

Titan T5000 Dynamic Pools



Dell Unity: Dynamic Pools

Abstract

This white paper provides an overview of Dell Unity dynamic pool technology including information on the benefits, underlying structures, and management methods.

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Executive summary

The Dell Unity product line is a simple, easy-to-use, and intelligent storage system which helps meet the needs of IT professionals in large or small companies. The systems are designed with flash in mind and leverage the latest cloud-based data management, efficiency, rich data services, and mobility technologies. The Dell Unity product line comes in a variety of deployment models from purpose-built all-flash or hybrid configurations to converged infrastructure and even virtual storage appliances. To further increase the flexibility of configuration options, the dynamic pools feature was introduced.

Dynamic pools is a pool technology first introduced for all-flash systems in Dell Unity OE version 4.2 and later. In OE version 5.2 and later, dynamic pools are supported on hybrid flash systems. Dynamic pools replaces the previous pool technology, now referred to as traditional pools, as the default pool type for all-flash systems in OE version 4.2 and hybrid flash systems in OE 5.2. Dynamic pools utilize advanced RAID techniques and distributed sparing to offer better storage utilization and more simplified planning than traditional pools. Dynamic pools provides a number of benefits over traditional pools, which are discussed throughout this document.

This document provides in-depth information about dynamic pools including the underlying architecture of and all hidden components of the pool structure. Also discussed are the configurations supported by dynamic pools, which outline the drives supported within a dynamic pool, the number of drives supported, and the RAID types and widths supported. Information on creating and managing dynamic pools is also provided, which can easily be achieved through Unisphere™, Unisphere CLI, and REST API. The interoperability of dynamic pools with other software features is also discussed.

Audience

This white paper is intended for customers, partners, and employees who are planning to utilize dynamic pools. It assumes familiarity with Dell Unity storage and the management software.

Terminology

All-flash pool: A pool which contains only flash drives.

Block storage resources: LUNs, consistency groups and VMware VMFS datastores.

Compression: A data-reduction method which reduces the physical amount of storage required to save a dataset.

Consistency group: A storage instance which contains one or more LUNs within a storage system. Consistency groups help organize the storage allocated for a particular host or hosts. Data protection configurations, such as replication and snapshot settings, on a consistency group affect all the LUNs contained in the group, providing ease of management and crash consistency if the LUNs are dependent on each other.

Data at Rest Encryption (D@RE): The process of encrypting data and protecting it against unauthorized access unless valid keys are provided. This prevents data from being accessed and provides a mechanism to quickly crypto-erase data.

Deduplication: A data -method which reduces the physical amount of storage required to save a data set.

Drive extent: A portion of a drive contained within a dynamic pool. Each drive extent is used to provide usable capacity to the pool, or spare space.

Drive partnership group: A collection of drives of the same drive type which have been combined into a hidden dynamic pool object. The drive partnership group contains a maximum of 64 drives, and is used to provide space to the pool.

Dynamic pool: A pool type introduced in Dell Unity OE version 4.2 to provide space to storage resources. Dynamic pools allow for flexible deployment models and reduced rebuild times and flash wear compared to Traditional pools.

Dynamic pool private RAID group: A hidden dynamic pool object created using RAID extents. A dynamic pool private LUN is created on each private RAID group, which is then used to partition space to storage resources created on the pool.

Dynamic pool private LUN: A hidden dynamic pool object created on a dynamic pool private RAID group. The private LUN is later partitioned into 256 MB slices, which are used as the underlying storage objects for storage resources created on the pool.

File storage resources: File systems (NFS, SMB) and VMware NFS datastores.

Flash drive (SSD): A flash-based storage device used to store data.

Hybrid Pool: A Pool which does not contain only Flash Drives. A Hybrid Pool typically contains more than one type of drive technology, such as Flash, SAS, and NL-SAS.

LUN: A block-based storage resource which a user provisions. It represents a SCSI logical unit.

Pool: A set of drives that provide specific storage characteristics for the resources that use them, such as LUNs, VMware datastores, and file systems.

RAID extent: An object created using drive extents to provide RAID protection for the data within the pool. Once the RAID type and stripe width (RAID width) for the pool is set, each RAID extent provides the RAID protection for the pool. As an example, if the dynamic pool is created with RAID 5 (4+1) protection, a RAID extent contains 5 drive extents to provide the 4+1 protection.

REST API: An application programming interface (API) that utilizes familiar HTTP operations like GET, POST, and DELETE. REST architecture includes certain constraints that ensure that different implementations of REST conform to the same guiding principles, thereby allowing developers the ease of application development when working with different REST API deployments.

Snapshot: A snapshot, also called a Dell Unity Snapshot, is a point-in-time view of a storage resource. When a snapshot is taken, the snapshot is an exact copy of the source storage resource, and shares all blocks of data with it. As data changes on the source, new blocks are allocated and written to. Snapshot technology can be used to take a snapshot of a block or file storage resource.

Spare space extent: A drive extent reserved as spare space within the dynamic pool. Spare space extents are only utilized to replace extents on a failing or failed drive within the same drive partnership group.

Storage resource: An addressable and configurable storage instance associated with a specific quantity of storage. LUNs, file systems, and VMware datastores constitute storage resources.

Stripe width: The stripe width, also known as the stripe RAID width, is the number of drive extents used for the RAID type chosen for the pool. For example, a RAID 5 (4+1) RAID extent has a stripe width of 5 (4+1), and therefore contains 5 drive extents.

Traditional pool: The pool technology available within Dell Unity systems before the dynamic pools feature was released. Traditional pools continue to be supported, and can be managed through Unisphere, Unisphere CLI, and REST API. To create a traditional pool, Unisphere CLI or REST API must be used.

Unisphere: A web-based management environment used to create storage resources, configure and schedule protection for stored data, and manage and monitor other storage operations.

Unisphere CLI (UEMCLI): The command line interface (CLI) for managing Dell Unity storage systems.

1 Overview

A pool is a collection of drives within the system arranged into an aggregated group, with some form of RAID protection applied to the drives to provide redundancy. The capacity within the pool, minus the overhead for the RAID protection selected, can be used to provision block, file, or VMware® vSphere® Virtual Volumes™ (vVols) storage resources. Dynamic pools were released in Dell Unity OE version 4.2 for all-flash systems and hybrid flash systems in OE 5.2. This feature increases the flexibility of configuration options within the system with an entirely redesigned pool structure. In Dell Unisphere™, dynamic pools is the default pool type for all-flash systems in OE 4.2 and later and hybrid flash systems in OE 5.2 and later. Dynamic pools can be created, expanded, and deleted like traditional pools, but include other improvements as well.

Within a traditional pool, private pool RAID groups are created based on the RAID protection and width selected at time of pool creation or expansion. These private RAID groups are fixed in width, and drives must be added to the pool in drive-count multiples which match the stripe width selected. Dynamic pools eliminate the need to design a pool based on a multiple of a stripe width. When creating a dynamic pool, once a minimum drive count for a given RAID protection has been selected, the user can select almost any number of drives to place within the pool. This allows planning a pool based on a specific capacity without concern for stripe-width-based multiples of drives counts. When expanding a dynamic pool, since the stripe-width multiple does not apply, the user can also expand by a specific target capacity. In most cases, the user can add a single drive to the pool to increase its capacity. These features provide flexible deployment models which improves the planning and provisioning process. The total cost of ownership of the configuration is also reduced because extra drives needed to fulfill a stripe-width multiple are eliminated.

In systems that use traditional pools, hot spares must be included in the configuration. This requirement increases the cost of a solution for drives that are left unused within the system, and are only used when a drive is failing or has failed. For dynamic pools, space is reserved within the pool to replace drives which may fail or have failed within the pool. This space is considered overhead, and is not part of the usable capacity of the pool. With this, hot spares are not required for dynamic pools, and all drives within a storage system can be placed within a dynamic pool. To fully use the drives within a dynamic pool, the user data and space reserved for drive failures is spread across all drives within the pool. This helps to spread out application I/O across the drives within the pool, and also helps to spread out and mitigate wear across the drives.

As dynamic pools are created without using discreet groups of drives, rebuild operations are different than rebuilds occurring within a traditional pool. When a drive is failing or has failed with a traditional pool, a hot spare is engaged and used to replace the bad drive. This replacement is one-to-one, and the speed of the proactive copy or rebuild operation is limited by the fixed width of the private RAID group and the single targeted hot spare. With dynamic pools, regions of RAID and regions within the pool used for drive replacement are spread across the drives within the pool. In this design, multiple regions of a failing or failed drive can be rebuilt simultaneously. As the space for the replacement is spread across the drives in the pool, the proactive copy or rebuild operations are also targeted to more than one drive. With these features, the amount of time to replace a failed drive is significantly reduced.

2 Architecture

This section covers the underlying architecture of dynamic pools, with each of the subsections outlining a building block of the overall dynamic pool structure. While there are many elements to dynamic pools, most of the following topics are hidden to the user in Unisphere, Unisphere CLI, and REST API. They are only discussed to provide insight into the underlying components of dynamic pools. Creating or expanding a dynamic pool involves determining only the number of drives to attain the usable capacity required.

2.1 Drives

A pool is a set of drives that provide specific storage characteristics for storage resources created on the pool to utilize. A typical all-flash system contains either SAS flash 3 or SAS flash 4 drives of the same capacity which are used to create pools within the system. A typical hybrid flash system contains a mix of flash, SAS, and NL-SAS drives to create pools within the system. With dynamic pools, a drive is the most basic part of the pool. Once a pool has been created, other dynamic pool structures are created on the drives to provide the usable capacity to the user, and provide fault tolerance.

2.2 Drive partnership groups

When a dynamic pool is created or expanded, the selected drives are placed into drive partnership groups. A drive partnership group is a group of drives of the same drive type which are combined into a hidden dynamic pool object. The number of drives placed in each group directly depends on the number and type of drives selected at pool creation, or selected later when the pool is expanded. A dynamic pool always includes at least one drive partnership group, and each drive within a dynamic pool can only be part of a single drive partnership group. For the life of the pool, a drive never changes the drive partnership group that it is part of.

Each drive partnership group can only contain a single drive type, though different sizes of a particular drive type can be mixed within the group. Figure 1 shows an example of a dynamic pool created with different drive types and sizes. In this example, all SAS flash 3 drives are placed into a single drive partnership group, while all SAS flash 4 drives are placed into their own drive partnership group. A typical all-flash configuration contains a single drive type and size, but dynamic pools allow for different drive types and sizes to be mixed.

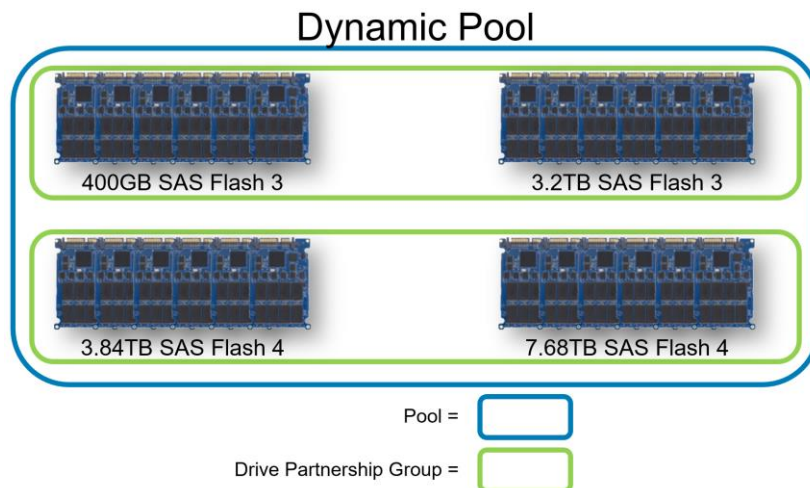


Figure 1 Drive partnership group example with SAS flash 3 and SAS flash 4 drives

Within a hybrid system, adding flash, SAS, and NL-SAS drives into a multi-tiered pool is common. As each drive partnership group can only contain a single drive type, flash, SAS, and NL-SAS drives will be placed into

their own drive partnership groups. Furthermore, different speed spinning drives can be added to the same dynamic pool but will be placed into their own drive partnership groups for performance reasons. For example, 10K RPM and 15K RPM drives residing in the same pool will be placed into different drive partnership groups regardless of the drive size as shown in the figure below. In this example, the 6TB and 12TB NL-SAS drives are placed in the same drive partnership group as they have the same speed rating.

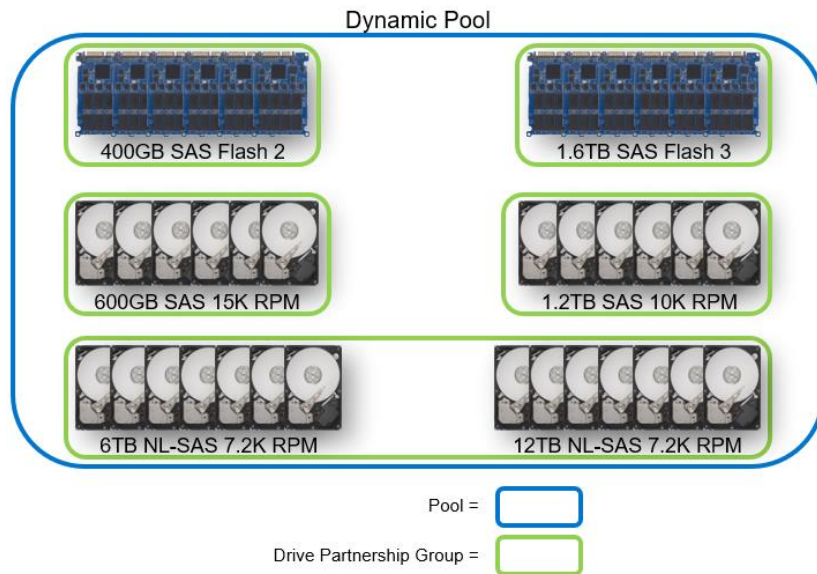


Figure 2 Drive partnership group example with multiple drive types

The maximum number of drives contained within a drive partnership group is 64. When more drives of the same type are included in the pool, more drive partnership groups are created. Each drive partnership group is started with a minimum number of drives, which is controlled by the RAID type and stripe width of the pool. Once the RAID type and stripe width are set for a particular drive type, all drive partnership groups containing that type of drive will use those settings. When a drive partnership group is full, another minimum number of drives is needed to create the next drive partnership group with the same RAID type and stripe width. This topic is covered in further detail in section 3 on supported configurations.

Figure 3 shows an example of multiple dynamic pools and drive partnership groups. In the left image, the dynamic pool has only six drives of the same type. All of these drives are placed into a single drive partnership group at time of pool creation. The middle image is a pool which contains 64 drives of the same type. The pool may have been created with 64 drives, or was created with less drives and later expanded. Since the total number of drives is 64, they are all placed into a single drive partnership group, and the group is considered full. The right image is an example of a dynamic pool which contains 70 drives. Since a drive partnership group is considered full at 64 drives, the remaining six drives are placed in a new drive partnership group. As with the middle pool, this pool may have been created using 70 drives, or was expanded after creation to reach this drive count.

