



XCubeSAN Series White Paper

Auto Tiering 2.0



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XCubeSAN Storage System 4U & 6U Models

Model Name	Controller Type	Form Factor, Bay Count, and Rack Unit
XS5224D	Dual Controller	LFF 24-disk 4U Chassis
XS3224D	Dual Controller	LFF 24-disk 4U Chassis
XS3224S	Single Controller	LFF 24-disk 4U Chassis
XS1224D	Dual Controller	LFF 24-disk 4U Chassis
XS1224S	Single Controller	LFF 24-disk 4U Chassis

XCubeSAN Storage System 3U 19" Rack Mount Models

Model Name	Controller Type	Form Factor, Bay Count, and Rack Unit
XS5216D	Dual Controller	LFF 16-disk 3U Chassis
XS3216D	Dual Controller	LFF 16-disk 3U Chassis
XS3216S	Single Controller	LFF 16-disk 3U Chassis
XS1216D	Dual Controller	LFF 16-disk 3U Chassis
XS1216S	Single Controller	LFF 16-disk 3U Chassis

XCubeSAN Storage System 2U 19" Rack Mount Models

Model Name	Controller Type	Form Factor, Bay Count, and Rack Unit
XS5212D	Dual Controller	LFF 12-disk 2U Chassis
XS5212S	Single Controller	LFF 12-disk 2U Chassis
XS3212D	Dual Controller	LFF 12-disk 2U Chassis
XS3212S	Single Controller	LFF 12-disk 2U Chassis
XS1212D	Dual Controller	LFF 12-disk 2U Chassis
XS1212S	Single Controller	LFF 12-disk 2U Chassis
XS5226D	Dual Controller	SFF 26-disk 2U Chassis
XS5226S	Single Controller	SFF 26-disk 2U Chassis
XS3226D	Dual Controller	SFF 26-disk 2U Chassis
XS3226S	Single Controller	SFF 26-disk 2U Chassis
XS1226D	Dual Controller	SFF 26-disk 2U Chassis

XS1226S	Single Controller	SFF 26-disk 2U Chassis
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Auto Tiering 2.0

Executive Summary

QSAN auto tiering cost-effectively and dynamically places hot data on SSD or faster hard drives and cold data on lower cost high-capacity drives, allowing you to optimize application performance without straining your budget or sacrificing capacity.

Our algorithm uses intelligent data analysis that continuously monitors data usage and ranks this data based on how often it is accessed. It will then use this information and make a decision on where your data should be.

The intuitive SANOS 4.0 web UI interactively shows the data being gathered; how this data is being used, and how much of each tier storage should be assigned based on this information. Then at the scheduled time, the most accessed blocks that have been marked as hot data will be migrated into the lowest cost - highest capacity drive tier.

All of this is managed in the background without user intervention. This tiered pool will also function the same as any standard QSAN pool, and access to our enterprise features such as snapshot and remote replication remains unchanged. This intelligent movement of data will allow the highest performance for the data you use the most, while keeping the total cost of ownership low and taking the burden of data management away from the IT organization.

Auto tiering is a feature available on XCubeSAN series and requires license to activate. This document discusses the Auto tiering technology and describes its features, functions, management, and best practice.



INFORMATION:

Auto tiering 2.0 with flexible RAID and disk configurations is available in SANOS firmware 1.2.0.

Audience

This document is applicable for QSAN customers and partners who are familiar with QSAN products and considering using auto tiering function. Any settings which are configured with basic operations will not be detailed in this document. If there is any question, please refer to the user manuals of products, or contact QSAN support for further assistance.

Overview

From the perspective of storage features, the performance of SSDs are high, but the cost is also high per GB. Relatively speaking, the cost of a traditional hard drive is low, so as performance is relatively poor. If we follow the 80/20 rule to configure storage systems, all-SSD configurations are unreasonable for all but the most intensive applications. In fact, SSD will be needed in only a small part for most typical applications, regardless of whether or not a critical application, thus giving SSD resources for general storage needs is hugely cost-prohibitive. Although traditional hard disk performance is enough for general applications which I/O requirements are not high, the traditional all-hard-drive configuration is also gradually been inadequate.

On the other hand, the data itself has a lifecycle. Since the data in the course of its life cycle, it has experienced different levels of activity. In common usage, when creating the data, it is usually used. As the age of the data increases, it is accessed less often.

The Solution

Therefore, to balance performance and cost factors, adapting hybrid storage architecture with a mixture of SSDs and traditional HDDs seem to be the most reasonable approach for modern IT environments. Generally, SSD-based storage capacity in 10 to 15% of the total storage capacity should be enough to fulfill the requirements of critical high I/O applications. An automated tiering pool is a simple and elegant solution for dynamically matching storage requirements with changes in the frequency of data access.

