replicated Thin Clone becomes a Full clone on the destination storage system.
- A production storage resource cannot be deleted if it has associated Thin Clones.
- Unisphere Move option is not supported for Thin Clones.

LUN Refresh Operation - 1 of 2

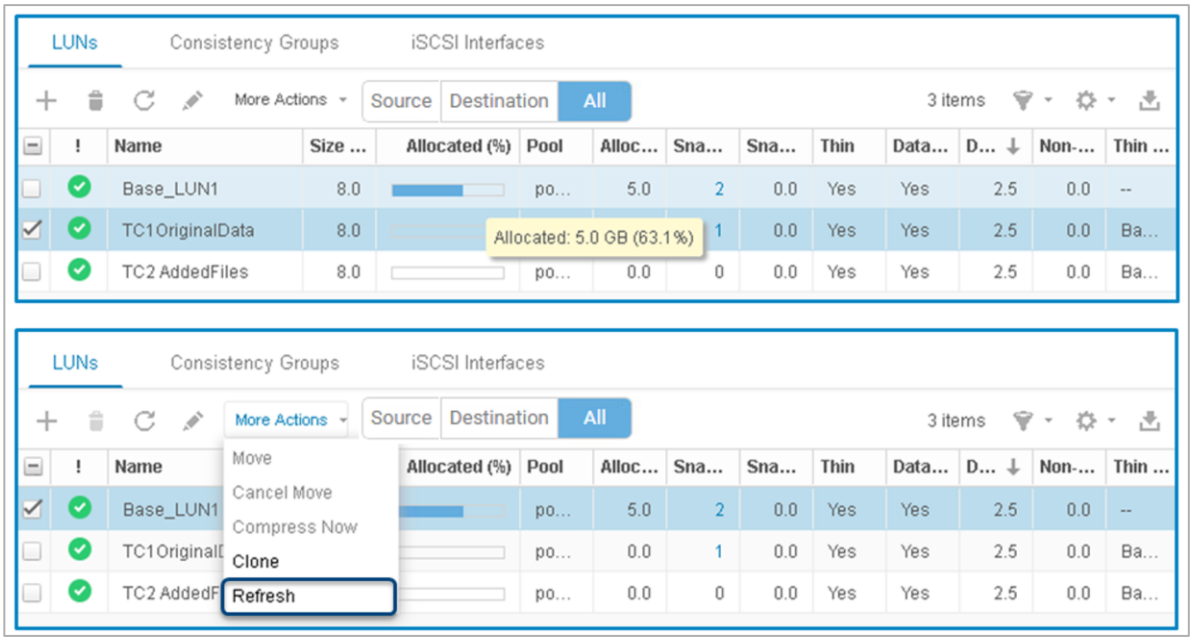
This page shows the Unisphere LUNs page with the example of a Base LUN and its respective Thin Clones.

In the example, Base_LUN1 has two Clones that are taken at different times:

- The Base_LUN1 has an allocated percentage of 63.1.
- TC1OriginalData was a clone of the original Base_LUN1 and has an allocation of 2.1 percent.
- TC2 AddedFiles were taken after adding files to the Base_LUN1.

For the top window, a snapshot that is taken of TC1OriginalData is used to populate the Base_LUN1 with the original data.