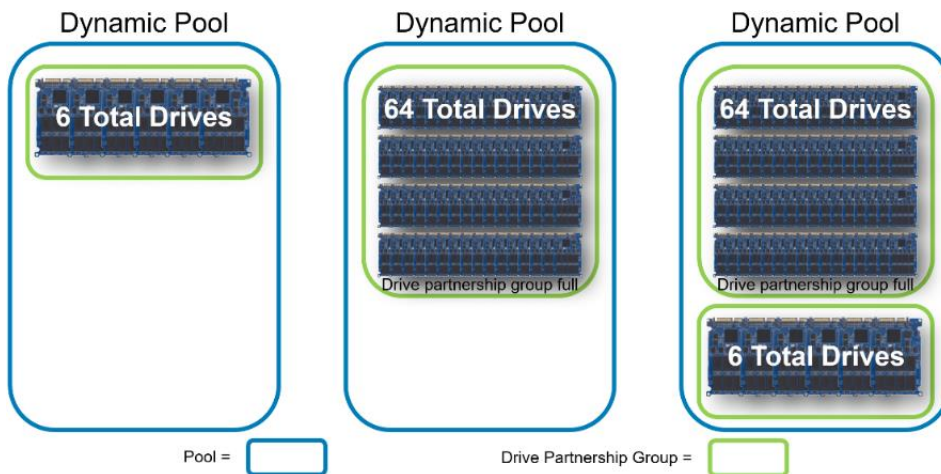


Figure 3 Drive partnership group example

The drive partnership group within a dynamic pool is used to limit the amount of drives other dynamic pool objects can cross. These objects include drive extents, RAID extents, spare space extents, and dynamic pool private RAID groups, all of which are explained in the following subsections. This level of division ensures the data is not spread across a large amount of drives, which can increase the risk of encountering multiple drive failures and could degrade or break the RAID protection selected.

2.3 Drive extents

A drive extent within a dynamic pool is simply a portion of a drive that is gigabytes in size. The size of each extent is fixed for each drive type. After a dynamic pool is created on the system, each drive within a dynamic pool is partitioned into drive extents. The number of extents created on each drive directly depends on the drive type and size. Each extent within a drive is either used to store user data, or reserved as space to replace a failing or faulted drive within the pool.

Figure 4 shows two drives, a 400 GB SAS FLASH 3 drive and an 800 GB SAS flash 3 drive, partitioned into drive extents. Since all drive extents for this drive type are equal in size, the number of extents created on the 800 GB drive is twice the number created on the 400 GB drive.

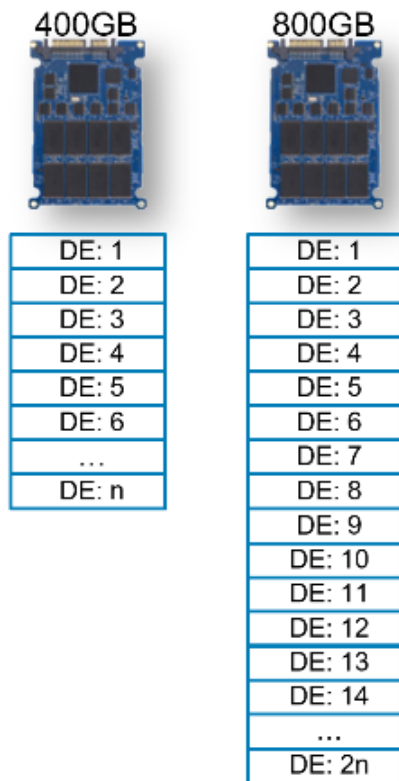


Figure 4 Drive extent example with SAS flash 3 drives

2.4 Spare space extents

Unlike traditional pools, dynamic pools do not require dedicated hot spare drives. Instead, space within each pool is reserved and can only be used to replace a failing or failed drive. After a dynamic pool is created and the drives are partitioned into drive extents, a number of drive extents are reserved and marked as spare space extents within each tier of the pool. The number of spare space extents reserved within a dynamic pool directly depends on the number of drives within the pool, the types of drives within the pool, the size of the drives within the pool, and the hot spare capacity setting. The hot spare capacity setting is new in Dell Unity OE version 5.1 release.

The hot spare capacity setting allows a user to reserve either 1 drive (default) or 2 drives worth of spare space for every 32 drives within a pool at the time of pool creation. If the pool being created has multiple tiers, the hot spare capacity can be set for each drive tier during pool creation. The hot spare capacity setting can also be set for a new drive tier when expanding a pool. When creating or expanding a pool the minimum number of drives required for each tier depends on the stripe width and the hot spare capacity set for the tier. The amount of spare space reserved always ensures that either one or two drives of the largest drive's usable capacity within each tier can be replaced with the spare space extents remaining within the pool. Reserving additional spare space does not improve the reliability of the RAID protection for the pool. Spare space extents within a tier are only used to replace extents within the same tier.

Spare space is counted as part of a pool's overhead, as with RAID overhead, and is not reported to the user. Spare space is also not part of the usable capacity within the pool for user data. If a pool were to become full and a drive failure occurred, there would still be spare-space extents within the pool to complete the rebuild operation. The amount of spare space within the pool is reserved at the time of pool creation and when expanding a pool. It cannot be modified on an existing pool. When a drive count crosses the 32 drive count,

additional spare space extents are reserved from the additional capacity being added to the pool based on the hot spare capacity setting. When expanding a pool in Unisphere in this instance, the amount of usable capacity would show less than that total amount of drive capacity being added to the pool.

Figure 5 shows an example of a 6-drive dynamic pool. Each drive extent in this example is marked with a **Dx DE y** label signifying which drive and which extent it is, such as D1 DE 1 (drive 1, drive extent 1). At time of creation, several extents on each drive are reserved as spare space extents, denoted in the figure as **Spare**. Spare space extents are also reserved when adding a new tier to a pool. The amount of spare space extents directly depends on the hot spare capacity setting for the tier. The figure shows that spare space extents are evenly spread across the drives within the pool. For demonstration purposes, all spare space extents are shown at the end of usable capacity of each drive. This is not necessarily the way extents are allocated by the dynamic pool algorithms.

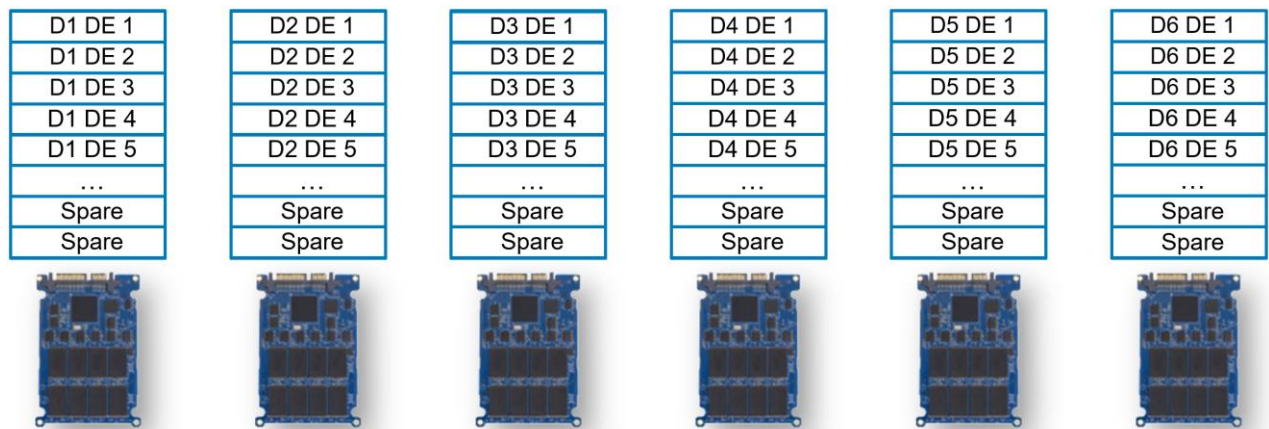


Figure 5 Spare space example within a 6-drive dynamic pool

2.5 RAID extents

After spare space extents are reserved within the dynamic pool, RAID extents are created with the remaining drive extents within each tier of the pool. A RAID extent is a collection of drive extents from a common drive partnership group which complete the stripe width chosen for a particular RAID type. For example, if RAID 5 is selected as the RAID type, and 4+1 is selected as the stripe width for a particular tier in the pool, the RAID extent would contain 5 drive extents (4+1), one for each element of the stripe width. The RAID extent provides RAID protection for user data stored within the dynamic pool, and is later used to provide usable capacity to the pool for storage resource creation. A single RAID extent cannot contain two drive extents from a single drive for protection purposes. Also, RAID extents must contain drive extents from only a single drive partnership group.

Figure 6 shows an example of a dynamic pool created with six drives, assuming that RAID 5 (4+1) has been selected. In this example, a number of extents have already been reserved as spare space extents, and the first three RAID extents are shown. Each RAID extent in this example contains five drive extents, due to the 4+1 stripe width. The five-drive extents are selected from the drives within the drive partnership group, and no 2 extents are selected from the same drive. For ease of illustration, the drive extents selected are in order across the drives within the pool. Within a real system, the dynamic pool algorithm will select drive extents from different drives seemingly at random within the drive partnership group.

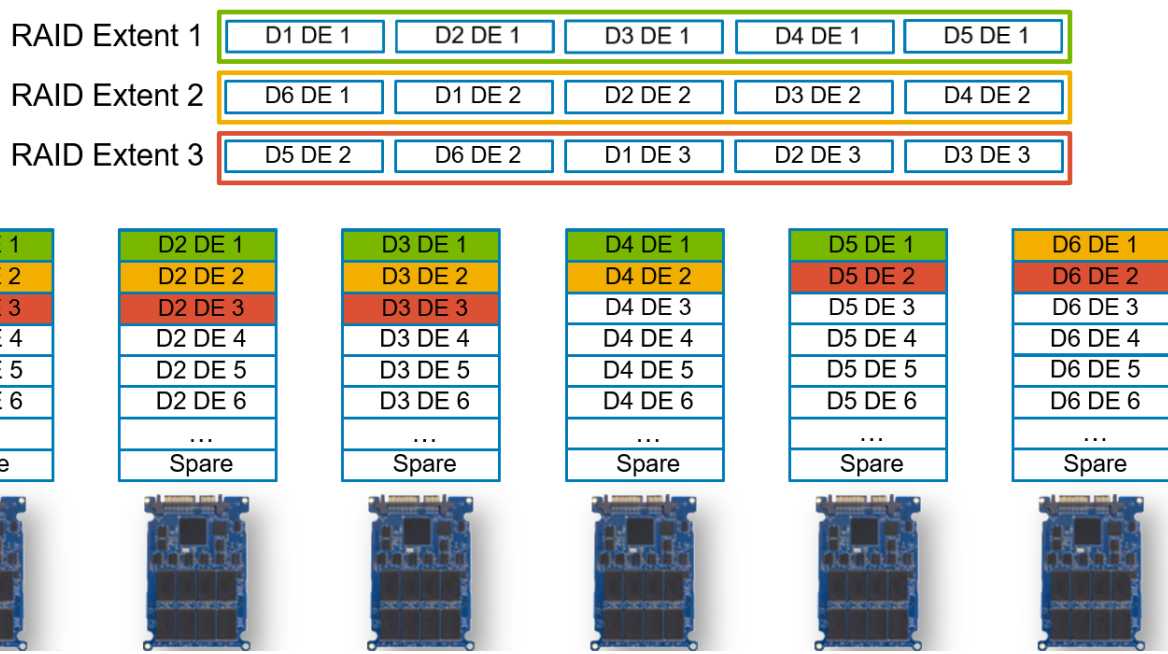


Figure 6 RAID extent example

2.6 Dynamic pool private RAID groups and LUNs

Within a pool on a Dell Unity system, whether Traditional or Dynamic, exists one or more private RAID groups and a single private LUN created on each. These objects, as the names suggest, are underlying components of the system that are not shown in Unisphere, CLI, or REST API. The private RAID group is used to provide space to the private LUN, which provides space in the form of 256 MB slices to the user for storage resource allocation. In a traditional pool, the private RAID group is created by combining a number of drives into a physical RAID group within the system, whose RAID protection and width matches the settings chosen at time of creation or pool expansion. In the case of dynamic pools, the private RAID group concept and the creation of the private LUN and 256 MB slices on top of the usable capacity remain the same. What is different is how space is provided to the private RAID group.

Within dynamic pools, a private RAID group is created using a combination of RAID extents. Depending on the number of drives selected at time of pool creation or expansion, the dynamic pool software will determine how many RAID extents and private RAID groups to create. Later, a single private LUN is created on each private RAID group.

Figure 7 shows an example of a dynamic pool and the private RAID groups created in it. In this example, the dynamic pool consists of six drives of the same size and type. Once the drives extents are combined into RAID extents, the RAID extents are added to dynamic pool private RAID groups. The number of RAID extents contained in each private RAID group are equal, though this is not always the case. For illustration purposes, the RAID extents were created by taking drive extents in order across the drives, though this is not necessarily the order the dynamic pool algorithm will take them. Each tier within a multi-tiered pool will have its own private RAID groups and LUNs.

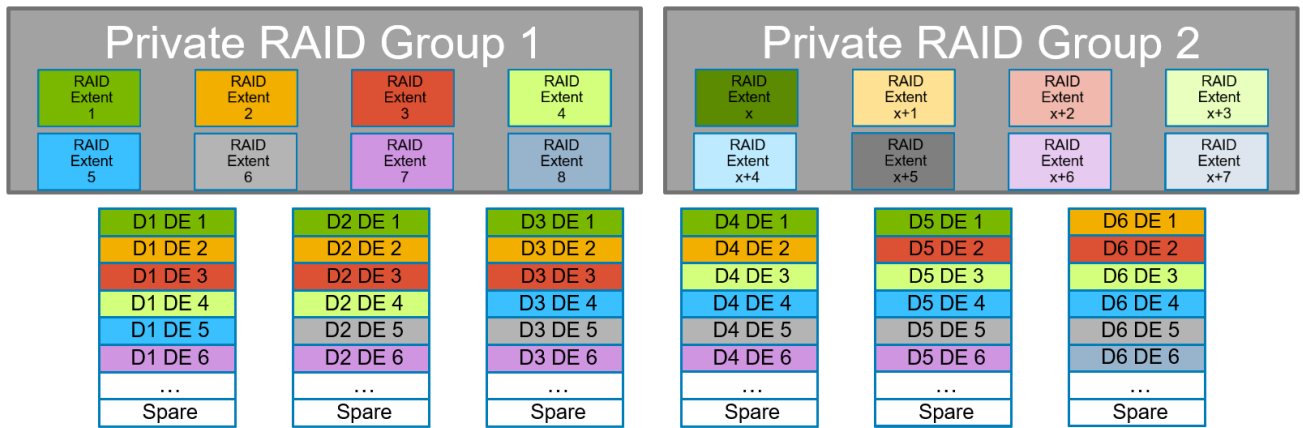


Figure 7 Dynamic pool private RAID group example

After RAID extents are assigned to a private RAID group, the usable space for each extent is combined into a private LUN. The private LUN is later carved into 256 MB slices for storage resource allocation. To ensure user data is spread across as many drives possible, the RAID extents are broken into pieces, a few MBs in size, and combined through concatenation into the private LUN. This ensures that each 256 MB slice contains pieces of multiple RAID extents within the private RAID group.

Figure 8 is an example of a private LUN created using RAID extents within a private RAID group. Pieces of each RAID extent are concatenated together to form the useable capacity of the private LUN. Later, the private LUN is carved into 256 MB slices, which are used to provide space for storage resources created on the dynamic pool. The benefit of allocating space in this manner is that a single 256 MB slice worth of data is spread across multiple RAID extents. These RAID extents may be spread across all drives within a single drive partnership group, which can contain up to 64 drives. This spreading out of data helps to not only spread the workload throughout the drive partnership group, but also spread out wear as much as possible due to the workload. When creating a storage resource on a dynamic pool, such as a LUN or file system, 256 MB slices for the resource will be taken from the different private LUNs within the dynamic pool to further spread out the workload.