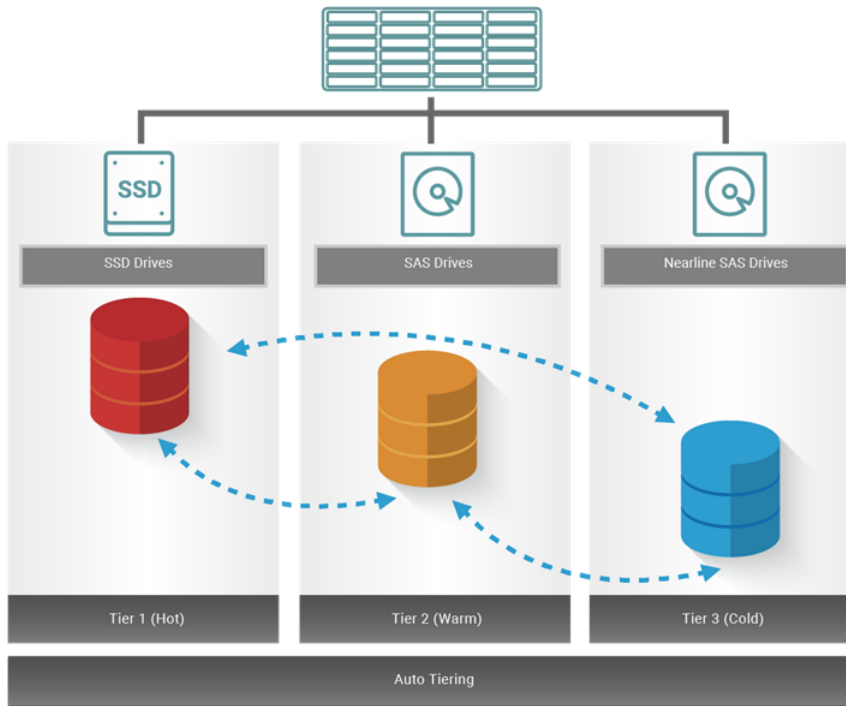


Figure 1 Auto Tiering Pool

Tier Categories

As the name suggestion, auto tiering must have two tiers at least. Automated tiering pool segregated disk drives into three categories for dual controllers and four for single controller.

- Tier 1: SSD drives for extreme performance tier
- Tier 2: SAS drives (15K or 10K RPM SAS HDD) for performance tier
- Tier 3: Nearline SAS drives (7.2K or lower RPM SAS HDD) for capacity tier
- Tier 4: SATA drives for capacity tier (for single controller only, not recommended)

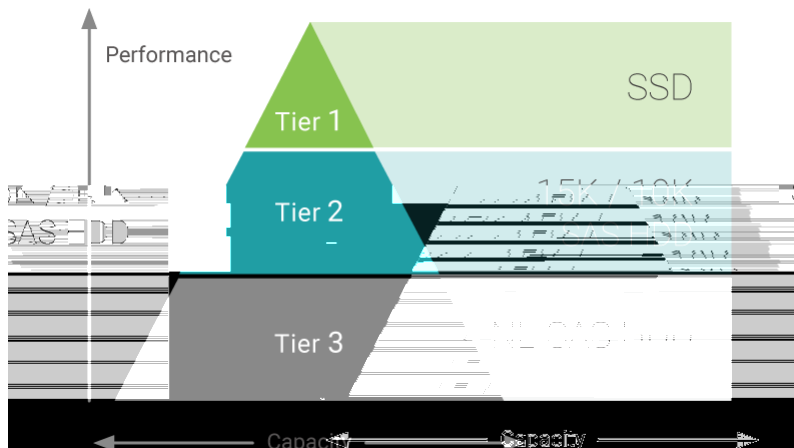


Figure 2 3 Levels of Tiered Storage

Tier 1 / SSD Tier / Extreme Performance Tier

Use the SSD tier when response time and performance are the most important criteria for storage. This tier uses flash technology that does not contain moving parts. This revolutionary technology eliminates the rotation latencies and can improve performance and save energy significantly.

Compared to traditional spinning drives, SSD drives have higher cost per gigabyte, but lower per IO cost. For the best practice, use the SSD drive to get data that requires fast response time and high IOPS. Auto tiering enables you to optimize the use of these high-performance resources because it automatically relocates "hot" data to the SSD tier.

Tier 2 / SAS HDD Tier / Performance Tier

Use the SAS HDD tier to achieve a combination of performance and capacity. The SAS HDD tier provides high levels of performance, reliability, and capacity. SAS HDD stores data on a series of fast rotating disks based on mechanical hard disk drive technology.

This tier includes 15K and 10K RPM spinning drives, which are valuable because it provides a high level performance with consistent response time, high throughput and good bandwidth at moderate price.

Tier 3 / NL-SAS HDD Tier / Capacity Tier

Use the NL-SAS HDD tier to reduce the cost per GB of data. This tier consists of 7.2K or lower RPM SAS HDD which is designed to achieve the maximum capacity at an appropriate performance level. While NL-SAS HDDs have slower speeds than SAS HDDs, NL-SAS HDDs

dictate if and when data can be moved between the tiers, and in many cases provides the ability to pin data to tiers permanently or for specific periods of time.

Auto Tiering Architecture

A newly created auto tiering pool is based on thin provisioning technology. Each tier works based on one or more disk groups. The following is the storage architecture of an auto tiering pool.