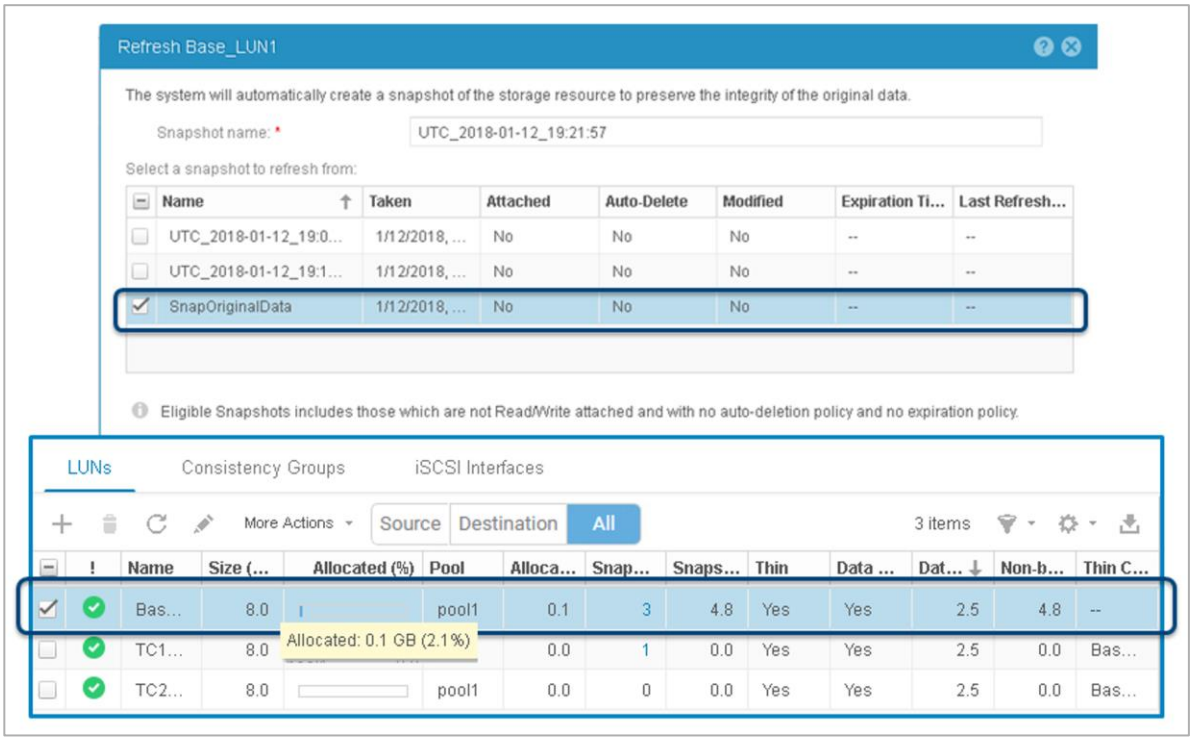
For the bottom window, the Base_LUN1 has been selected and the Refresh option is used to populate the base LUN.



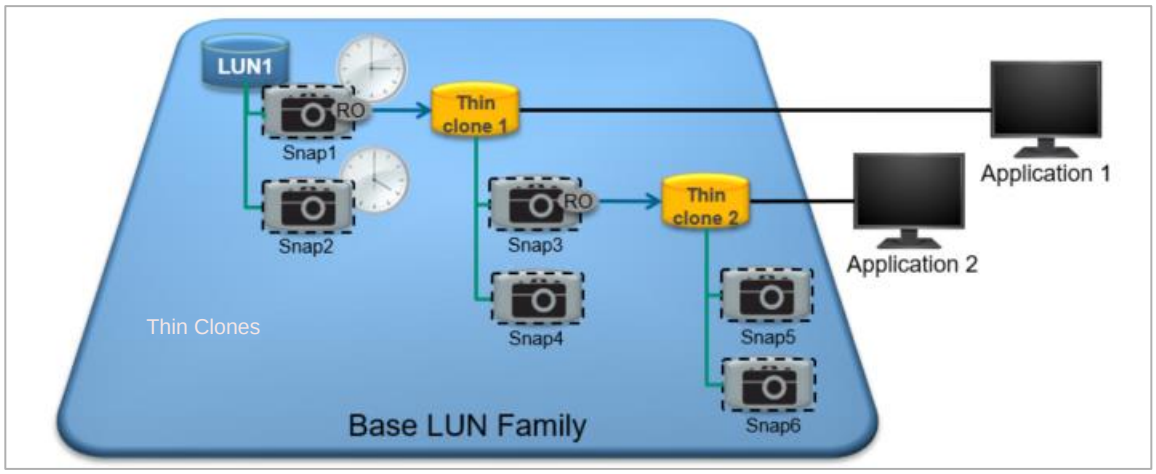
LUN Refresh Operation - 2 of 2

In the top window, the SnapOriginalData resource has been selected. Note the Attached and Auto-Delete options must display a No status state.

The bottom window shows that the results after the Base_LUN1 has been updated with the SnapOriginalData snapshot. The properties of Base_LUN1 show that the Allocated space is only 2.1% after the refresh.