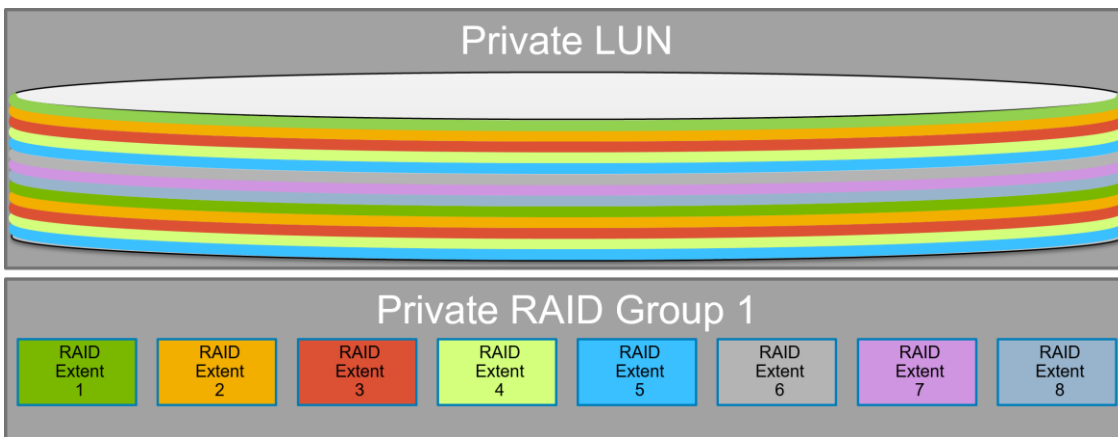


Figure 8 Dynamic pool RAID extent and private LUN example

2.7 Expanding a dynamic pool

To provide flexibility, a user is able to expand an existing tier by one or more drives or add a new drive tier to a pool under most circumstances. The only time an expansion is not allowed is if the number of drives being

added to an existing tier is more than enough to fill a drive partnership group, but not enough to also fulfill the minimum drive requirements to start another. In this instance, either less drives or more drives need to be added to the pool. This topic is covered in further detail in the Supported Configurations section of this paper.

When a single drive is successfully added to a dynamic pool, the space is either added as usable capacity for storage resources or spare space. The drive's capacity is only added as spare space if the requirement for spare space extents has been increased. In this instance, one or more drives need to be added to the pool to increase the usable capacity within the pool, based on the hot spare capacity setting for the tier. To make the usable capacity available to the pool, a rebalance of drive extents within the dynamic pool drive partnership group must occur. This process is necessary as RAID extents cannot include drive extents entirely from the newly added drive. In the background, drives extents are relocated throughout the drive partnership group. During this time, CPU resources are utilized for relocation operations, but priority is always given to user I/O and the relocation process will throttle to not impact performance. This operation does take time to complete. The capacity will be available within the pool once the job completes.

Figure 9 shows an example of expanding a dynamic pool by a single drive which does not increase the spare space requirement. If the spare space requirement increases, a drive extent relocation still occurs and spare space extents are spread out across the drives within the drive partnership group. In this example, drive extents are first created on the newly added drive. Since no two extents from a drive can be placed into a RAID extent, the drive extents must be rebalanced. To rebalance drive extents, the dynamic pool algorithms first identify a drive extent to relocate, and a location on the new drive to place it. This movement is a copy operation, which frees the original location of the drive extent for use. This process is repeated until all new space is spread across the drives within the drive partnership group.

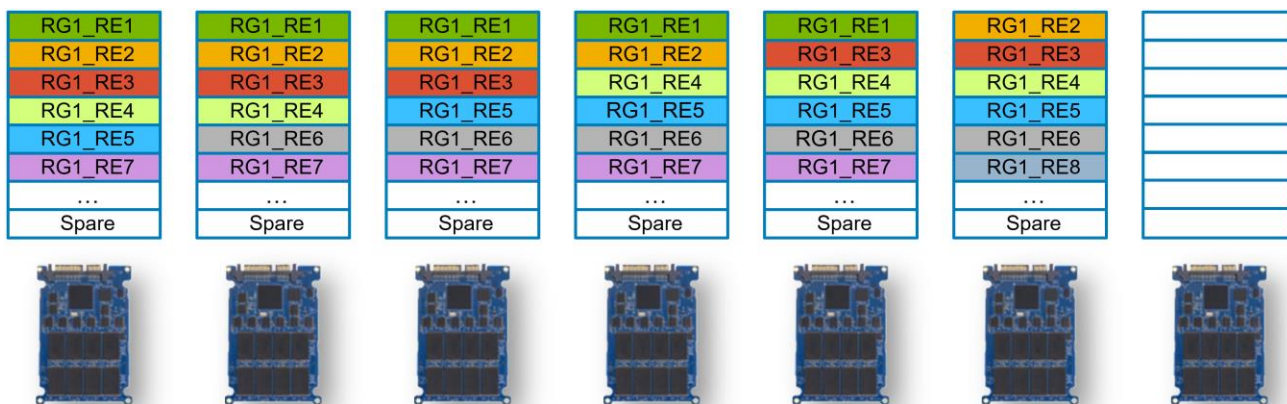


Figure 9 Dynamic pool single drive expansion example with additional drive

Figure 10 shows the state of the drive partnership group after the relocation of drive extents has occurred. Used drive extents from various drives within the drive partnership group have been relocated to the newly added drive to free space. At this point, free drive extents from different drives can be combined into RAID extents, and a new private dynamic pool RAID group and LUN will be created. Once this process completes, the usable capacity of the pool will be increased for use.

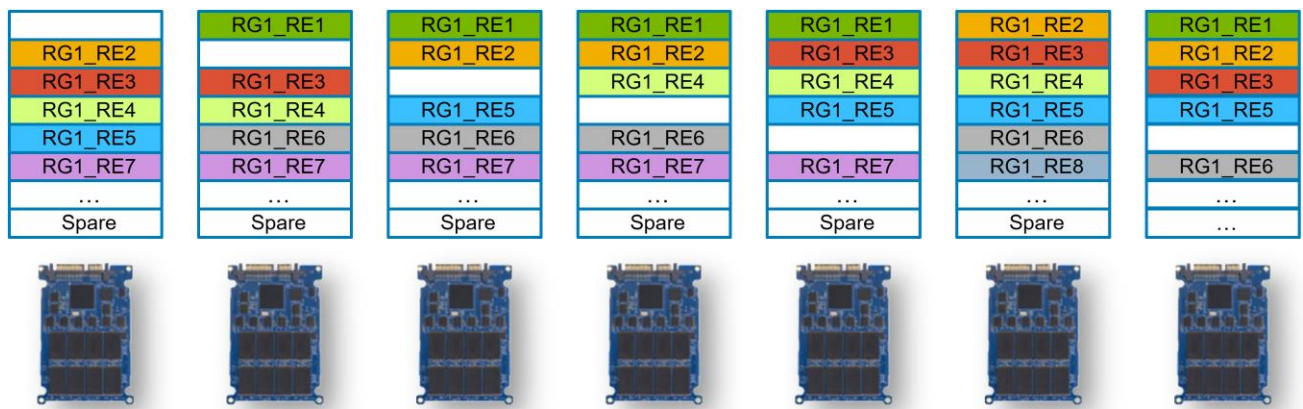


Figure 10 Dynamic pool single drive expansion example with rebalance complete.

When the number of drives added to the pool for a particular tier matches the stripe width plus one drive and the spare space amount does not increase, space can quickly be made available to the pool. In this situation, drive extents, RAID extents, and the private RAID group and LUN can quickly be created on the new drives, and no upfront relocations need to occur. After the space is made available to the pool, a background relocation process is started to spread used and spare space extents out across the drives within the drive partnership group. This process ensures that application workloads, wear, and spare space are spread out among the drives within the drive partnership group.

In Dell Unity OE version 4.5 the dynamic pool expansion job for particular drive counts may be treated as multiple operations within the system. When expanding a flash tier by a drive count equal to or less than the stripe width, a single drive expansion process will occur before the remaining drives will be added to the pool. These operations will be seen as a single job in Unisphere. This change does not affect the total amount of space being added to the pool, and allows for a portion of the space to be made available during the expansion process if the spare space requirement is not increased by the first drive of the expansion. This change does not affect single drive expansions, expanding the pool with a drive count equal to the stripe width + 1 or more, expanding an existing performance or capacity tier, and expanding the pool with a new drive type.

Figure 11 shows an example of a pool created with six drives. For this example, assume the pool is a RAID 5 (4+1), and after some period of time the pool is expanded using an additional six drives, bringing the total drive count to 12. This additional drive count matches the current stripe width of 4+1 plus an additional drive. In this instance, all dynamic pool components can quickly be created on the new drives, and space can be made available to the pool. After this is done, drive extents are relocated across the existing and new drives to spread out the spare space extents, as well as the drive extents containing user data. This operation is a background process, which will throttle as needed so it does not impact application I/O.

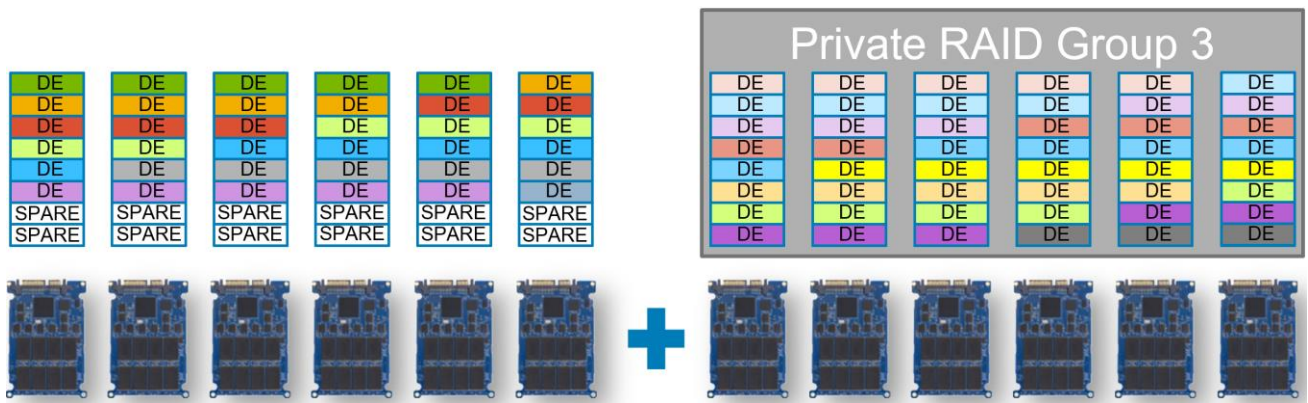


Figure 11 Dynamic pool multiple drive expansion example

When a drive expansion process is started, a job is created in the system and is run as a background task. The additional capacity is not available within the dynamic pool being expanded until the process completes. The job's progress can be tracked in Unisphere by reviewing the Jobs page, or through Unisphere CLI or REST API. The amount of time the overall expansion process takes, directly depends on the number of drives being added, and the size and type of drives.

2.8 Proactive copy and drive rebuilds

As mentioned previously, dynamic pools contain spare space extents to replace a drive going bad or a failed drive within the pool. The spare space extents can either be used as a target of a proactive copy operation, or a rebuild of a degraded RAID extent due to a faulted drive. In either case, spare space extents are used within the same drive partnership group as the bad drive.

The Dell Unity software tracks all drive errors, and if a drive is receiving errors above the OE's internal thresholds, a proactive copy operation may be started. A proactive copy operation is the process of copying data from a drive going bad to a new location. Once the copy operation completes, the drive is failed by the software. Since this is a copy operation, the proactive copy completes much faster than a full drive rebuild. In the case of dynamic pools, a proactive copy operation copies a drive extent from the failing drive to a spare space extent within the same drive partnership group within the pool. During this operation, the system ensures the destination drive for each RAID extent does not already contain an extent from the same RAID extent. To ensure the proactive copy operation completes quickly, multiple drives extents can be copied from the failing drive at the same time. The target destination extents for proactive copy operations are also not selected from the same destination drive, which also spreads out the workload.

If a drive were to fail before it could be proactively copied, a rebuild operation must occur. Within a dynamic pool, a failed drive rebuild occurs by rebuilding the degraded RAID extents within the drive partnership group. A RAID extent is considered degraded when at least one of the drive extents within the RAID extent is no longer available. During the rebuild of a RAID extent, the remaining drive extents within the RAID extent are used to rebuild the missing drive extent to a spare space extent. Once complete, the spare space extent becomes part of the RAID extent and the RAID extent is no longer degraded. As the various RAID extents needing to be rebuilt and spare space extents are spread across many drives within the drive partnership group, many drives are engaged to complete the rebuild operations.

The number of drive failures that can be tolerated at the same time within a dynamic pool depends on the RAID protection and the location of the failures within the pool. As previously stated, the hot spare capacity setting does not improve the reliability of the RAID protection for the pool. For all RAID protections, if single drive failure occurs in different drive partnership groups, the rebuild operations can occur in parallel if enough

spare space is present within the drive partnership groups the drives have failed in. For RAID 5, as long as two failures are not sustained within a single RAID extent, data access remains available. For RAID 6, two failures can occur within a single RAID extent without causing a data unavailable situation. Multiple drives within a single RAID 6 RAID extent can be rebuilt at the same time if enough spare space extents exist within the drive partnership group to rebuild both drives. For RAID 1/0, multiple failures can occur within the same RAID extent as long as a primary drive and its mirror are not lost within a single mirrored pair.

After the proactive copy or RAID extent rebuilds complete, the failed drive must be replaced in the system. At this time, the number of spare space extents has been reduced within the drive partnership group due to the failed drive and rebuild operations. If a free drive exists within the system, and it is the same size or larger and the same drive type as the failed drive, it will be consumed by the dynamic pool to replace the missing spare space extents. This operation closely resembles a single drive expansion, and the spare space extents will be rebalanced across the drives within the drive partnership group. Once the failed drive is replaced, it is left free within the system. If no free drives exist within the system, once the failed drive has been replaced, the new drive becomes consumed by the dynamic pool and the rebalance of spare space extents will occur.

2.9 Wear balancing within a dynamic pool

Within Dell Unity storage systems, managing wear within flash drives is crucial to extending the lifespan of the drives. Due to data access patterns and end user applications, certain areas within a LUN, file system, VMware datastore, or other storage resource may have hotspots of activity. If this activity consists of writes, certain areas of particular drives may be targeted, which may increase the wear of the drives. Internally, all flash drives used within the storage systems have spare cells to manage wear. Dell Unity systems include additional wear mitigation techniques to help extend the lifespan of flash drives.

As outlined in the previous sections, dynamic pools have been designed to spread out workloads and wear as evenly as possible. First, dynamic pools do not require hot spares, like traditional pools. These drives are engaged and utilized within the pool. When creating a dynamic pool, user data is spread across all drives as much as possible. When expanding a dynamic pool, user data again is spread out as evenly as possible to distribute customer workloads and wear as much as possible.

Wear is also managed and mitigated across drive partnership groups within a dynamic pool. If a certain drive partnership group is wearing faster than another, 256 MB slices can be moved from one drive partnership group to another. This migration of data then moves the workload targeted at that data within the 256 MB slice to a new location. Wear balancing is not performed within a drive partnership group, since moving data within a drive partnership group actually causes more wear, as the data is being moved within the same set of drives.

If a drive is close to the end of its usable life based on wear, a proactive copy operation may be started by the system to replace the worn drive. This proactive copy does not copy drive extents within the drive to spare space extents within the pool, but rather to a free drive within the system if available. After the proactive copy operation completes, the drive is failed, an alert is generated, a call home is initiated, and the drive should be replaced. The proactive copy to spare space extents within the drive partnership group is not done because it would only increase the wear on the drives in the group, which may have the same amount of wear as the drive being replaced. If a valid spare is not available, no proactive copy operation is completed.