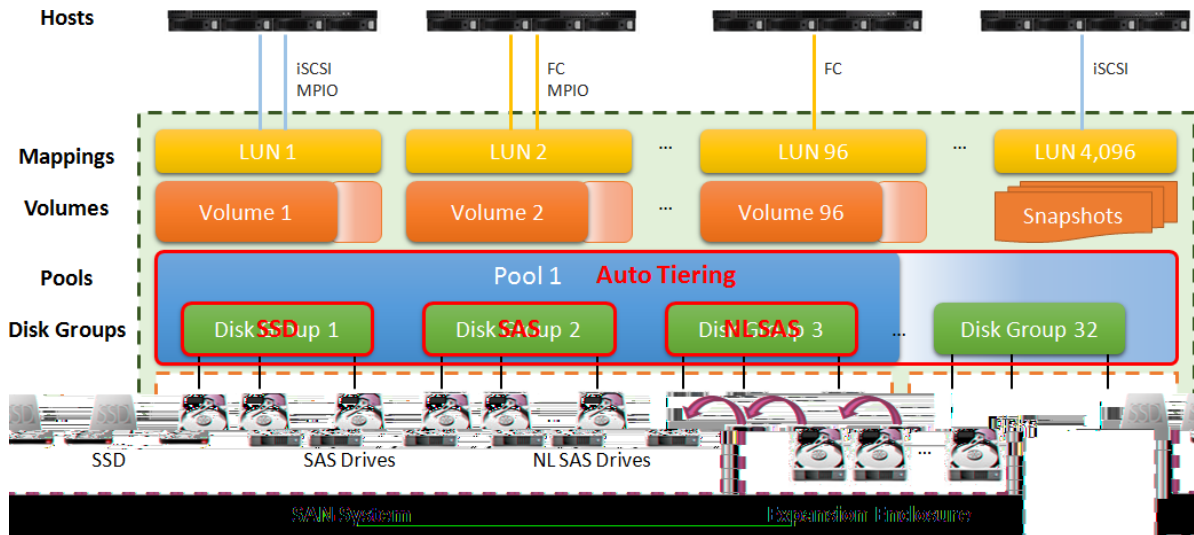


Figure 4 Storage Architecture of Auto Tiering Pool

To increase the capacity of an auto tiering pool, any tier (disk group) which contains either one tier of SSDs, SAS HDDs, or NL-SAS HDDs can be added to the pool any time. An auto tiering pool can have up to 32 disk groups with each disk group contains up to 64 disk drives. And the maximum disk drive quantity in a pool is 256. The maximum addressable capacity of each disk group is 64TB. So the maximum capacity in a system is 256TB. For more information about pool operation, please refer to the [Configuring Auto Tiering Pools](#) section.

Table 1 Auto Tiering Pool Parameters

Item	Value
Maximum disk group quantity in a pool	32
Maximum disk drive quantity in a disk group (include dedicated spares)	64

Maximum disk drive quantity in a pool (include dedicated spares)	256
Maximum pool quantity per system	64
Maximum dedicated spare quantity in a pool	8
Maximum tiers (include SSD, SAS HDD, NL-SAS HDD)	3
Maximum addressable capacity of a disk group	64TB
Maximum addressable capacity of an auto tiering pool	256TB
Maximum addressable capacity of total auto tiering pools (include thin provisioning pools)	1,024TB
Provisioning granularity	1GB

By design, the auto tiering feature allows selecting policies that define how data are moved between different tiers, and in many cases provides the ability to pin data to tiers permanently or for specific periods of time.

Auto tiering storage is the assignment of different categories of data to different disk types. It operates based on relocating the most active data up to the highest available tier and the least active data down to the lowest tier. Auto tiering works based on an allocation unit (granularity) of 1GB and relocates data by moving the entire unit to the appropriate tier, depending on the tiering policy selected for that particular volume.

In order to ensure sufficient space in the higher tiers, 10% of the space is reserved in each higher tier to prepare for the data allocation for those tiering policies which would allocate initial space in highest available tiers. By reclaiming this 10% headroom, the least active units within each tier move to lower tiers. The whole mechanism of auto tiering contains three steps, statistic collection by accessed counts, ranking hotness data by the statistic collection, and then relocation data via ranking.

Intelligent Auto Tiering Mechanism

Auto tiering storage management system manages the data relocation and monitors the data hotness ratio using half-life coefficient and advanced ranking algorithm. It operates on three major functions.

Statistics Collection

The volume space is divided into units of equal size in which the hotness is collected and analyzed per hour. This is also called sub LUN. Activity level of a sub LUN is determined by counting the quantity of read and write access on the sub LUN. Logical volume manager maintains a cumulative I/O count and weights each I/O by how recently it arrived. The new coming I/O is given a full weight. After approximately 24 hours, the weight of this IO is nearly cut in half and continues to decrease. The reduction weight is processing per hour by our precision algorithm. This statistics collection occurs continuously in the background for auto tiering pool.

Ranking

This analysis produces a rank ordering of each sub LUN within the pool. Note that the policies of volumes would affect how sub LUNs are ranked.

After analysis, the system would generate following information for each tier:

- The amount of data to be moved up
- The amount of data to be moved down
- The amount of data to be moved into a tier.



TIP:

The hotness analysis process which includes statistics collection and ranking may take minutes to complete.

Relocation

According to the hotness analysis, relocation is processed during the user-defined relocation window, which is the number of minutes given to the relocation process. When the window closes, the relocation process would stop relocating data. The other parameter is relocation rate which controls speed of the relocation process. Valid value of relocation rate is Fast, Medium, and Slow.

Auto tiering promotes sub LUNs according to the candidate list that it created in the analysis stage. During relocation, it prioritizes relocating sub LUNs to higher tiers. At the same time, sub LUNs are only relocated to higher tiers if the space they occupy is required for a higher priority. Using the mechanism, auto tiering makes sure that the higher performing drives are always used.