Data Reduction and Advanced Deduplication with Snapshots and Thin Clones



Dell Unity Snapshots and Thin Clones are fully supported with data reduction and Advanced Deduplication. Snapshots and Thin Clones also benefit from the space savings that are achieved on the source storage resource.

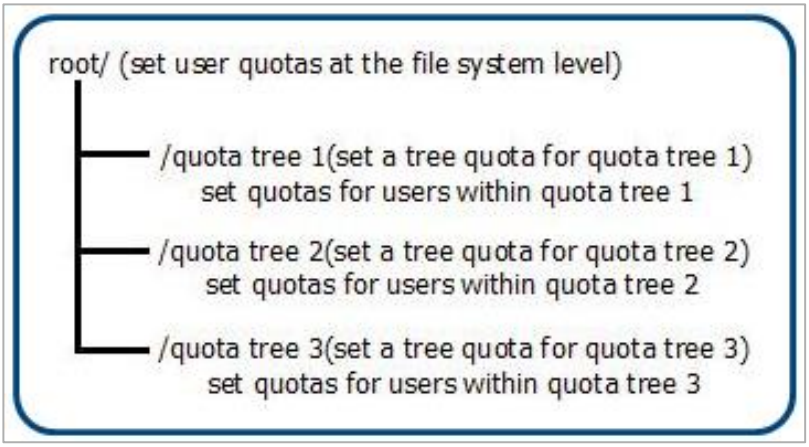
Both Snapshots and Thin Clones support deduplicated blocks.

- Snapshot and Thin Clone metadata can reference deduplicated blocks so when reading from a snapshot which references a deduplicated block, the block is re-created and sent to the host.
- When a source resource receives a write to a deduplicated block which is shared with a snapshot or Thin Clone, a normal redirect on write occurs. The software then determines if a block must be allocated.

When writing to a Snapshot or Thin Clone, the I/O is subject to the same data efficiency mechanism as the storage resource. Which efficiency algorithms are applied depends on the Data Reduction and Advanced Deduplication settings of the parent resource.

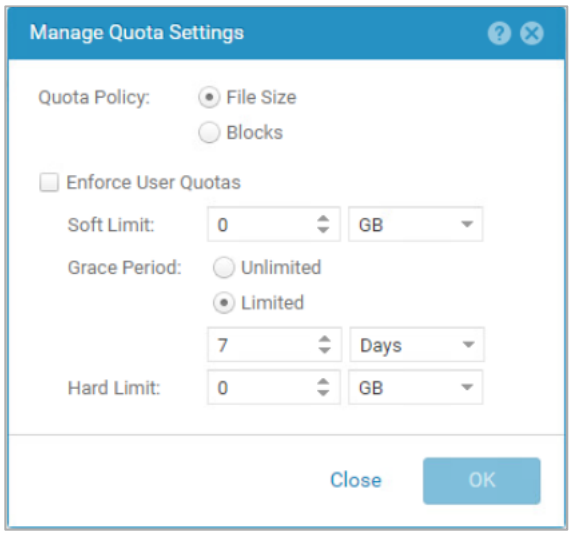
File System Quotas

File System Quotas overview



- **Track file system usage**
  - Dell EMC Unity storage systems support file system quotas which enable storage administrators to track and limit usage of a file system. Limiting usage is not the only application of quotas. The quota tracking capability can be useful for tracking and reporting usage by simply setting the quota limits to zero.
- **Limits usage**
  - Quota limits can be designated for users, or a directory tree. Limits are stored in quota records for each user and quota tree. Limits are also stored for users within a quota tree.
- **Usage determined by Quota Policy**
  - Quota policies ensure that the file system is configured to use the quota policy that best suits the client environment. Users have a choice of File Size [the default], or the Blocks policy. The File Size quota policy calculates the disk usage based on logical file sizes in 1 KB increments. The block quota policy calculates the disk usage in file system blocks in 8 KB units.
- **Quota limits**
  - Hard and soft limits set on the amount of disk space allowed for consumption.

File System Quotas Configuration



Dell EMC recommends that quotas are configured before the storage system becomes active in a production environment. Quotas can be configured after a file system is created.

Default quota settings can be configured for an environment where the same set of limits are applied to many users.