In Dell Unity OE version 4.2 and later, system alert messages are sent at 180, 90, and 30 days before a flash drive is expected to reach 100% wear. At the 60-day mark, Dell support is notified by a call home that the drive may reach 100% wear, and a replacement is required. These alerts are generated for each individual drive.

3 Supported configurations

Before creating a dynamic pool, there are several items to consider. These include, but are not limited to, the overall size of the pool, which drive type and how many drives to use, and the data protection scheme. The following subsections outline the dynamic pool supported configurations and background information needed when creating and expanding a dynamic pool.

3.1 Supported drives

Dell Unity storage systems support a variety of drive type and size options. Choosing between the options available depends what needs to be achieved in the solution. If density is the main concern, using a small amount of larger drives may be preferable. If performance is the main concern, then using a larger count of smaller drives may be selected. In most cases, a balance of the overall footprint of the system, performance, and overall cost of the solution is factored into the decision.

In a typical configuration for an all-flash system, all drives within the system are the same size and type. An all-flash system containing different drive sizes or types typically occurs when additional drives are purchased to expand the capacity of an all-flash system. In hybrid systems, a mix of flash, SAS, and NL-SAS drives is typical. Dynamic pools support mixing different drive sizes and types within a single pool. This allows flexibility in the solution. Within the pool, flash, SAS, and NL-SAS drives cannot exist within the same drive partnership group, as outlined in Figure 2. Each drive type is subject to the stripe width and minimum drive count requirements which is explained later. For hybrid systems, SAS and NL-SAS system drives, DPE drives 0, 1, 2 and 3, are not supported within a dynamic pool. System drives can still be placed in traditional pools.

Mixing different drive sizes of the same type and speed is supported within a dynamic pool, and the drives are placed within the same drive partnership group. This may occur when a pool's capacity is critically low and the pool must be expanded to increase the capacity, or a spare of the same size is not available. When this occurs, there are situations where the entire capacity of the largest drive(s) may not be usable. This unusable space is not reported to the user. The entire capacity of a particular drive size is only available when the drive count within the drive partnership group for the drive in question matches or exceeds the stripe width plus one drive. It is not recommended to mix different size drives of the same type for this reason, unless an adequate number of drives are available to meet or exceed the stripe width plus one drive requirement.

Figure 12 shows an example of a dynamic pool created with 5 x 400 GB drives and 1 x 800 GB flash drive. This assumes there is a RAID 5 pool with a stripe width of 4+1. In this example, many of the drive extents on the 800 GB drive cannot be used. These drive extents are outlined in red. This situation can also occur with SAS and NL-SAS drives.

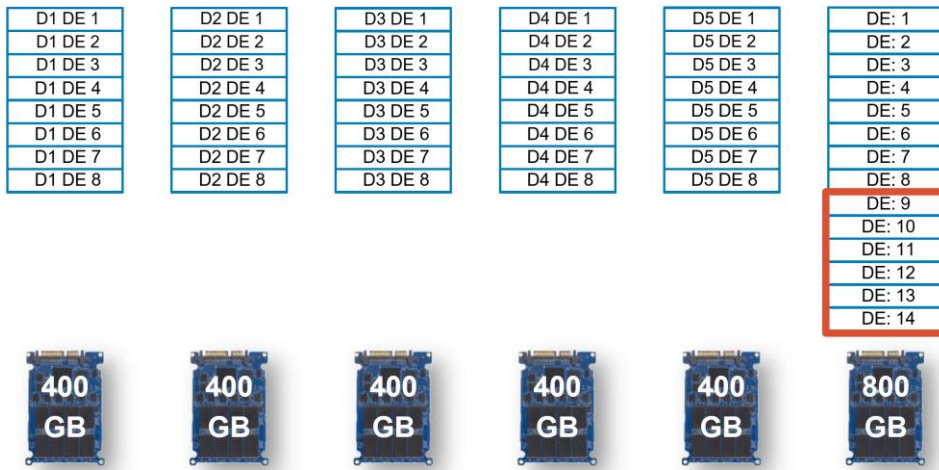


Figure 12 Dynamic pool with mixed drive sizes and space unavailable for use

Figure 13 shows an example of a dynamic pool created as a RAID 5 pool with a stripe width of 4+1. In this example all drive extents are available for use. This pool may have been created this way, or the pool shown in Figure 13 was expanded with additional 800 GB drives to recover the missing space. In either case, all drive extents are available for use, and can be provisioned as spare space extents or RAID extents. If the last 800 GB drive within the example below was a 1.6 TB drive of the same drive type, then only 800 GBs of space would be usable.



Figure 13 Dynamic pool with mixed drive sizes and space available for use

3.2 Supported RAID types

Dynamic pools support several RAID protection levels, including RAID 1/0 (also known as RAID 10), RAID 5, and RAID 6. In pool that contains multiple tiers, the protection level is set per drive tier. RAID 1/0 is best suited for applications with fast or high processing requirements, such as enterprise servers and moderate-sized database systems. It provides both high performance and reliability at medium cost, while providing lower capacity per drive. RAID 5 is best suited for transaction processing and often used for general purpose storage, as well as for relational database and enterprise resource systems. Depending on the drives used, RAID 5 can provide a fairly low cost per GB while still retaining redundancy. RAID 6 is best suited for read-biased workloads, such as archiving and backup to drive, and provides the best redundancy of all supported RAID types.

When creating a dynamic pool, the RAID type will be specified for each drive tier by the user depending on the protection level they require. In Unisphere, RAID 6 is the default and only option for the NL-SAS Capacity Tier. If RAID 1/0 or 5 is required for the Capacity Tier, Unisphere CLI or REST API can be used to create the pool or expand it with NL-SAS drives. Once the pool is created, the RAID type selected will be set for all current and future drive partnership groups within the tier of the pool. Once the RAID type is set for a tier, it is persisted for the lifetime of the pool and cannot be changed later.

3.3 Supported stripe widths

A dynamic pool's stripe width, also known as the RAID width, is the number of drive extents used for the RAID type chosen for the pool. For example, a RAID 5 (4+1) RAID extent contains five drive extents. Four drive extents' worth of space within the 4+1 RAID extent are used to store data, while one drive extent's worth of space is used to store parity data. When creating a dynamic pool, the method in which the pool is created will determine if the stripe width is selected by the system, or by the user. When creating a pool through Unisphere CLI or REST API, the stripe width is specified by the user.

When creating a dynamic pool in Unisphere, the user selects the RAID type desired, but the stripe width is selected by the system automatically. The stripe width selected by the system directly depends on the number of drives selected at pool creation. Table 1 shows the various supported RAID types, and the correlation between the number of drives selected during pool creation and the stripe width Unisphere selects. For example, when RAID 5 is selected during pool creation in Unisphere, and eight drives are selected, the stripe width is automatically set to 4+1 by the system. If the drive count is 14 or more for RAID 5, a 12+1 width is selected. The selection of the larger stripe widths provides more usable capacity to the user. If you would like to force the system to choose a particular width, select only a specific number of drives at pool creation and later expand the pool with the remaining drives.

Table 1 Unisphere selected stripe widths based on drive count

RAID type	Number of drives at pool creation	Stripe width selected
RAID 5	6 to 9	4+1
RAID 5	10 to 13	8+1
RAID 5	14 or more	12+1
RAID 6	7 or 8	4+2
RAID 6	9 or 10	6+2
RAID 6	11 or 12	8+2
RAID 6	13 to 14	10+2
RAID 6	15 or 16	12+2
RAID 6	17 or more	14+2
RAID 1/0	3 or 4	1+1
RAID 1/0	5 or 6	2+2
RAID 1/0	7 or 8	3+3
RAID 1/0	9 or more	4+4

3.4 Minimum drive counts

When creating a dynamic pool, there is a minimum number of drives that need to be selected for each tier to create the pool. This number directly depends on the RAID type selected for each tier, and a warning will be provided if the minimum drive count is not satisfied.

Table 2 shows the relationship between the RAID type, the stripe width, and the minimum number of drives. This table only shows the smallest stripe widths supported, and the minimum number of drives it takes to create them. As an example, the smallest RAID 5 stripe width the system supports is a 4+1. The smallest drive tier created with the RAID 5 4+1 configuration is 6 drives. The minimum drive count includes the number of drives specified in the stripe width, plus the hot spare capacity. The hot spare capacity is selected by the user at pool creation or when expanding the pool with a new drive tier, and can either be set to 1 or 2 drives for every 32 drives in the pool.

Table 2 Dynamic pool minimum drive counts at creation.

RAID type	Stripe width	Minimum number of drives	How it is calculated
RAID 5	4+1	6	(4+1) + hot spare capacity
RAID 6	4+2	7	(4+2) + hot spare capacity
RAID 1/0	1+1	3	(1+1) + hot spare capacity

4 Traditional pools

After upgrading to a code that supports dynamic pools, traditional pools continue to be supported. However, on all-flash systems, Unisphere no longer allows the creation of a traditional pool in OE version 4.2 and later. For hybrid systems, creating a traditional pool in Unisphere is no longer supported in OE version 5.2 and later. Creating a traditional pool while running these releases requires using the Unisphere CLI or REST API. Viewing, managing, and expanding a traditional pool will continue to be supported using Unisphere, but only the creation option has been removed. When running the Create Pool wizard in Unisphere, a dynamic pool is created.

For ease of reporting and determining pool types, a new property for pools has been added to distinguish between a traditional pool and a dynamic pool. The Type field allows the users to quickly discern between the different pool types. This value is available in the various pool related windows as well as through Unisphere CLI and REST API.

There are a few pool configurations in which the total number of drives required for a configuration is higher in a dynamic pool configuration when compared to a similar configuration created with traditional pools. Specifically, this occurs when multiple pools are created with small drive counts with the same type of drive. For instance, if the solution requires two pools of 15 drives' worth of capacity each, a single hot spare would be required for traditional pools. For the same capacity, dynamic pools would require a single drive's worth of spare space per pool, which increases the size of the solution by one drive. In this instance, it may be more cost effective to use traditional pools, though the other benefits of dynamic pools provide would be lost.

5 Management

Creating and managing dynamic pools from Unisphere, Unisphere CLI, and REST API is easy and intuitive. The following subsections outline how to view the various drives within the system and how to create, view the properties of, and expand a dynamic pool. Unisphere examples for each of these areas are shown. For more information on using Unisphere CLI, refer to the *Unisphere Command Line Interface User Guide* on [Dell Technologies Info Hub](#). For information on managing dynamic pools from REST API, consult the REST API documentation which can be accessed directly from any Dell Unity system:

REST API Programmer's Guide: https://<Management_IP>/apidocs/programmers-guide/index.html

REST API Reference Guide: https://<Management_IP>/apidocs/index.html

In these examples, **<Management_IP>** is the management IP of your system.

5.1 Viewing the drives within the system

5.1.1 All-flash systems

In Dell Unity OE 4.2 and later, changes have been made to the **System Settings > Storage Configuration** section for all-flash systems. **Drives** is the only section under **Storage Configuration** in all-flash systems. As shown in Figure 14, this section displays all available drives within the system, along with other useful information. This figure displays many drives of varying sizes for demonstration purposes only. It is unlikely that a single all-flash system would have this many different drive types and sizes. The **Drives** page shows the available drives in the **Drive Type** column, with each entry shown by drive size. The **Total** column shows the number of drives of that size and type in the system currently.

Drive Type ↑	Total	Unconfigured		Configured	
		Available	Traditional Spare	Dynamic Pool	Traditional Pool
1.6 TB SAS Flash 3	1	1	0	0	0
3.2 TB SAS Flash 3	1	1	0	0	0
7.68 TB SAS Flash 4	74	74	0	0	0
15.36 TB SAS Flash 4	18	8	1	0	9
800 GB SAS Flash 3	6	6	0	0	0

Figure 14 System Settings > Storage Configuration > Drives (All-flash system)

The **Unconfigured** column has two sub-columns below it: **Available** and **Traditional Spare**. The **Available** column shows how many free drives are currently within the system. These drives can be used to create a dynamic pool. The **Traditional Spare** column shows how many drives are needed for traditional pool hot spares. In the example in Figure 14, one 15.36 TB SAS flash 4 drive needs to be reserved on the system as Traditional Spare, as denoted by the **1** in the 15.36 TB SAS flash 4 row within the **Traditional Spare** column.

The **Configured** column is also subdivided into two sub-columns: **Dynamic Pool** and **Traditional Pool**. These sub-columns show how many drives are currently configured within Dynamic Pools and traditional pools. In this example, a number of 15.36 TB SAS flash 4 drives have been placed into a traditional pool, and no other pools or drives have been configured on the system. Traditional pool information is not displayed in the **Drives** page if no traditional pools exist on the system.

For each non-zero number listed under the **Unconfigured** column, a clickable link is present. As shown in Figure 15, when the link for the 74 unconfigured 7.68 TB SAS flash 4 drives are selected in the **Unconfigured** column, a drive list is displayed. This list shows the drive locations for the free drives within the system, along with other information. This table can be used to easily determine the locations of the free drives within the system.

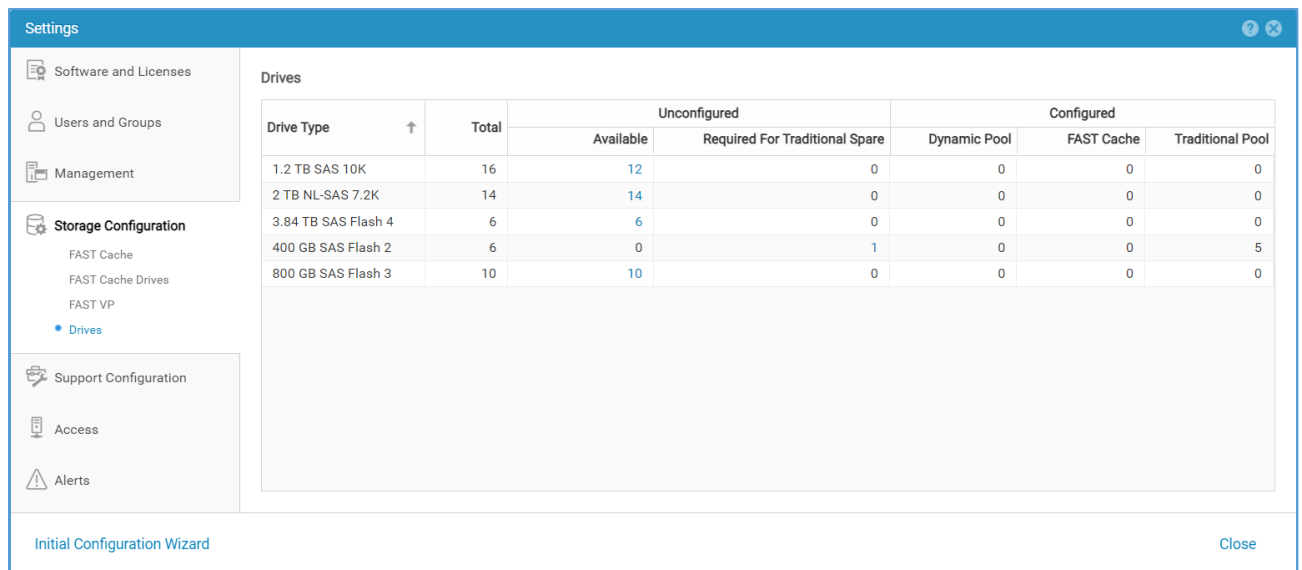
Unconfigured Drives					
74 items					
!	Name	↑	Type	Drive Size (GB)	Rotational Speed (RPM)
✓	DAE 0 1 Drive 0		SAS Flash 4	7,006.9	--
✓	DAE 0 1 Drive 1		SAS Flash 4	7,006.9	--
✓	DAE 0 1 Drive 2		SAS Flash 4	7,006.9	--
✓	DAE 0 1 Drive 3		SAS Flash 4	7,006.9	--
✓	DAE 0 1 Drive 4		SAS Flash 4	7,006.9	--
✓	DAE 0 1 Drive 5		SAS Flash 4	7,006.9	--
✓	DAE 0 1 Drive 6		SAS Flash 4	7,006.9	--
✓	DAE 0 1 Drive 7		SAS Flash 4	7,006.9	--

Figure 15 System Settings > Storage Configuration > Drives page with hyperlink selected

5.1.2 Hybrid flash systems

In Dell Unity OE 5.2 and later, changes have been made to the **System Settings > Storage Configuration > Drives** page for hybrid systems. Along with the traditional and dynamic pool information that is displayed for all-flash systems, hybrid systems also display the **FAST Cache** column. The **FAST Cache** column displays how many drives are currently configured in FAST Cache. An example of the **Drives** page can be seen in Figure 16.