During I/O, as data is written to a pool, auto tiering attempts to move it to the higher tiers if space is available and the tiering policy allows for it. As we describe before, the relocation process will keep 10% of the free space in all tiers. This space is reserved for any new allocations of higher priority sub LUNs before the next relocation. Lower tiers are used for capacity when needed. The entire relocation process is complete automatically based on the user-defined relocation schedule, or manually if user triggers by himself. The following figure provides an illustration of how auto tiering can improve sub LUN placement in a pool.

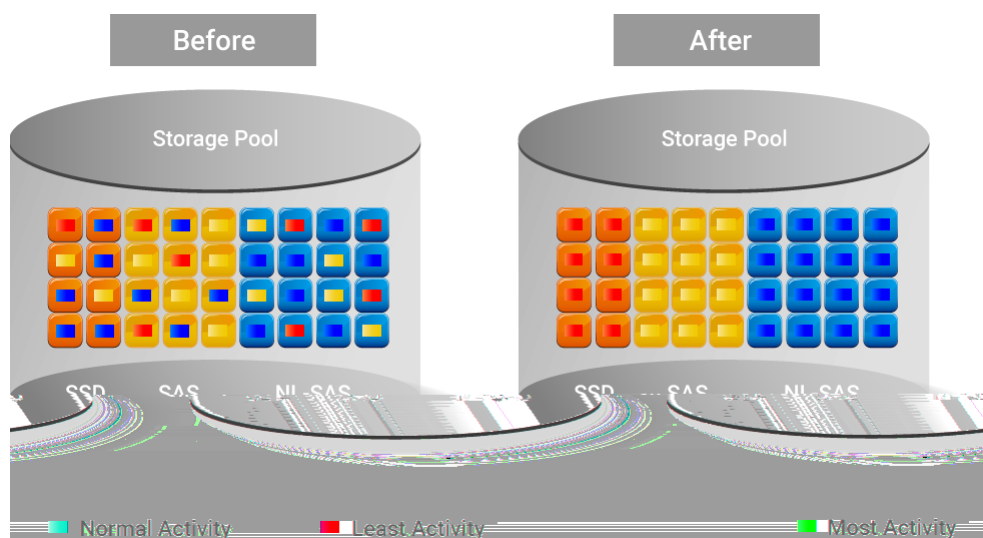


Figure 5 Auto Tiering Relocation

Tiering Policies

For the best performance in various environments, auto tiering has a completely automated feature that implements a set of tiering policies. Tiering policies determine how new allocations and ongoing relocations should apply within a volume for those requirements. Auto tiering uses an algorithm to make data relocation decisions based on the activity level of each unit. It ranks the order of data relocation across all volumes within each separate pool. The system uses this information in combination with the tiering policy per volume to create a candidate list for data movement. The following volume policies are available:

Auto Tiering (Default)

all the data in the lower tiers. This policy automatically relocates data to the most appropriate tier based on the activity level of each data. Sub LUNs are relocated based on

Enable Auto Tiering License

The auto tiering function is optional. Before using it, you have to enable auto tiering license. Select the **Update** function tab in the **Maintenance** function submenu, download **Request License** file and send to your local sales to obtain a License Key. After getting the license key, click the **Choose File** button to select it, and then click the **Apply** button to enable. When the license is enabled, please reboot the system. Each license key is unique and dedicated to a specific system. If you have already enabled, this option will be invisible.

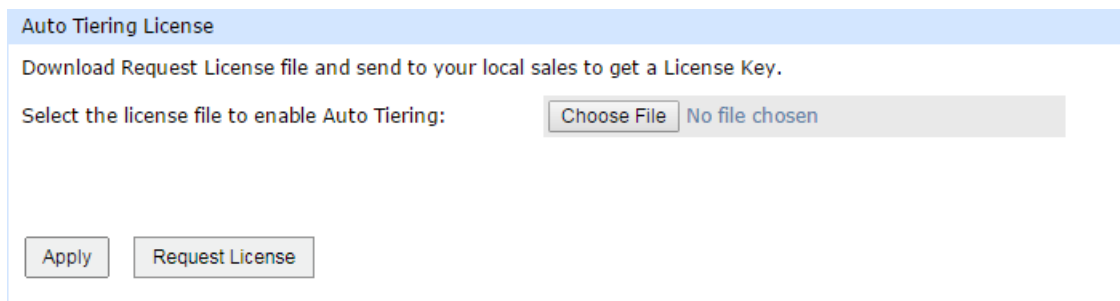


Figure 7 Enable Auto Tiering License

Create an Auto Tiering Pool

Here is an example of creating an auto tiering pool with 3 tiers, each tier has 3 disks configured in RAID 5. At the first time of creating an auto tiering pool, it may contain at least 2 tiers (disk groups) and the maximum quantity of disk in a tier (disk group) is 8.

1. Select the **Pools** function submenu, click the **Create Pool** button. It will scan available disks first.



TIP:

It may take 20 ~ 30 seconds to scan disks if your system has more than 200 disk drives. Please wait patiently.

Figure 8 Create an Auto Tiering Pool Step 1

2. Select the Pool Type as Auto Tiering (Thin Provisioning Enabled). This option is available when auto-tiering license is enabled.
3. Enter a Pool Name for the pool. The maximum length of the pool name is 16 characters. Valid characters are [A~Z | a~z | 0~9 | -_<>].
4. Select a Preferred Controller from the drop-down list. The backend I/O resources in this pool will be processed by the preferred controller which you specified. This option is available when dual controllers are installed.
5. Click the Next button to continue.