Open the Manage Quota Settings window:

1. Select the file system to edit.
2. Click the pencil icon to edit the selected file system.
3. Select the **Quotas** tab.
4. Click **Manage Quota Settings**.

These parameters can be configured from the *Manage Quota Settings* window:

- Quota policy: File size [default] or Blocks
- Soft limit
- Hard limit
- Grace period

The **soft limit** is a capacity threshold. When file usage exceeds the threshold, a countdown timer begins. The timer, or grace period, continues to count down as

long as the soft limit is exceeded. However, data can still be written to the file system. If the soft limit remains exceeded and the grace period expires, no new data may be added to the particular directory. Users associated with the quota are also prohibited from writing new data. When the capacity is reduced beneath the soft limit before the grace period expires, access is allowed to the file system

The **grace period** can be limited by days, hours and minutes, or unlimited. When the grace period is unlimited, data can be written to file system until the **quota hard limit** is reached.

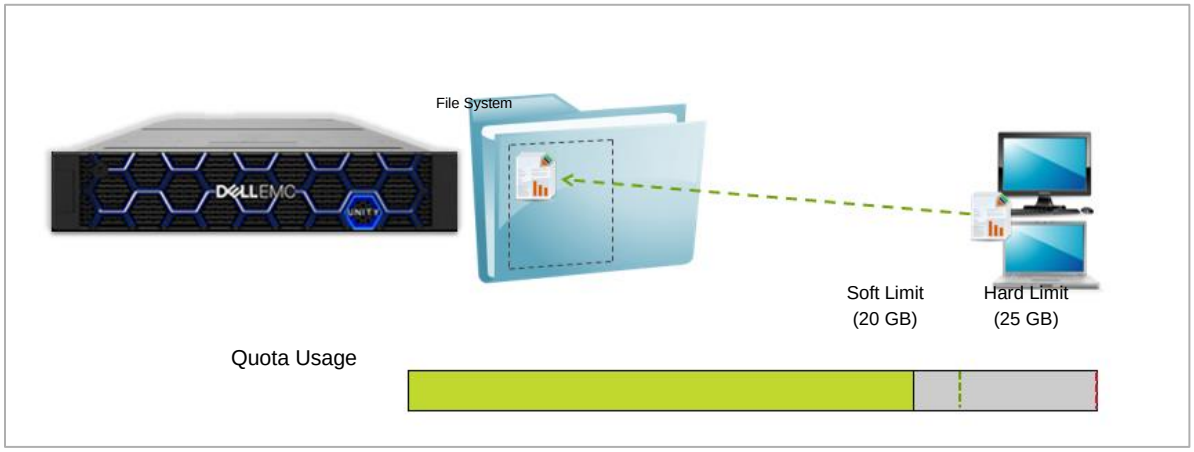
A **hard limit** is also set for each quota configured. When the hard limit is reached, no new data can be added to the file system or directory. The quota must be increased, or data must be removed from the file system before more data can be added.

Quota Usage

File system quotas can track and report usage of a file system.

- When the **Soft Quota limit** is reached
  - Storage administrator receives notification of the event
  - Grace period is invoked, if the quota policy is set with a defined limit of days, hours or minutes.

In this example, a user quota was configured on a file system for a particular user. The Soft Limit is 20 GB, the Grace Period is one day, and the Hard Limit is 25 GB. The user copies 16 GB of data to the file system. Since the capacity is less than the user's quota, the user can still add more files to the file system.