Also shown in Figure 16, the total number of **Available** 1.2 TB SAS 10K drives is 12, while the **Total** drive count within the system is 16. In this system 1.2 TB SAS drives are used as the system drives. As SAS and NL-SAS system drives are not allowed in a dynamic pool, as outlined in the Supported drives section of this paper, four drives are not available. These drives can be placed into a traditional pool if required.

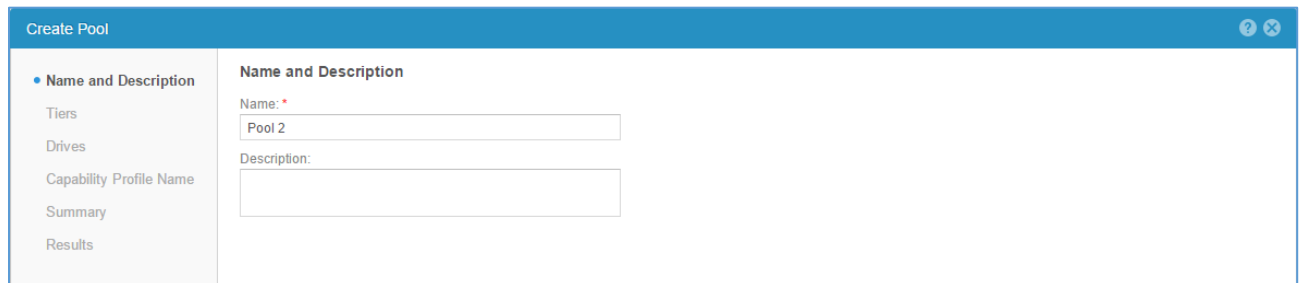


Drive Type	Total	Unconfigured		Configured		
		Available	Required For Traditional Spare	Dynamic Pool	FAST Cache	Traditional Pool
1.2 TB SAS 10K	16	12	0	0	0	0
2 TB NL-SAS 7.2K	14	14	0	0	0	0
3.84 TB SAS Flash 4	6	6	0	0	0	0
400 GB SAS Flash 2	6	0	1	0	0	5
800 GB SAS Flash 3	10	10	0	0	0	0

Figure 16 System Settings > Storage Configuration > Drives (Hybrid-flash system)

5.2 Creating a dynamic pool

In Dell Unity OE version 4.2 and later, a dynamic pool is the only pool type that can be created in Unisphere for an all-flash system. This is also true for hybrid systems running OE version 5.2 and later. Creating a traditional pool requires using the Unisphere CLI or REST API. From the **Pools** page in Unisphere, select the plus (+) symbol to **Launch the Create Pool Wizard** to create a dynamic pool. Figure 17 shows the **Name and Description** step within the **Create Pool** wizard. On this page, provide a name for the pool and a short description to provide additional information about the pool, such as what the pool should be used for.



Create Pool

- Name and Description**
 - Tiers
 - Drives
 - Capability Profile Name
 - Summary
 - Results

Name and Description

Name: *

Pool 2

Description:

Figure 17 Create Pool wizard > Name and Description

The next step within the **Create Pool** wizard is the **Tiers** step. In this step, the **Tiers** to add to the pool are selected, and the RAID type and hot spare capacity for each tier can also be customized. In this example a dynamic pool is being created on an all-flash system. In a hybrid system the options available depends on the available drive types within the system. As shown in Figure 18, **Extreme Performance Tier** is the only available choice in this all-flash system. Once Extreme Performance Tier is selected, choose the RAID protection for the pool. RAID 5 is the default selection when creating a pool.

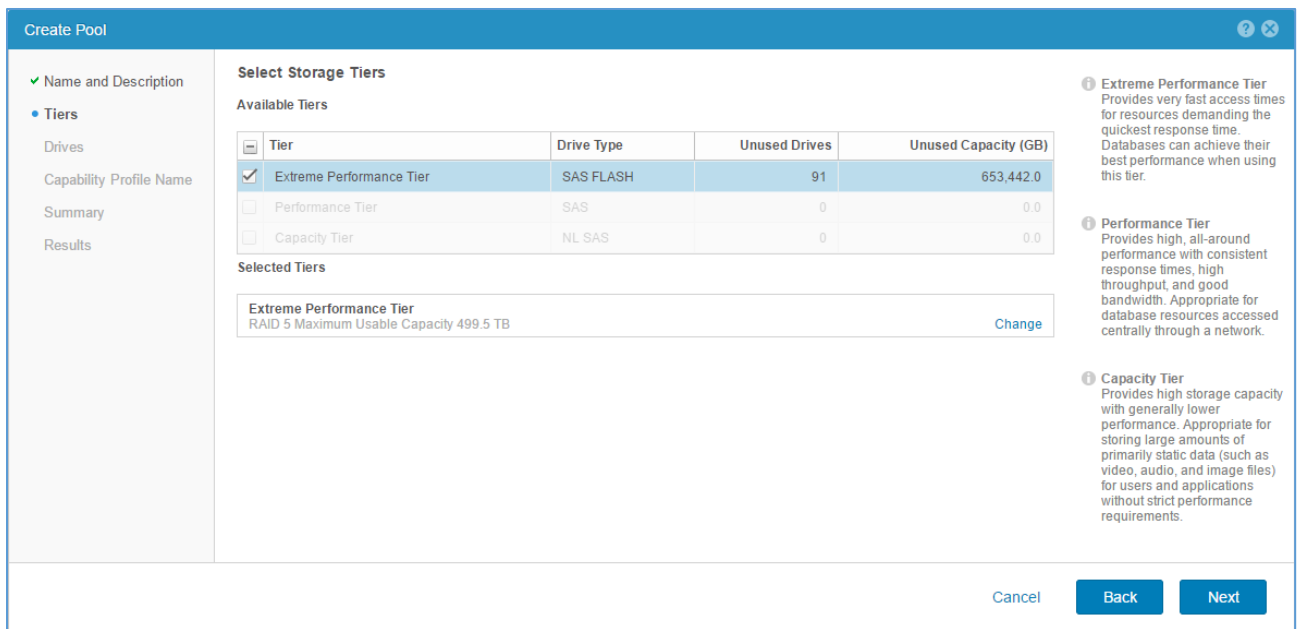


Figure 18 Create Pool wizard > Tiers

Figure 19 shows the available RAID configuration options when **Change** is selected within the **Tiers** step. For the **Extreme Performance Tier** and **Performance Tier**, the available choices are **RAID 5**, **RAID 6**, and **RAID 1/0**, which all have their benefits and use cases. When creating a dynamic pool with NL-SAS drives, **RAID 6** is the only available option in Unisphere for the **Capacity Tier**. To select a particular RAID type, select the radio button by the desired RAID type. The **Maximum Usable Capacity** for each RAID type is also shown, which assumes all current free drives within the system are used to create a pool. This number factors in the RAID overhead for each available choice. This is also where the **Hot Spare Capacity** value is configured for the **Tier**. Valid options are 1/32 (default) or 2/32. The RAID setting and hot spare capacity setting are configured independently on each Tier.

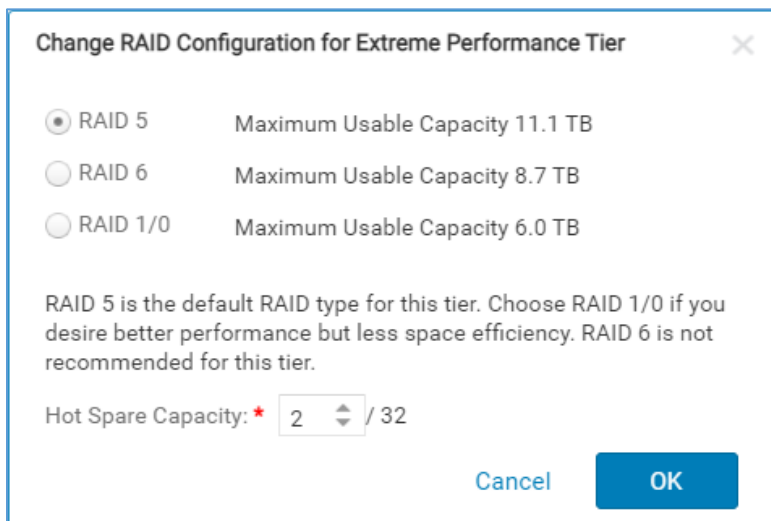
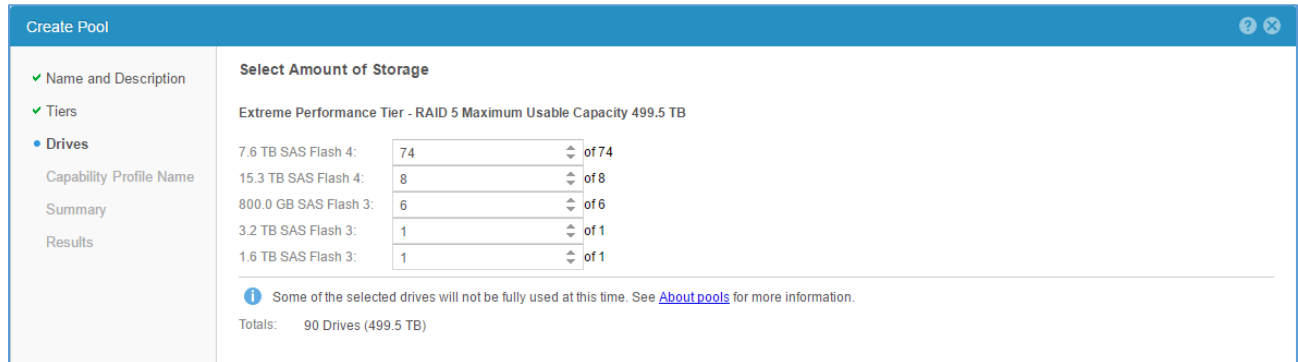


Figure 19 Create Pool > Change RAID Configuration for Extreme Performance Tier

After completing the **Tiers** step and customizing the RAID type for the Tier, the **Drives** step is shown. Within the **Drives** step, the number of drives of each type to place into the pool can be customized. This step only shows drives for the tiers selected in the previous step, and all free drives that have not been reserved as

Traditional Spares are selected by default. The only time all drives are not selected by default is if an invalid drive count for the pool will be selected. As mentioned in section 2, dynamic pools are not created with multiples of drives, and most counts above the minimum drive counts can be selected. This screen also includes the **Maximum Usable Capacity** at the top of the window. The capacity displayed is based on the RAID protection chosen and if all free drives within the system were selected. **Totals**, shown at the bottom of the window, is the total drive capacity for only the drives selected.



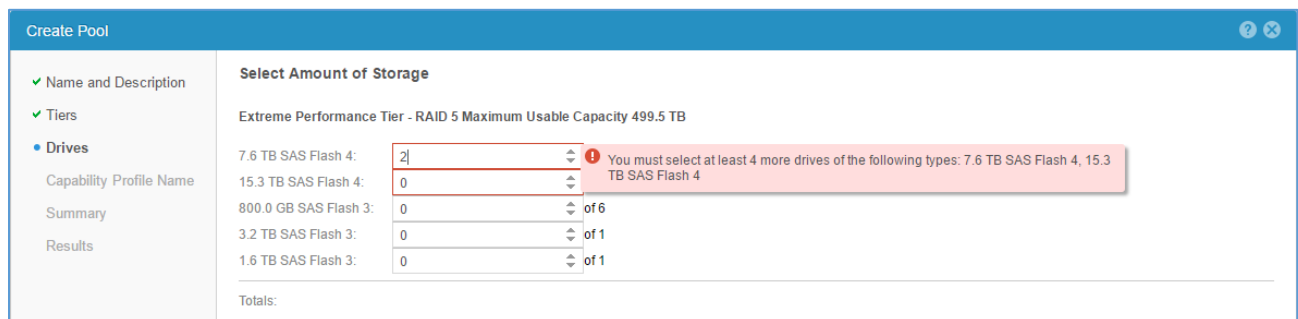
Drive Type	Selected	Available
7.6 TB SAS Flash 4	74	of 74
15.3 TB SAS Flash 4	8	of 8
800.0 GB SAS Flash 3	6	of 6
3.2 TB SAS Flash 3	1	of 1
1.6 TB SAS Flash 3	1	of 1

Totals: 90 Drives (499.5 TB)

Figure 20 Create Pool wizard > Drives

Also shown in this example is an informational message stating that the capacity for some of the drives selected will not be fully used at this time. This is done to warn the user that not all space from all drives selected will be usable at this time. This occurs when the number of drives for a particular drive size is not at least the value of a stripe width plus one additional drive. In Figure 20, there are only 1 x 1.6 TB and 1 x 3.2 TB SAS flash 4 drives available, which is why the message is displayed. This topic is covered in more detail in section 3.1 on supported drives.

The **Drives** step also provides information when the minimum number of drives selected does not match or exceed the minimum required for the RAID type selected. In Figure 21, the minimum drive count of six for RAID 5 has not been met. Currently, only 2 x 7.6 TB SAS flash 4 drives have been selected. Since different size drives can be mixed, the warning displayed shows that at least four more of the same drive types listed must be selected.



Drive Type	Selected	Available
7.6 TB SAS Flash 4	2	
15.3 TB SAS Flash 4	0	
800.0 GB SAS Flash 3	0	of 6
3.2 TB SAS Flash 3	0	of 1
1.6 TB SAS Flash 3	0	of 1

Totals:

Figure 21 Create Pool wizard > Drives with minimum drive count not selected

As outlined in section 2.2 on drive partnership groups, there are a few drive counts that cannot be selected when creating or expanding a dynamic pool. This occurs when the minimum number of drives to start the next drive partnership group has not been met.

As shown in Figure 22, when the number of drives selected is invalid due to the drive partnership group criteria not being met, a warning is displayed. This warning outlines the options available, either the drive count can be reduced or increased by some number of drives.