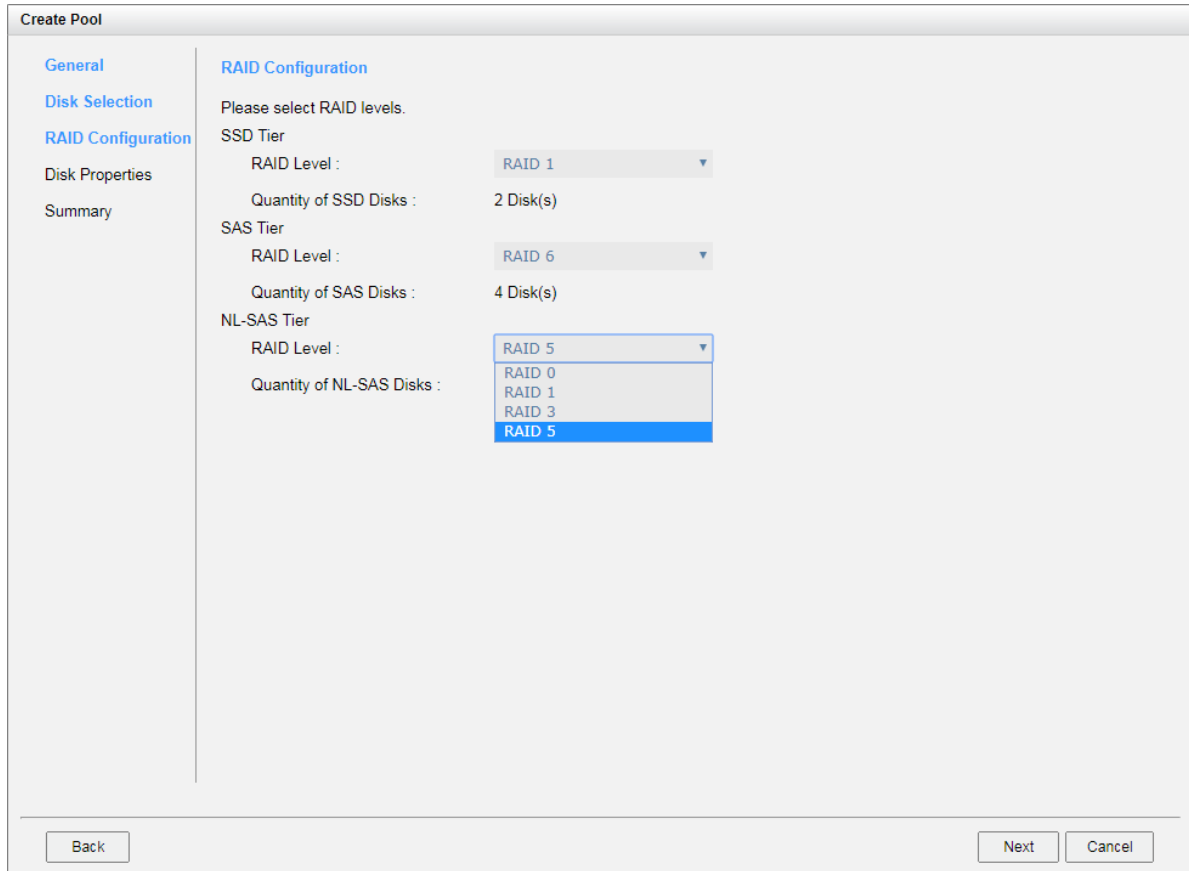


Figure 10 Create an Auto Tiering Pool Step 3

8. Select a RAID Level from the drop-down list which lists available RAID level only according to the disk selection for each tier. And also select a Quantity of Subgroups if the combination RAID level is selected.
9. Click the Next button to continue.