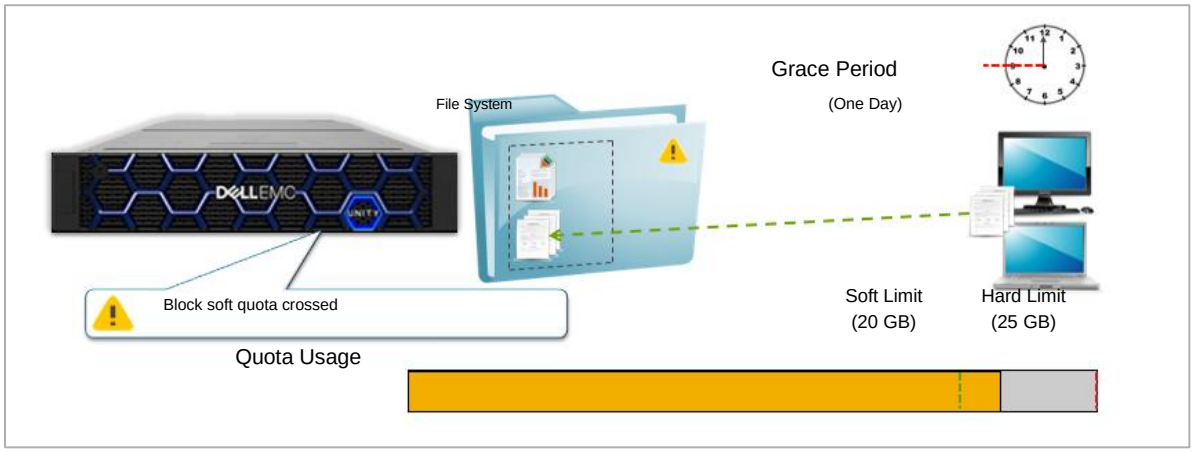


Quota Limit

Soft Limit

When the **Soft Quota limit** is reached,

- Storage administrator receives notification of the event
- Grace period is invoked



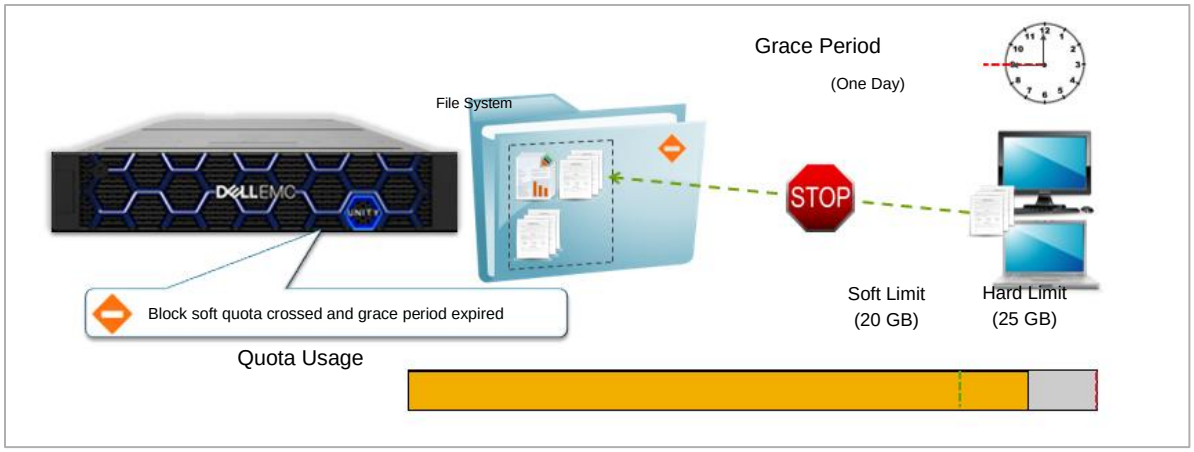
In this example, the user crosses the 20 GB soft limit. The storage administrator receives an alert in Unisphere stating that the soft quota for this user has been crossed.

The Grace Period of one day begins to count down. Users are still able to add data to the file system. Before the expiration of the Grace Period, file system usage must be less than the soft limit.

Grace Period

When the **Grace Period** is reached,

- The system issues a warning when the grace period is reached
- Storage administrator receives notification of the event