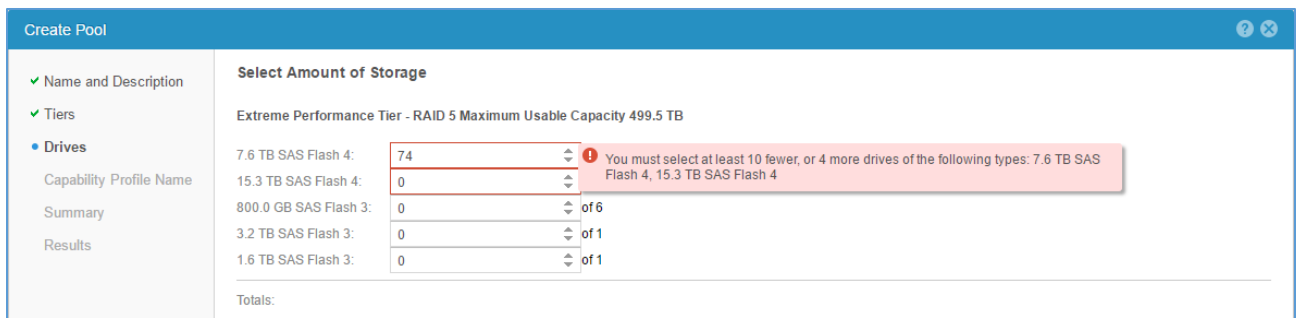


Figure 22 Create Pool wizard > Drives with invalid drive count selected

Figure 23 shows an example when only the 7.6 TB SAS flash drives are selected. When the number of drives meets the minimum drive counts required, and all space can be utilized, no warnings are displayed. As mentioned previously, a typical all-flash configuration would most likely not include this many different drive sizes and types.

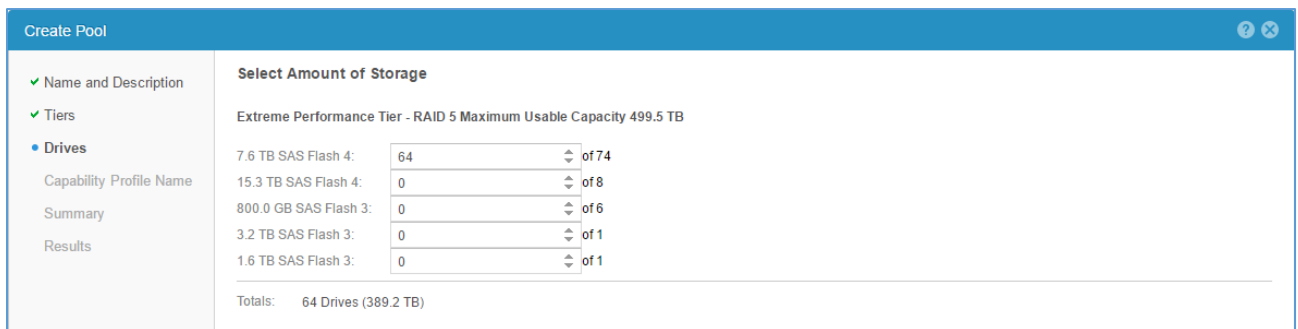


Figure 23 Create Pool wizard > Drives with desired drive count selected

The next step within the **Create Pool** wizard is the **Capability Profile Name** step. If the dynamic pool will be used for vVol storage, a VMware capability profile must be created for the pool. If desired, selected the check box by the **Create VMware Capability Profile for the Pool** option and provide a **Name** and an optional **Description**. This example does not create a capability profile.

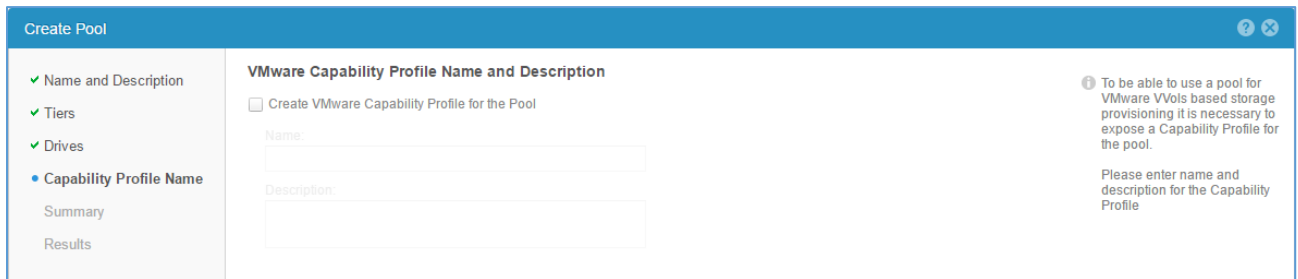


Figure 24 Create Pool wizard > Capability Profile Name

The last step within the **Create Pool** wizard is the **Summary** step. This step summarizes the choices made within the previous steps. As shown in Figure 25, the **Name**, **Description**, **Tier**, **RAID Configuration**, **Drive Type**, **Drives**, **Usable Capacity**, and **Hot Spare Capacity** based on the previous selections are shown. If any information needs to be changed, click **Back** to correct a choice. Otherwise, select **Finish** to create the dynamic pool.

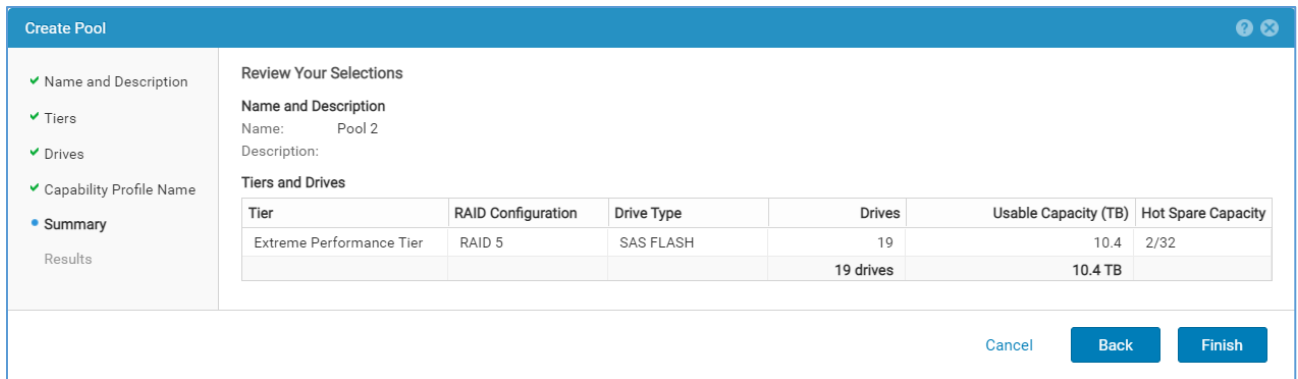


Figure 25 Create Pool wizard > Summary

The last page within the **Create Pool** wizard is the **Results** page. Once the pool creation occurs, a background task is started and this wizard can be closed. In this window, the **Overall Status** of the background task is displayed, as well as **Details** for each step in the process. Figure 26 shows an example of the **Results** page when the pool creation is allowed to complete.

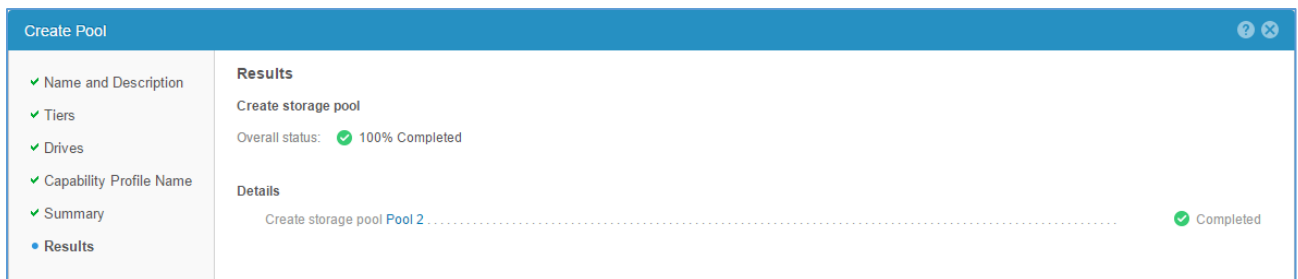


Figure 26 Create Pool wizard > Results

5.3 Viewing the properties of a dynamic pool

To view the pools created on the system, select **Pools** under the **Storage** header in the left pane of Unisphere. On this page, the pools are shown along with other information. The **Type** column is available in OE versions that support dynamic pools. This column can be added to the view by selecting the **Customize your view** button, denoted by the sun icon, and selecting the **Type** check box under **Columns**.

Figure 27 shows an all-flash system with multiple pools created on it. This example shows how to easily determine which pool is a traditional pool and which one is a dynamic pool by reviewing the **Type** column. The **Type** can also be seen in the quick properties view to the right after a pool is selected. To view the properties of a pool, select the **View/Edit** button, denoted by the pencil icon, or double-click the pool name.

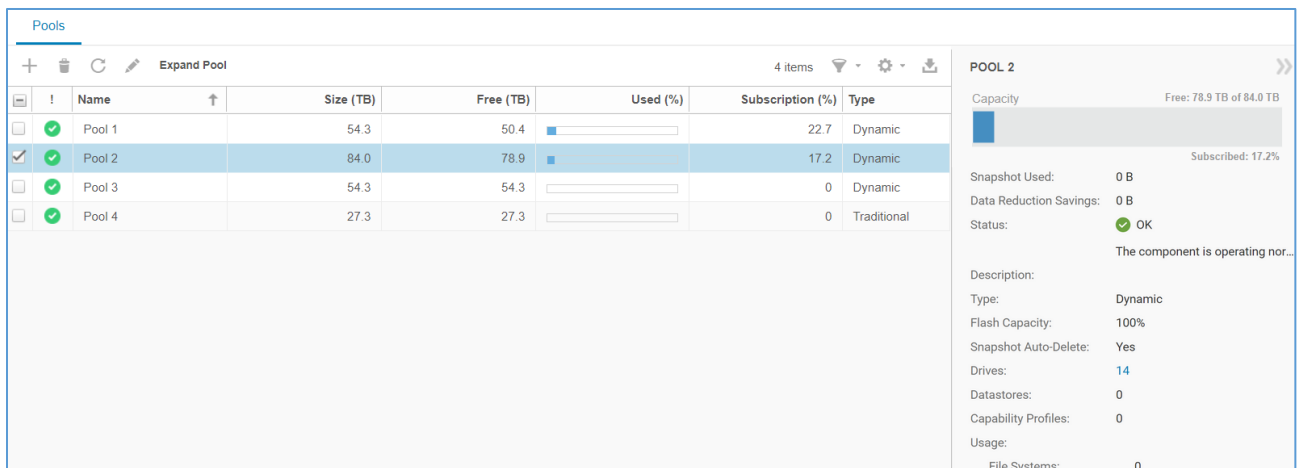


Figure 27 Unisphere > Pools page

The Pool Properties window on all-flash storage systems contains five tabs: **General**, **Drives**, **Usage**, **Snapshot Settings**, and **RAID**. Hybrid systems has an additional tab named **FAST VP**. The **General** tab is shown by default when opening the Pool Properties window. Within the window is basic information about the pool, such as its **Name**, **Description**, **Size**, **Flash Capacity**, and **Type**. An example of this screen for a hybrid model system is shown in Figure 28.

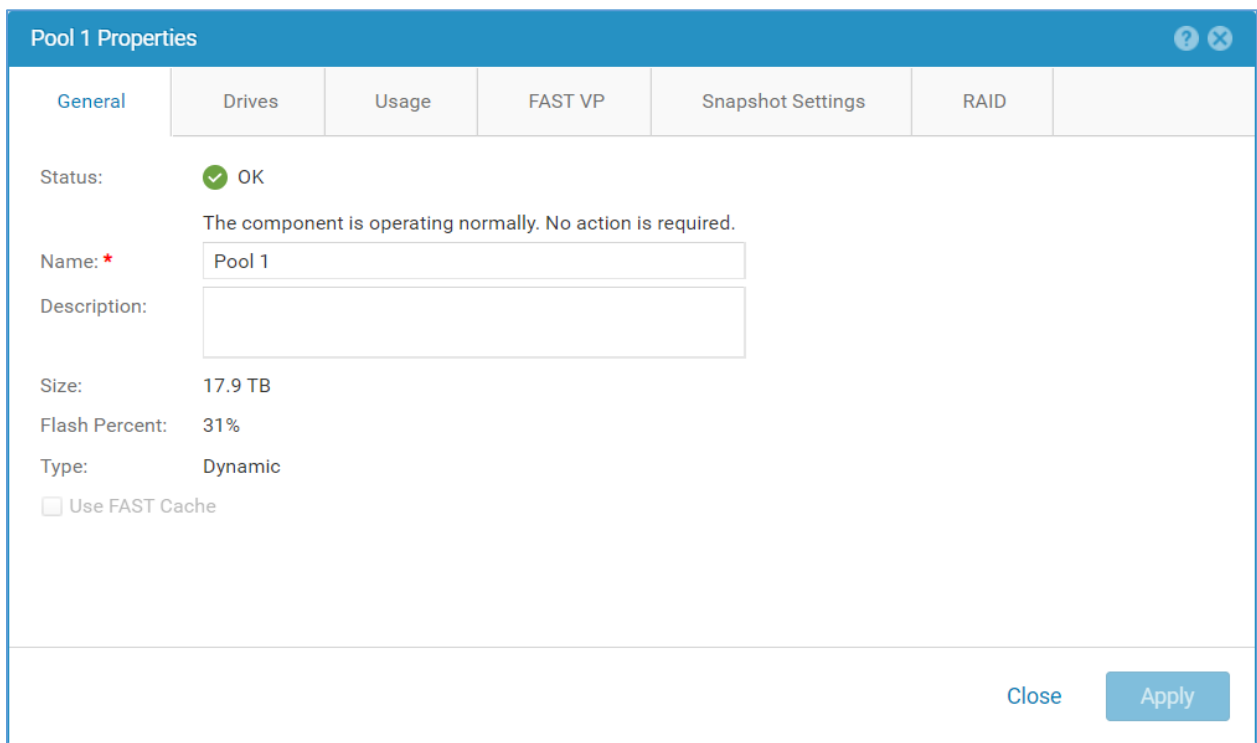


Figure 28 Dynamic Pool Properties window > General tab

The second tab within the Pool Properties window is the **Drives** tab. This tab displays all drives currently in use by the pool. This tab has a number of default columns which include **Name**, **Type**, **Capacity (GB)**, **Details (K RPM)**, and **Estimate EOL**. The **Tier** column is also shown for hybrid model systems. These columns can be further sorted or filtered as needed. Figure 29 shows an example of this screen for a hybrid model system.

Pool 1 Properties							
General		Drives	Usage	FAST VP	Snapshot Settings	RAID	
↻ 24 items 🔍 ⚙️							
!	Name	Type	Tier	Capacity (GB)	Details (K RPM)	Estimated EOL	
✓	DAE 0 0 Drive 0	SAS Flash 3	Extreme Performance Tier	733.5	--	1643	
✓	DAE 0 0 Drive 1	SAS Flash 3	Extreme Performance Tier	733.5	--	1679	
✓	DAE 0 0 Drive 2	SAS Flash 3	Extreme Performance Tier	733.5	--	1679	
✓	DAE 0 0 Drive 3	SAS Flash 3	Extreme Performance Tier	733.5	--	1698	
✓	DAE 0 0 Drive 4	SAS Flash 3	Extreme Performance Tier	733.5	--	1679	
✓	DAE 0 0 Drive 5	SAS Flash 3	Extreme Performance Tier	733.5	--	1643	
✓	DAE 0 0 Drive 6	SAS Flash 3	Extreme Performance Tier	733.5	--	1661	
✓	DAE 0 0 Drive 7	SAS Flash 3	Extreme Performance Tier	733.5	--	1606	
✓	DAE 0 0 Drive 8	SAS Flash 3	Extreme Performance Tier	733.5	--	1661	
							Close

Figure 29 Dynamic Pool Properties window > Drives tab

The next tab within the Pool Properties window is the **Usage** tab. This tab includes subcategories such as **Capacity**, which includes capacity information about the pool, and **Storage Resources**, which lists what is currently created on the pool. As shown in Figure 30, the Capacity section includes information about the pool. The **Non-base Space**, **Used**, **Preallocated Space**, and **Free** capacities are all shown. Below the chart is the **Alert Threshold**, which is customizable and allows the user to have the system flag an alert when the storage allocation surpasses the percentage set. The **Data Reduction Savings** can also be seen on this screen, which includes the **GBs**, **Percentage**, and **Ratio** savings values. In OE 4.3, Compression Savings has been replaced with Data Reduction Savings. Lastly, a chart on the pool usage is present.