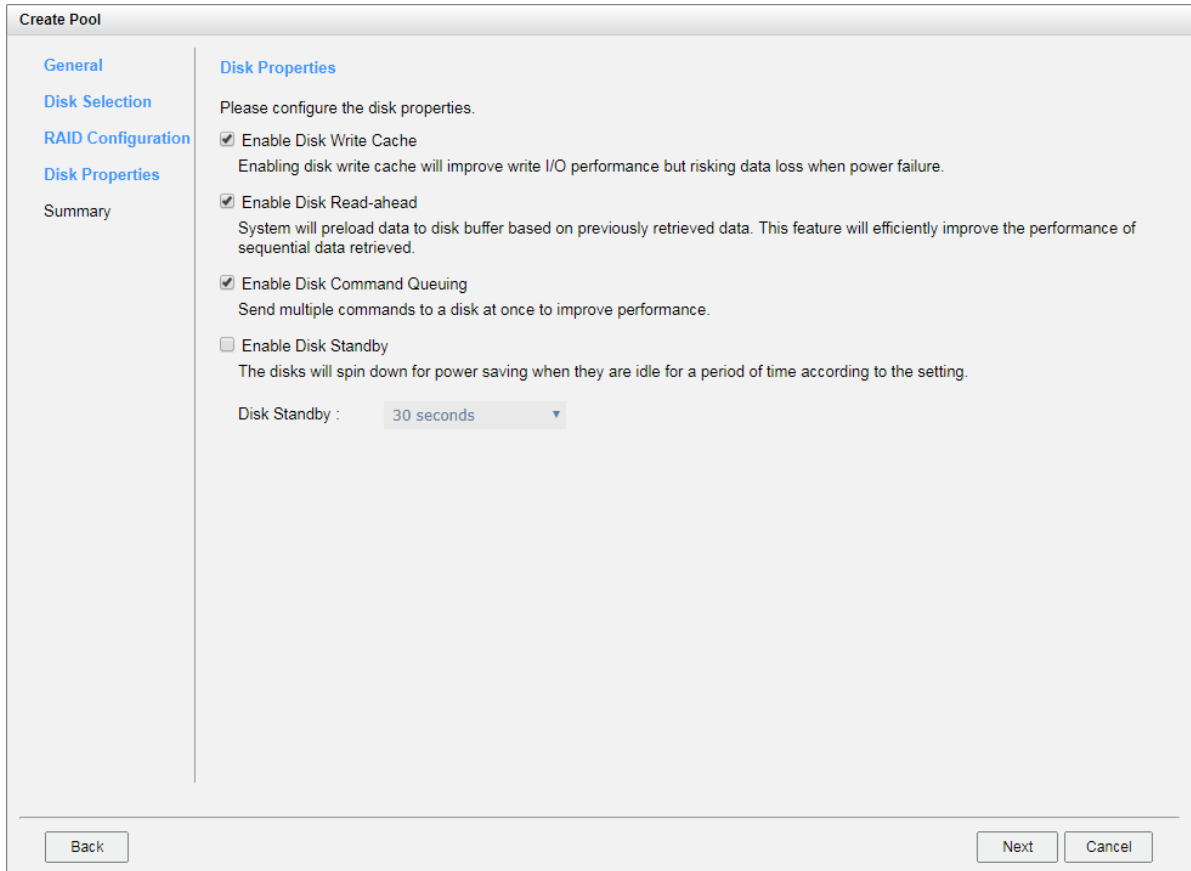


Figure 11 Create an Auto Tiering Pool Step 4

10. Disk properties can also be configured optionally in this step:

- **Enable Disk Write Cache:** Check to enable the write cache option of disks. Enabling disk write cache will improve write I/O performance but have a risk of losing data when power failure.
- **Enable Disk Read-ahead:** Check to enable the read-ahead function of disks. System will preload data to disk buffer based on previously retrieved data. This feature will efficiently improve the performance of sequential data retrieved.
- **Enable Disk Command Queuing:** Check to enable the command queue function of disks. Send multiple commands to a disk at once to improve performance.
- **Enable Disk Standby:** Check to enable the auto spin down function of disks. The disks will be spun down for power saving when they are idle for the period of time specified.

11. Click the **Next** button to continue.

Figure 12 Create an Auto Tiering Pool Wizard Step 5

12. By default, we set relocation schedule at 00:00 daily, relocation period set to 00:00 which means let relocation process run until it finishes, and relocation rate to fast.
13. After confirmation at summary page, click the Finish button to create a pool.

	Pool Name	Status	Health	Total	Free	Available	Thin Provisioning	Auto Tiering	Volumes	Current Controller
▼	Pool-3	Online	Good	18.92 TB	18.92 TB	18.92 TB	Enabled	Enabled	0	Controller 1

Create Pool

Figure 13 An Auto Tiering Pool is Created

14. The pool has been created. If necessary, click the Create Pool button again to create others.



TIP:

Auto Tiering 2.0 supports flexible RAID and disk configurations. You can create each tier (disk group) with different RAID level and different quantity of disk. For example, SSD tier uses 4 disks with RAID 10 for extreme performance, SAS tier uses 6 disks with RAID 6, and NL-SAS tier uses 8 disks with RAID 5 for capacity.



CAUTION:

Because the auto tiering pool is based on thin provisioning technology, please always watch the system logs of thin provisioning pool. If the used capacity of the thin provisioning pool reaches 95% (default thin provisioning policy), the system will deactivate the pool to avoid data loss. So the host cannot access the pool at this time. You have to expand the pool capacity, and then activate the pool to resolve the issue.

List Auto Tiering Pools

Pool View

Click a pool; it will display the related disk groups. Similarly, click a disk group; it will display the related disk drives. The pool properties can be configured by clicking the functions button ▼ to the left side of the specific pool.

	Pool Name	Status	Health	Total	Free	Available	Thin Provisioning	Auto Tiering	Volumes	Current Controller
▼	Pool-3	Online	Good	13.46 TB	13.46 TB	13.46 TB	Enabled	Enabled	0	Controller 1

Disk Groups								
	No.	Status	Health	Total	Free	Tier Level	Disks Used	RAID
▼	1	Online	Good	10.92 TB	10.92 TB	NL-SAS	3	RAID 5
▼	2	Online	Good	2.18 TB	2.18 TB	SAS	4	RAID 6
▼	3	Online	Good	372.00 GB	372.00 GB	SSD	2	RAID 1

Disks							
Enclosure ID	Slot	Status	Health	Capacity	Disk Type	Manufacturer	Model
0	1	Online	Good	372.36 GB	SAS SSD 12.0Gb/s	SEAGATE	ST400FM0053
0	2	Online	Good	372.36 GB	SAS SSD 12.0Gb/s	SEAGATE	ST400FM0053

Create Pool

Figure 14 List Auto Tiering Pools

This table shows the column descriptions.