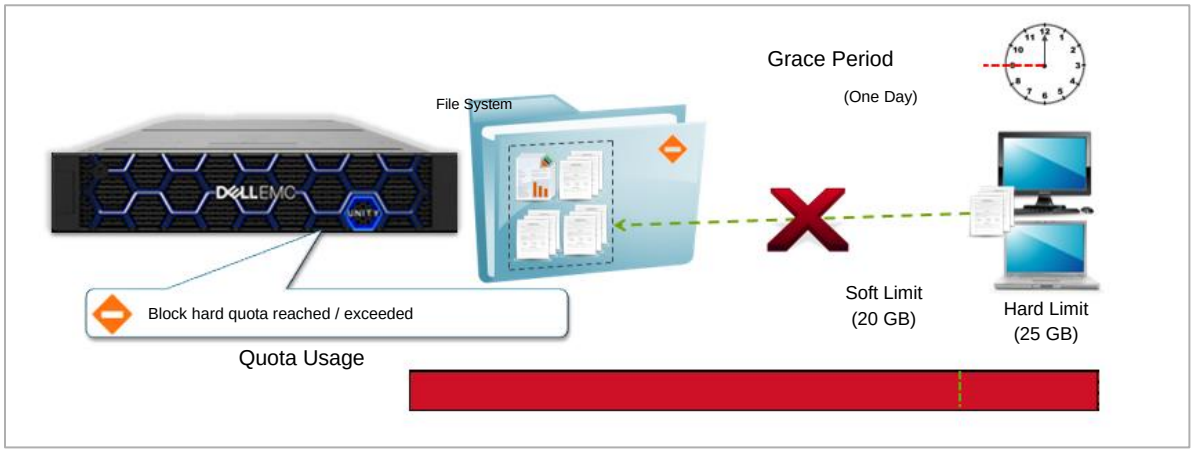
When the Grace Period is reached and the usage is still over the soft limit, the system issues a warning. The storage administrator receives a notification of the event.

The transfer of more data to the file system is interrupted until file system usage is less than the allowed soft limit.

Hard Limit

When the **Hard Limit** is reached,

- Error message is sent to client, and user requests are denied
- Storage administrator receives notification of the event



If the Grace Period has not expired and data remains being written to the file system, eventually the Hard Limit is reached.

When the hard limit is reached, users can no longer add data to the file system and the storage administrator receives a notification.

Storage Efficiency Key Points

1. **Data Reduction**
   a. Dell Unity XT Data Reduction provides space savings by using data deduplication and compression.
   b. Data reduction is supported on All Flash pools created on Dell Unity XT Hybrid Flash systems or Dell Unity XT All Flash systems.
   c. Data reduction is supported on thin storage resources: LUNs, LUNs within a Consistency Group, file systems, and VMware VMFS and NFS datastores.
2. **FAST VP**
   a. Dell Unity Fully Automated Storage Tiering for Virtual Pools (FAST VP) monitors the data access patterns within heterogeneous pools on the system.
   b. In storage pools with Flash, SAS and NL-SAS, FAST VP uses the Flash drives for active data, and low cost spinning drives for less active data.
   c. There are four tiering policies: **Start High then Auto-tier** (default), **Highest Available tier**, **Auto Tier**, **Lowest Available Tier**.
   d. RAID levels for each tier can be selected when creating a pool. The supported RAID levels are **RAID 1/0**, **RAID 5** and **RAID 6**.
   e. Data relocation can be schedule the system level, or manually started at the storage pool level.
3. **Thin Clones**
   a. A Thin Clone is a read/write copy of a thin block storage resource that shares blocks with the parent resource.
      - The resource is built from a snapshot of thin block storage resources: LUNs, LUNs member of a Consistency Group, or VMFS datastores.
      - Thin Clones can be created from Attached read-only or Unattached Snapshots with no auto-deletion policy and no expiration policy.
      - Thin Clones are supported on all Dell EMC Unity XT models including Dell EMC UnityVSA.
4. **File System Quotas**

a. Dell Unity XT systems support file system quotas which enable storage administrators to track and limit usage of a file system.
b. Quota limits can be designated for users, a directory tree, or users within a quota tree.
c. Quota policy can be configure to determine usage per File Size (the default), or Blocks.
d. The policies use hard and soft limits set on the amount of disk space allowed for consumption.

For more information, see the **Dell EMC Unity: Data Reduction**, **Dell EMC Unity: FAST Technology Overview**, **Dell EMC Unity: Snapshots and Thin Clones A Detailed Review**, and **Dell EMC Unity: NAS Capabilities** on the Dell Technologies Info Hub.