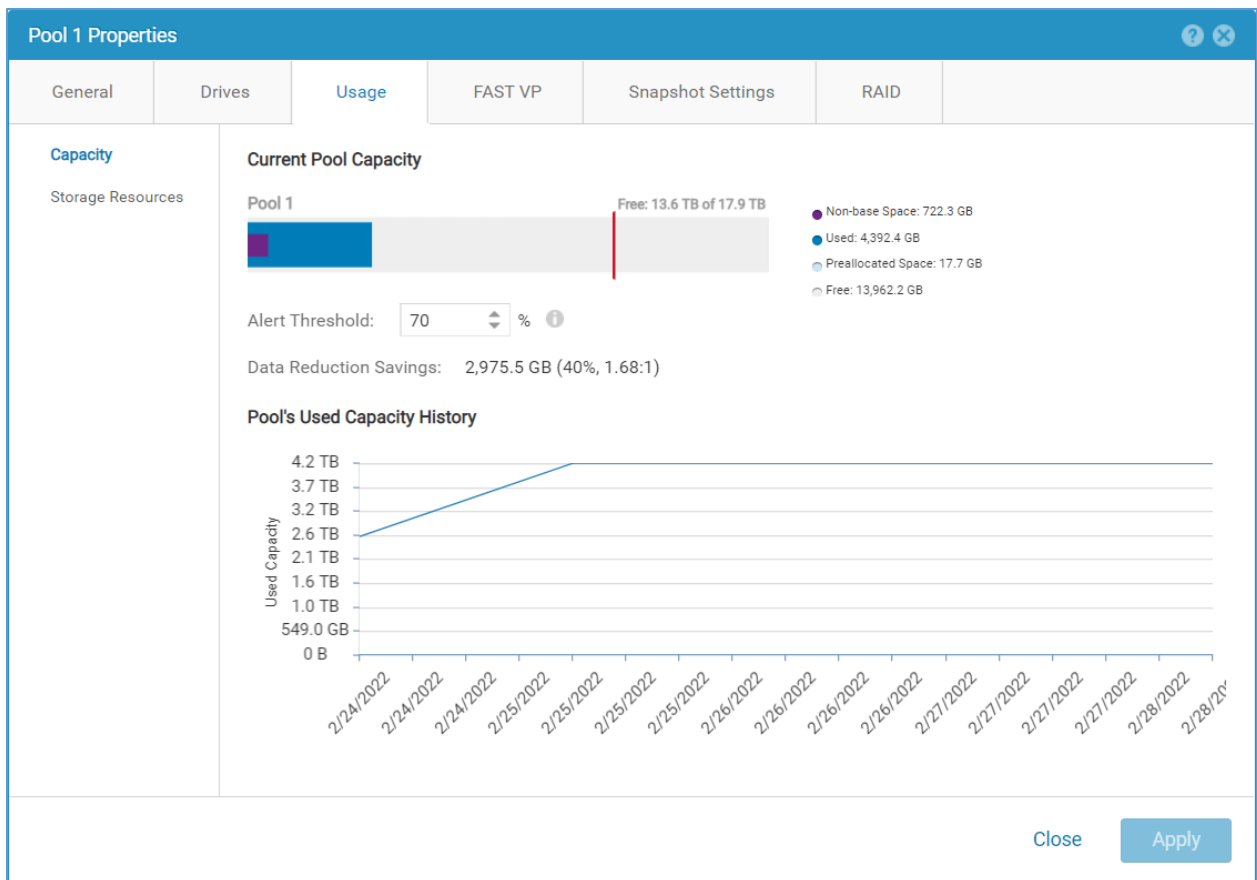


Figure 30 Dynamic Pool Properties window > Usage tab

For hybrid model systems, the FAST VP tab is displayed next. The FAST VP tab shows data relocation information for the Pool. Information for each Tier within the pool is displayed on this tab, along with data rebalance information for each tier. An example of this page is shown in Figure 31. These items are described in further detail within the *Dell EMC Unity: FAST Technology Overview* white paper on [Dell Technologies Info Hub](#).

The screenshot shows the 'Pool 1 Properties' window with the 'FAST VP' tab selected. At the top, there are tabs for 'General', 'Drives', 'Usage', 'FAST VP', 'Snapshot Settings', and 'RAID'. The 'FAST VP' tab is active and displays the following information:

- Data relocations scheduled: Yes (with an edit icon) and a link to 'Manage FAST VP system settings'.
- Relocation Information:**
 - Status: Not started
 - Last start time:
 - Time to relocate: 12:33
 - Last end time:
 - A 'Start Relocation' button.
- A table of storage tiers with columns: Tier, Move Up (GB), Move Down (GB), Rebalance (GB), Total Size (TB), and Free Size (TB).

Tier	Move Up (GB)	Move Down (GB)	Rebalance (GB)	Total Size (TB)	Free Size (TB)
ExtremePerformanceTier 10 SAS FLASH drives, RAID 5				5.6	4.8
PerformanceTier 6 SAS drives, RAID 5	↑ 494.0			4.2	3.7
CapacityTier 8 NL SAS drives, RAID 6	↑ 259.7			8.0	7.3

A 'Close' button is located at the bottom right of the window.

Figure 31 Dynamic Pool Properties window > FAST VP tab

The next tab within the Pool Properties window is the **Snapshot Settings** tab, which can be seen in Figure 32. Within this tab, the user can customize the auto-deletion mechanism based on space for snapshots within the system. By default, snapshots are only deleted when the **Total pool consumption** crosses the defined values within this window. The user can also select the **Snapshot pool consumption** option if they wish to control the maximum amount of space snapshot storage should use within the pool. These items are described in further detail within the *Dell EMC Unity: Snapshots and Thin Clones– A Detailed Review* white paper on [Dell Technologies Info Hub](#).

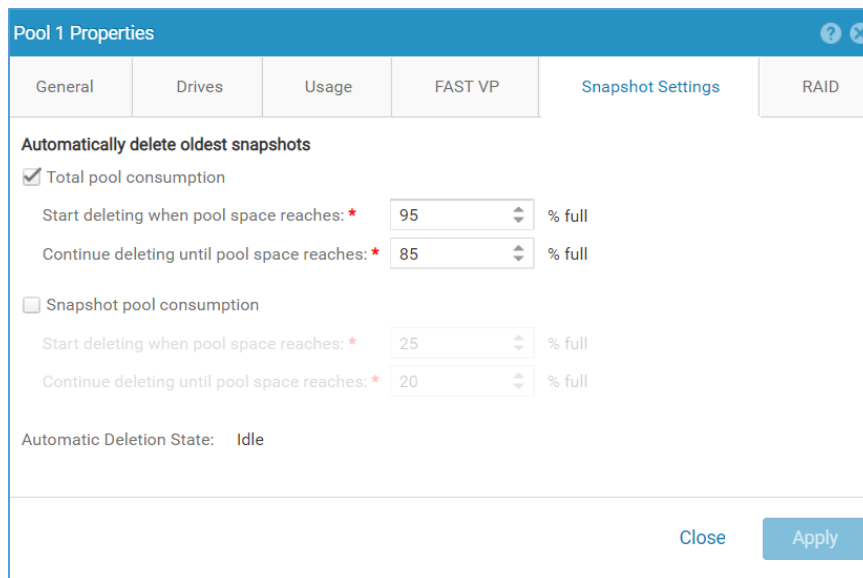


Figure 32 Dynamic Pool Properties window > Snapshot Settings tab

The last tab within the Pool Properties window is the **RAID** tab, which was added for dynamic pools and is shown in Figure 33. The RAID tab contains information such as the **Drive Types** utilized, the **RAID Type**, the **Stripe Width**, and the number of **Drives**. This information is displayed for each drive tier within the pool. In the figure, the dynamic pool contains three different drive tiers, and the Stripe Width and the number of drives is different per drive tier. The **Hot Spare Capacity** value for each drive tier is also displayed. In this example, 1 drive worth of spare space out of every 32 drives is reserved as hot spare space within each tier in the pool, although this value can be different across the tiers.

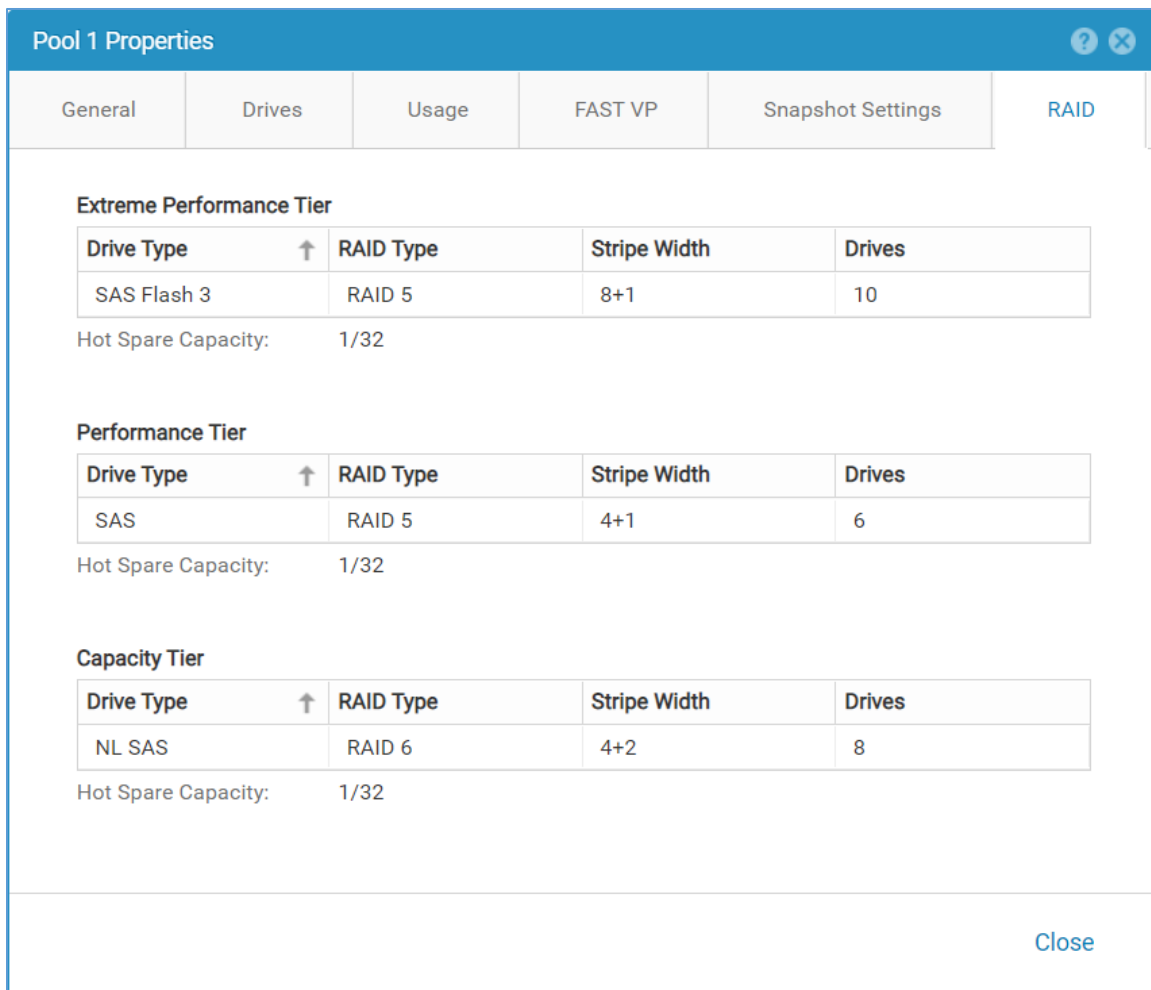


Figure 33 Dynamic Pool Properties window > RAID Settings tab

5.4 Expanding a dynamic pool

Expanding a pool is the process of adding additional drives to a tier or additional tiers, depending on the system model, to an existing pool within the system to increase its capacity. Like a traditional pool, a dynamic pool can be expanded at any time up to the system limits through Unisphere, Unisphere CLI, or REST API. To expand a pool in Unisphere, navigate to the Pools page by selecting **Pools** under the **Storage** header in the left pane of Unisphere, select the pool to expand, and select **Expand Pool**.

Figure 34 shows an example of the Pools page with the **Expand Pool** option in the top-left side of the screen.

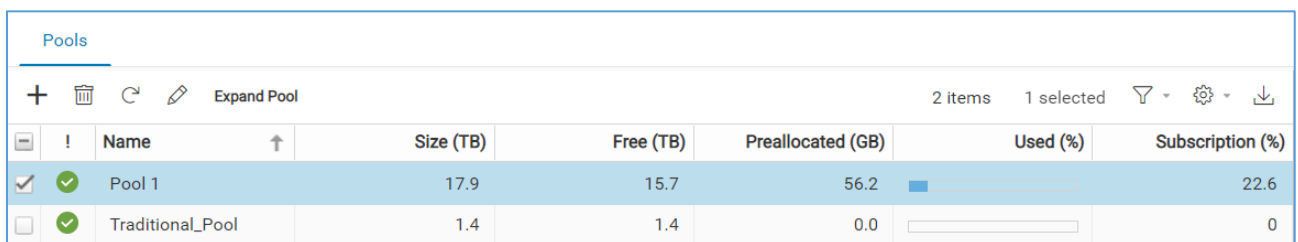


Figure 34 Unisphere > Pools page

The first step within the **Expand Pool** wizard is the **Storage Tiers** step. An example of this screen for a hybrid system is shown in Figure 35. Since this is a hybrid storage system, multiple **Tier** options are available. Once a tier is selected to expand the pool, the existing RAID type for the tier within the pool is shown. The RAID type and Hot Spare Capacity cannot be customized on an existing tier because they can only be set at pool creation or when the tier is added to the pool. Within a hybrid system, if an additional tier is being added to the pool the RAID type and Hot Spare Capacity values can be set for the new tier.

Expand Pool

Storage Tiers

Drives

Summary

Results

Select Storage Tiers

Pool Name: Pool 1

Current Pool Tiers

Tier	Drive Type	Drives	Current Usable Capacity (TB)	Free Size (TB)	Hot Spare Capacity
Capacity Tier	NL SAS	8	8.0	7.1	1/32
Extreme Performance Tier	SAS FLASH	10	5.6	4.9	1/32
Performance Tier	SAS	6	4.2	3.7	1/32

Tiers with available drives

Tier	Drive Type	Unused Drives	Unused Capacity (GB)
<input type="checkbox"/> Extreme Performance Tier	SAS FLASH	0	366.7
<input checked="" type="checkbox"/> Performance Tier	SAS	6	6,603.7
<input checked="" type="checkbox"/> Capacity Tier	NL SAS	6	11,006.1

Selected Tiers

Performance Tier
RAID 5 (Maximum Capacity), Maximum Usable Capacity 5.1 TB

Capacity Tier
RAID 6 (Maximum Capacity), Maximum Usable Capacity 7.1 TB

Extreme Performance Tier
Provides very fast access times for resources demanding the quickest response time. Databases can achieve their best performance when using this tier.

Performance Tier
Provides high, all-around performance with consistent response times, high throughput, and good bandwidth. Appropriate for database resources accessed centrally through a network.

Capacity Tier
Provides high storage capacity with generally lower performance. Appropriate for storing large amounts of primarily static data (such as video, audio, and image files) for users and applications without strict performance requirements.