Table 3 *Pool Column Descriptions*

Column Name	Description
Pool Name	The pool name.
Status	The status of the pool: <ul style="list-style-type: none"> • Online: The pool is online. • Offline: The pool is offline. • Rebuilding: The pool is being rebuilt. • Migrating: The pool is being migrated. • Relocating: The pool is being relocated.
Health	The health of the pool: <ul style="list-style-type: none"> • Good: The pool is good. • Failed: The pool is failed. • Degraded: The pool is not healthy and not complete. The reason could be missing or failed disks.
Total	Total capacity of the pool.
Free	Free capacity of the pool.
Available	Available capacity of the pool.
Thin Provisioning	The status of Thin provisioning: <ul style="list-style-type: none"> • Disabled. • Enabled.

Auto Tiering

The status of Auto Tiering:

- Disabled.
- Enabled.
- Not Supported: The pool contains the disk groups with mixed disk type.

Disk Type	The type of the disk drive: <ul style="list-style-type: none"> [SAS HDD NL-SAS HDD SAS SSD SATA SSD] [12.0Gb/s 6.0Gb/s 3.0Gb/s 1.5Gb/s]
Manufacturer	The manufacturer of the disk drive.
Model	The model name of disk drive.

Auto Tiering View

The Auto Tiering function tab in the Pools function submenu is only visible when auto tiering license is enabled. Click a pool; it will display the related tiering status. The pool properties can be configured by clicking the functions button ▼ to the left side of the specific pool.

	Name	Status	Health	Total	Free	Available	Volumes	Disks	Current Controller
▼	Pool-3	Online	Good	13.46 TB	13.46 TB	13.46 TB	0	9	Controller 1
Pool Tiering Status:									
Tier Level	Tier Capacity (GB)	Tier Used (GB)	Move Up (GB)	Move Down (GB)	Move In (GB)	Tier Status			
SSD	372	0	0	0	0				
SAS	2235	0	0	0	0				
NL-SAS	11177	0	0	0	0				

Figure 15 Auto Tiering Pools and Status

This table shows the column descriptions.

Table 6 Pool Tiering Status Column Descriptions

Column Name	Description
Tier Level	Tier categories, there are SSD, SAS, Nearline SAS, and SATA. The system will hide the tiers without any disk groups.
Tier Capacity	Total capacity of the tier.
Tier Used	Used capacity of the tier.
Move Up	The capacity prepares to move up to higher tier.
Move Down	The capacity prepares to move down to lower tier.
Move In	The capacity prepares to move in from other tiers.
Tier Status	Bar chart to show the tier status: <ul style="list-style-type: none"> Light Blue: Used capacity.

	<ul style="list-style-type: none"> • Orange: The data will move in. • Gray: Unallocated.
--	--

Operations on Auto Tiering Pools

Most operations are described in the Configuring Storage Pools section. For more information, please refer to the chapter 8.4.3, Operations on Thick Provisioning Pools section and the chapter 9.3.3, Operations on Thin Provisioning Pools section in the [XCubeSAN SANOS 4.0 User s Manual](#). We describe the operations about auto tiering in the following.

Schedule Relocation

Click ▼ -> Schedule Relocation to setup the relocation schedule in auto tiering pool. If the Relocation Period sets as 00:00, it will let relocation process run until it finishes.

Schedule Relocation

Pool Name : Pool-3

Frequency : Daily
 Weekly
 Repeat Every 12 Hours

Relocation Start Time (hh:mm) : 00:00

Relocation Period (hh:mm) : 00 : 00 (Set as 00:00 to let relocation process run until it finishes.)

Relocation Rate : Fast

OK Cancel

Figure 16 Relocation Schedule

Relocate Now

Click ▼ -> Relocate Now to perform relocation right now in an auto tiering pool. Similarly, if Relocation Period sets as 00:00, it will let relocation process run until it finishes.

Relocate Now

Pool Name : Pool-3

Relocation Period (hh:mm) : 00 : 00 (Set as 00:00 to let relocation process run until it finishes.)

Relocation Rate : Fast

OK Cancel

Figure 17 Relocate Now

Add a Tier (Disk Group) in an Auto Tiering Pool

The Add Disk Group function adds a disk group to a pool to increase the capacity.