Appendix: Supported Configurations for Data Reduction and Advanced Deduplication

Dell Unity OE	Technology	Supported Pool Type	Supported Models
4.3 / 4.4	Data Reduction	All Flash Pool [1]	300 | 400 | 500 | 600 300F | 400F | 500F | 600F 350F | 450F | 550F | 650F
4.5	Data Reduction	All Flash Pool [1]	300 | 400 | 500 | 600 300F | 400F | 500F | 600F 350F | 450F | 550F | 650F
	Data Reduction + Advanced Deduplication	All Flash Pool [2]	450F | 550F | 650F
5.0 / 5.1	Data Reduction	All Flash Pool [1]	300 | 400 | 500 | 600 300F | 400F | 500F | 600F 350F | 450F | 550F | 650F 380 | 480 | 680 | 880 380F | 480F | 680F | 880F

	Data Reduction + Advanced Deduplication	All Flash Pool [1]	450F | 550F | 650F 380 | 480 | 680 | 880 380F | 480F | 680F | 880F
5.2	Data Reduction	All Flash Pool [1]	300 | 400 | 500 | 600 300F | 400F | 500F | 600F 350F | 450F | 550F | 650F 380 | 480 | 680 | 880 380F | 480F | 680F | 880F
		Hybrid Pool [1, 3]	380 | 480 | 680 | 880
	Data Reduction + Advanced Deduplication	All Flash Pool [1]	450F | 550F | 650F 380 | 480 | 680 | 880 380F | 480F | 680F | 880F
		Hybrid Pool [1, 3]	380 | 480 | 680 | 880

[1] Resource can be created on either a Traditional or a Dynamic Pool (For systems that support Dynamic Pools).

[2] Resource can be created on a Dynamic Pool Only.

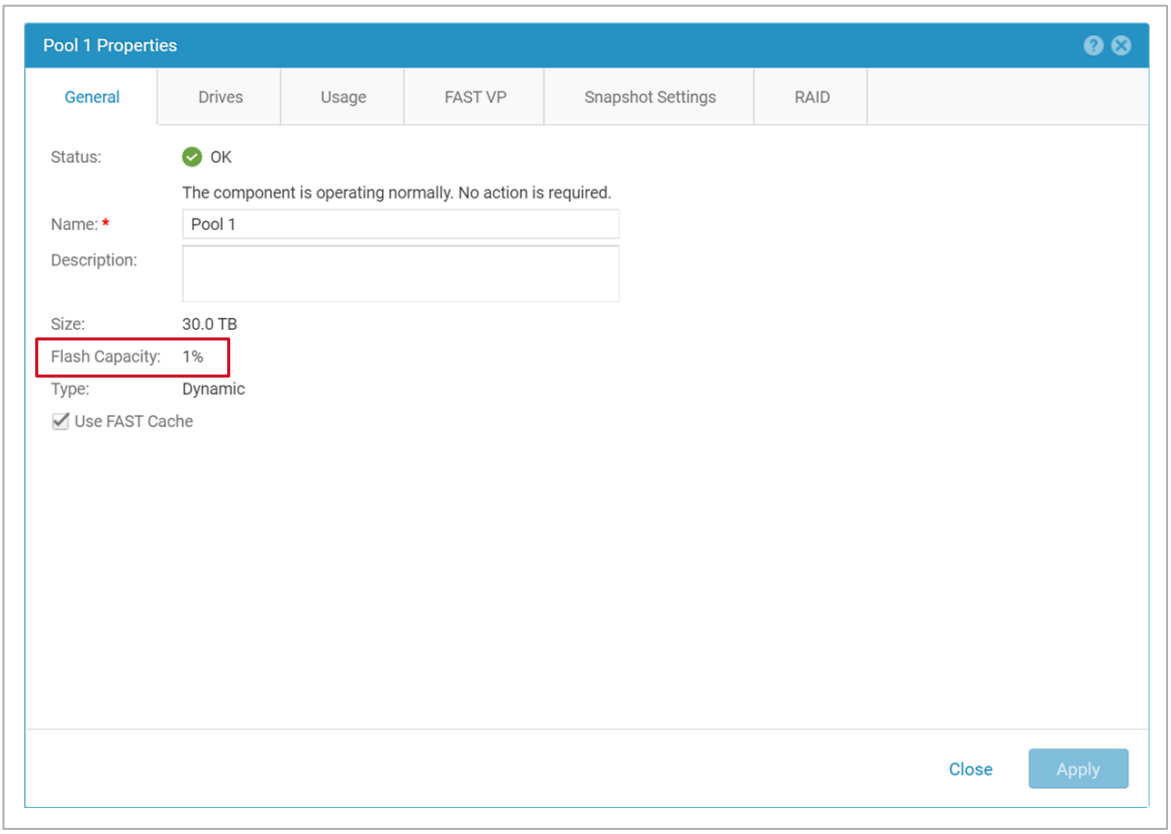
[3] The pool must contain a flash tier, and the total usable capacity of the flash tier must meet or exceed 10% of the total pool capacity.