Cancel **Next**

Figure 35 Expand Pool wizard > Storage Tiers

The next step in the **Expand Pool** wizard is the **Drives** step. All drives available within the system for the expansion are shown, along with the number of free drives for each drive size and type. Depending on the number of drives selected, **Totals** is updated with the number of drives and capacity that are added to the pool. In Figure 36, 6 x 1.2 TB SAS drives and 6 x 2.0 TB NL SAS drives are added to the pool.

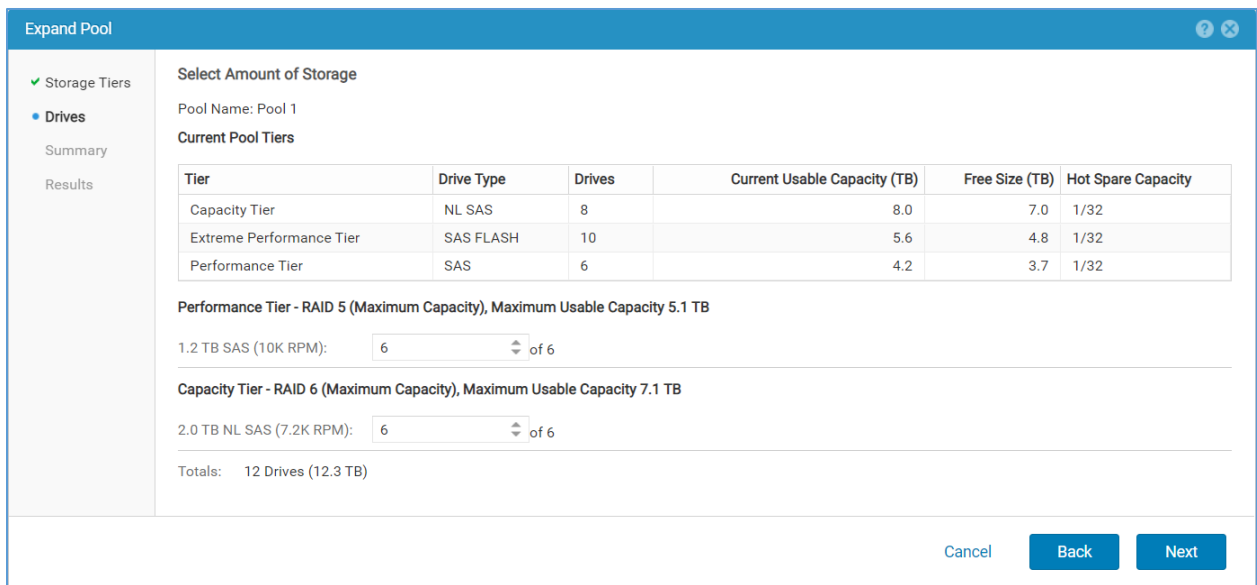


Figure 36 Expand Pool wizard > Drives step

The **Summary** step outlines the changes that will be made to the pool. Under **Tiers/Drive to Add to This Pool**, information is provided about the expansion. This information includes the existing **Tier** to be expanded, the **RAID Configuration**, the number of **Drives** being added, and the **Additional Usable Capacity (TB)** being added to the pool. If any changes need to be made, select the **Back** button. Otherwise, select **Finish**.

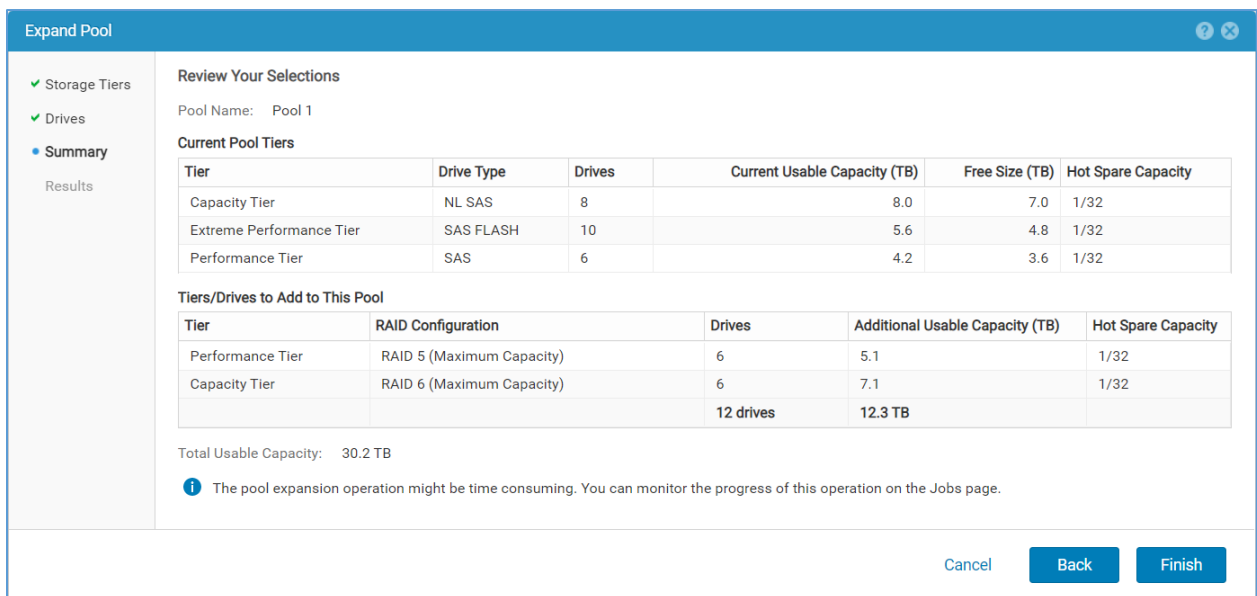


Figure 37 Expand Pool wizard > Summary

The last step within the **Expand Pool** wizard is the **Results** step. Once the expansion is started, a background job is started and the wizard can be closed. Not until the job completes is the space available within the pool. The length the expansion process takes directly depends on the number of drives being added to the pool. In Figure 38, the expansion process is allowed to finish before the window is closed.

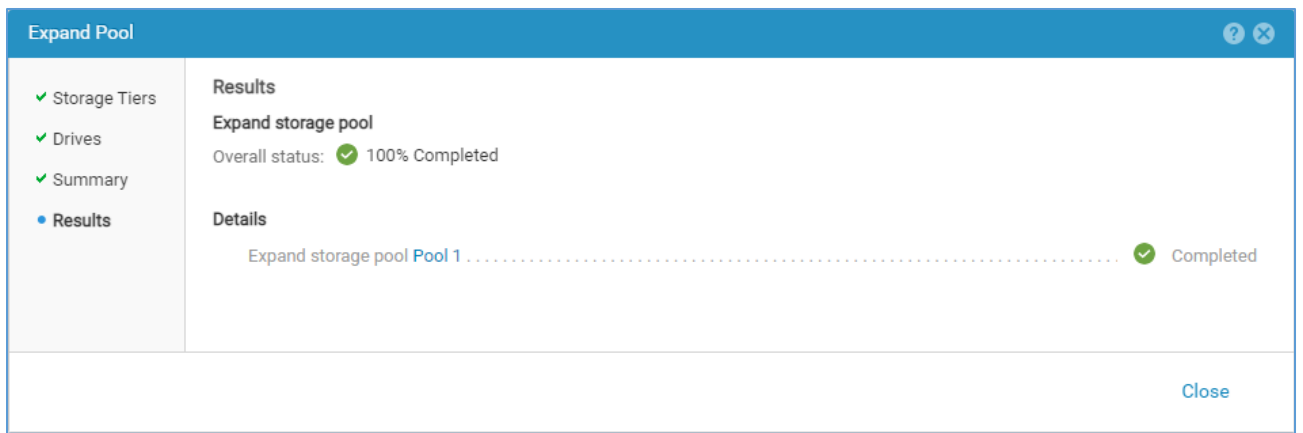


Figure 38 Expand Pool wizard > Results

6 Interoperability

Dynamic pools, like traditional pools, are fully supported with all storage resource types and software features within the system. While dynamic pools support all storage resource types and software features, other features of the storage system needed to be updated to support dynamic pools. The following subsections outline several made to certain software features to support dynamic pools.

6.1 Data at Rest Encryption

Data at Rest Encryption (D@RE) is fully supported on systems utilizing traditional pools and dynamic pools. With dynamic pools, changes to the D@RE algorithm were needed for D@RE to be supported. With traditional pools, encryption keys are created and allocated on a per drive basis within the traditional pool private RAID groups. This allocation of encryption keys occurs whenever a pool is created, or drives are added to the traditional pool. Knowing that the drive configuration is static, this model for allocating keys is complete.

With dynamic pools, multiple private RAID groups can span the same drives within a drive partnership group, which makes the traditional pool method of allocating keys not feasible. The key allocation algorithm has been updated to work with the tracking of the drive extents within each drive partnership group. The drive extent algorithm tracks which drives are used within the pool, and with this information, D@RE keys can be allocated to each individual drive. As drives are allocated to the pool, new keys can also be supplied. D@RE continues to be enabled at the time the storage system is initialized, and no further steps are needed for dynamic pools. For more information on Data at Rest Encryption, review the white paper *Dell EMC Unity: Data at Rest Encryption – A Detailed Review* on [Dell Technologies Info Hub](#).

6.2 Import

Dell Unity OE version 4.1 introduced Dell Unity native SAN copy import and file import. These features provide an automated method for migrating block storage resources, such as LUNs and consistency groups, and NFSv3 file systems mounted on a virtual data mover (VDM) from a VNX1/VNX2 storage system to a Dell Unity system. Dell Unity OE version 4.2 introduced support for CIFS-based file systems mounted on a VDM. In Dell Unity OE version 5.1, file import has been extended to include multiprotocol virtual data movers. When selecting the target pool for the import session, both Traditional and dynamic pools are supported. To further distinguish the different pools on the system, a Type field was added to the pool selection window to easily differentiate pool types. For more information on the import feature, review the white paper *Dell EMC Unity: Migration Technologies – A Detailed Review* on [Dell Technologies Info Hub](#).

6.3 Local LUN move

Dell Unity OE version 4.1 introduced the local LUN move feature. Local LUN move is a native feature within the storage system used to easily move LUNs and VMFS datastores within the same pool or between pools within the same system. The Local LUN move windows were updated to include support for dynamic pools, as the source or destination of the move session. When selecting the destination pool by name, a Type field was added to the window to easily report what type of pool, either Traditional or Dynamic, the selected pool is. Local LUN move can not only be used for manual load balancing between pools, but also for migrating resources from a traditional pool to a dynamic pool. For more information on Local LUN Move, review the white paper *Dell EMC Unity: Migration Technologies – A Detailed Review* on [Dell Technologies Info Hub](#).

6.4 Replication

Dell Unity native synchronous and asynchronous replication is fully supported with Traditional and dynamic pools. When configuring local or remote replication, the source or destination pool can be either type of pool, Traditional or Dynamic. This flexibility in configuration options allows systems which do not support dynamic pools, such as Dell UnityVSA, a Dell Unity hybrid system, or another all-flash system which is not running Dell Unity OE version 4.2 or later to replicate to or from a dynamic pool. When configuring replication, a Type field was added to easily determine the type of pool that was selected as the destination. This Type field is only present on systems running Dell Unity OE version 4.2 or later. For more information on Replication, review the white paper *Dell Unity: Replication Technologies – A Detailed Review* on [Dell Technologies Info Hub](#).

6.5 FAST VP

Fully Automated Storage Tiering for Virtual Pools (FAST VP) is a software feature found on hybrid model Dell Unity systems. FAST VP monitors the data access patterns within the Pools on the system, and dynamically matches the performance requirements of the data with drives that provide that level of performance. FAST VP is fully supported on hybrid systems utilizing traditional pools and dynamic pools. FAST VP can be controlled at the system level and individual pool level. For more information on FAST VP, review the white paper *Dell EMC Unity: FAST Technology Overview* on [Dell Technologies Info Hub](#).

7 Conclusion

Dell Unity OE version 4.2 introduced dynamic pool technology for Dell Unity all-flash storage systems. In OE version 5.2 support for dynamic pools on hybrid model systems was added. This is the default pool type when creating pools in Unisphere. This new pool technology is designed from the ground up, with a new method for allocating space within the pool than traditional pools. This design allows for flexible deployment options, and allows users to design or expand dynamic pools with a specific capacity in mind. The pool sizing requirements are based on minimum drive counts, and not drive multiples. As long as the minimum drive counts are met, the pool can be any number of drives, and can also be expanded by a single drive in most circumstances to increase the capacity of the pool.

With dynamic pools, no hot spares for failed drive replacement are required, since all space for drive rebuilds is allocated within the pool. Drives which would be reserved as hot spares for traditional pools are incorporated into the pool to further spread out user space and space to use for drive rebuilds. As drives within dynamic pools are partitioned into extents, the pool can easily move data around to balance workloads when the pool is expanded. If a drive fails, multiple extents can be rebuilt at the same time, and to multiple drives within the pool. This further reduces the amount of time a rebuild of a drive takes when compared to a rebuild within a traditional pool.

Dynamic pools are also designed to help mitigate flash wear. Since drives previously reserved as Hot Spares are now incorporated into the pool, the user data and workloads are spread out across more drives. This reduces the amount of wear per drive within the pool. Also, wear is further monitored within a dynamic pool, and if needed, data can be moved between drive partnership groups to further spread out wear. This is an automated process that requires no intervention by the user.

A Technical support and resources

[Dell.com/support](https://www.dell.com/support) is focused on meeting customer needs with proven services and support.

[Storage technical documents and videos](#) provide expertise that helps to ensure customer success on Dell storage platforms.

A.1 Related resources

The following documents can be found on [Dell Technologies Info Hub](#):

- Dell EMC Unity: Introduction to the Platform
- Dell Unity XT: Introduction to the Platform
- Dell Unity: Best Practices Guide
- Dell EMC Unity: Cloud Tiering Appliance (CTA)
- Dell EMC Unity: Compression
- Dell EMC Unity: Compression for File
- Dell EMC Unity: Data at Rest Encryption
- Dell EMC Unity: Data Integrity
- Dell Unity: Data Reduction
- Dell EMC Unity: DR Access and Testing
- Dell Unity: Dynamic Pools
- Dell EMC Unity: File-Level Retention (FLR)
- Dell Unity: High Availability
- Dell EMC Unity: Introduction to the Platform
- Dell Unity: NAS Capabilities
- Dell EMC Unity: MetroSync
- Dell EMC Unity: MetroSync and Home Directories
- Dell EMC Unity: MetroSync and VMware vSphere NFS Datastores
- Dell EMC Unity: Migration Technologies
- Dell EMC Unity: OpenStack Best Practices for Ocata Release
- Dell EMC Unity: Performance Metrics
- Dell Unity: Replication Technologies
- Dell EMC Unity: Snapshots and Thin Clones
- Dell EMC Unity: Operating Environment (OE) Overview
- Dell EMC Unity: Unisphere Overview
- Dell EMC Unity: Virtualization Integration
- Dell EMC UnityVSA
- Dell EMC Unity Cloud Edition with VMware Cloud on AWS
- Dell EMC Unity Data Reduction Analysis
- Dell EMC Unity: Migrating to Dell EMC Unity with SAN Copy
- Dell EMC Unity Storage with Microsoft Hyper-V
- Dell EMC Unity Storage with Microsoft SQL Server
- Dell EMC Unity Storage with Microsoft Exchange Server
- Dell EMC Unity Storage with VMware vSphere
- Dell EMC Unity Storage with Oracle Databases
- Dell EMC Unity 350F Storage with VMware Horizon View VDI