Appendix

Storage Resource on Low Flash Capacity Pool

When the **Flash Percent (%)** value of a hybrid flash dynamic pool is below 10%, data reduction is not supported for the storage resources.

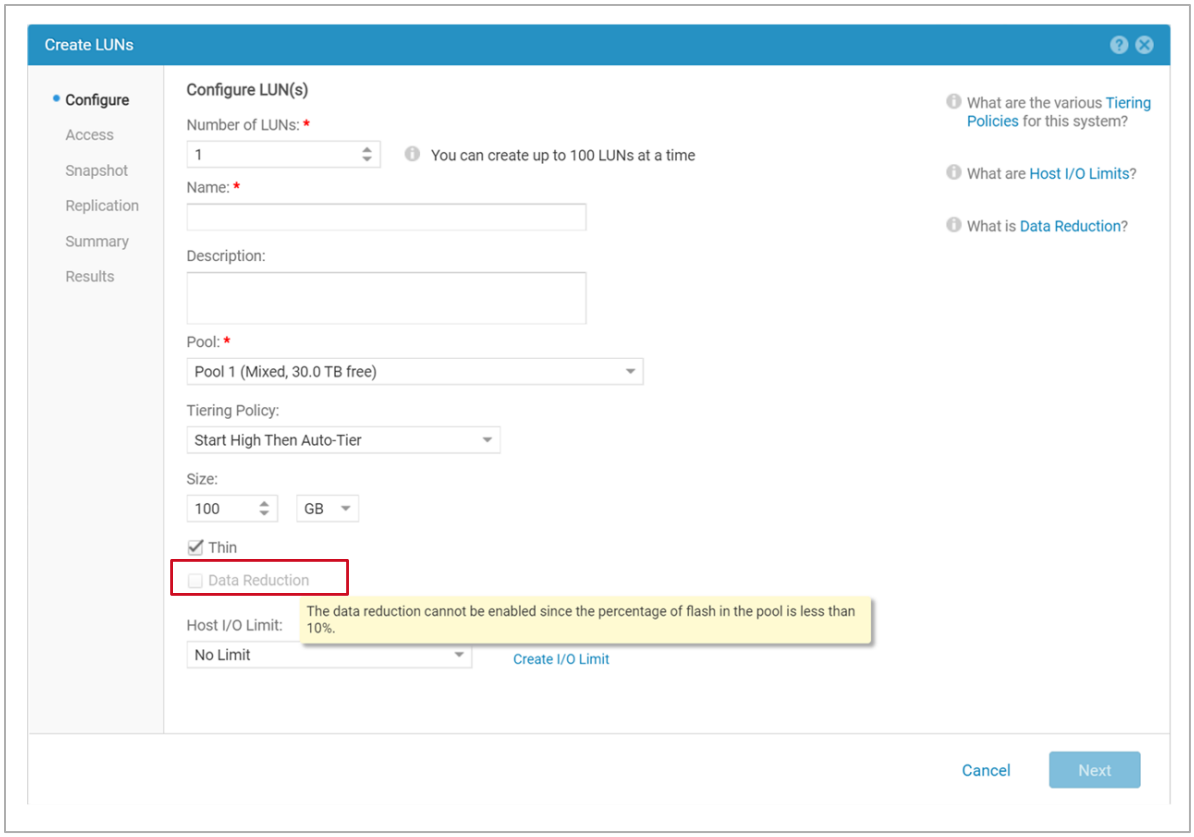
In the example, the Flash Percent (%) of **Pool 1** does not comply with the data reduction requirements.



Pool properties General tab showing the Flash Percent (%).

Data Reduction is disabled and unavailable for any storage resource that is created from the pool. The feature is grayed out, and a message explains the situation.

The example shows that data reduction is not available when creating a LUN on **Pool 1**.



Create LUN wizard with the Data Reduction option unavailable for configuration.