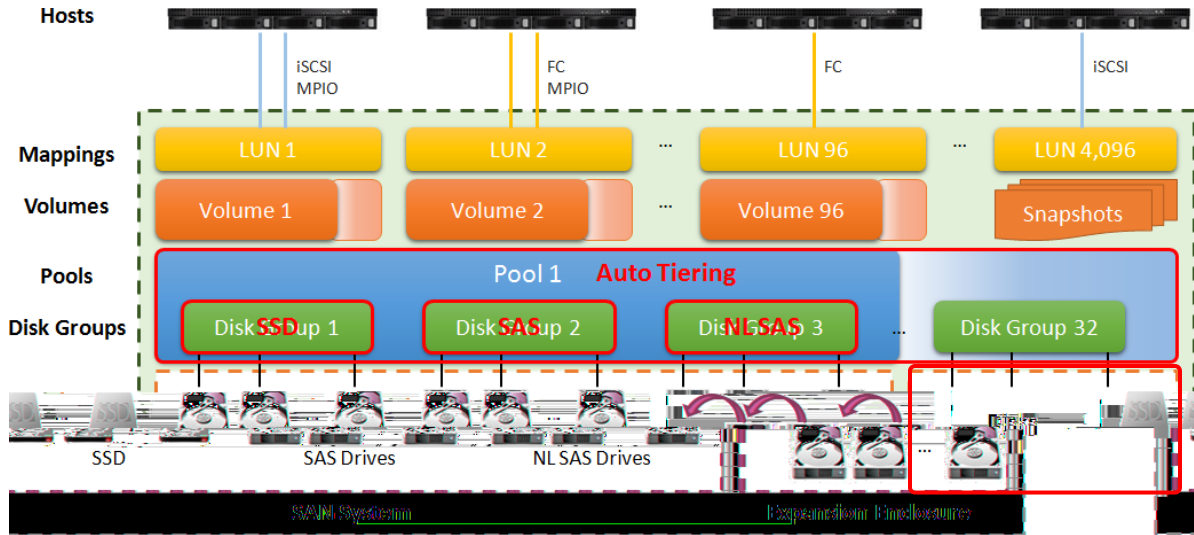


Figure 18 Add a Disk Group in an Auto Tiering Pool

Here is an example of adding a disk group in thin provisioning pool.

1. Select a pool, click ▼ -> Add Disk Group to add a disk group in the auto tiering pool.

Add Disk Group

Pool Type

Thin Provisioning : Enabled
 Auto Tiering : Enabled

RAID Level

Please select a RAID level.

RAID Level : RAID 10 ▼
 Quantity of Subgroups : 2 ▼

Select Disks

Please select disks to add a disk group. The maximum quantity of disk in a disk group is 64.

Enclosure ID : 0 (Head Unit: XS5216) ▼

Model		Enclosure ID	Slot	Health	Capacity	Disk Type	Manufacturer
ST400EM0052	<input type="checkbox"/>	0	3	Good	372.26 GB	SAS SSD 12.0Gb/s	SEAGATE

Figure 19 Add Disk Group

2. Select a RAID Level from the drop-down list and also select a Quantity of Subgroups if the combination RAID level is selected.
3. Please select disks to add a disk group. The maximum quantity of disk in a disk group is 64. Select an Enclosure from the drop-down list to select disks from the expansion enclosures.
4. Click the OK button to add a disk group.

Hot Spares in an Auto Tiering Pool

In an auto tiering pool, hot spare drives can only replace the drives of the same disk type. For example, a SSD tier can only be assigned SSD type drives as hot spares drives.

Enclosure ID: 0 (Head Unit: XS5216) ▾

<< first < prev 1 next > last >>

	Slot	Status	Health	Capacity	Disk Type	Usage	Pool Name	Manufacturer	Model
▾	1	Online	Good	372.36 GB	SAS SSD 12.0Gb/s	RAID	Pool-3	SEAGATE	ST400FM0053
▾	2	Online	Good	372.36 GB	SAS SSD 12.0Gb/s	RAID	Pool-3	SEAGATE	ST400FM0053
▾	3	Online	Good	372.36 GB	SAS SSD 12.0Gb/s	Dedicated Spare	Pool-3	SEAGATE	ST400FM0053
▾	4	Online	Good	372.36 GB	SAS SSD 12.0Gb/s	Free		SEAGATE	ST400FM0053
▾	5	Online	Good	744.96 GB	SAS SSD 12.0Gb/s	Free		MICRON	S630DC-800
▾	6	Online	Good	744.96 GB	SAS SSD 12.0Gb/s	Free		MICRON	S630DC-800
▾	7	Online	Good	744.96 GB	SAS SSD 12.0Gb/s	Free		MICRON	S630DC-800
▾	8	Online	Good	744.96 GB	SAS SSD 12.0Gb/s	Free		MICRON	S630DC-800
▾	9	Online	Good	1.09 TB	SAS HDD 12.0Gb/s	RAID	Pool-3	SEAGATE	ST1200MM0088
▾	10	Online	Good	1.09 TB	SAS HDD 12.0Gb/s	RAID	Pool-3	SEAGATE	ST1200MM0088
▾	11	Online	Good	1.09 TB	SAS HDD 12.0Gb/s	RAID	Pool-3	SEAGATE	ST1200MM0088
▾	12	Online	Good	1.09 TB	SAS HDD 12.0Gb/s	RAID	Pool-3	SEAGATE	ST1200MM0088
▾	13	Online	Good	5.46 TB	NL-SAS HDD 12.0Gb/s	RAID	Pool-3	SEAGATE	ST6000NM0014
▾	14	Online	Good	5.46 TB	NL-SAS HDD 12.0Gb/s	RAID	Pool-3	SEAGATE	ST6000NM0014
▾	15	Online	Good	5.46 TB	NL-SAS HDD 12.0Gb/s	RAID	Pool-3	SEAGATE	ST6000NM0014
▾	16	Online	Good	5.46 TB	NL-SAS HDD 12.0Gb/s	Dedicated Spare	Pool-3	SEAGATE	ST6000NM0014

Figure 20 Hot Spares in Auto Tiering Pool

Configure Volumes

This section will describe the operations of configuring volume in auto tiering pool.

Create a Volume in an Auto Tiering Pool

Here is an example of creating a volume in an auto tiering pool.

1. Select the Volumes function submenu, click the Create Volume button.

The screenshot shows a 'Create Volume' window with a sidebar on the left containing 'General', 'Advanced', and 'Summary' tabs. The 'General' tab is active, displaying 'Volume General Settings'. The settings include:

- Volume Name :** A text input field containing 'Vol-3' with an information icon to its right.
- Pool Name :** A dropdown menu showing 'Pool-3' and '(Available : 262144 GB)' to its right.
- Capacity :** A text input field containing '100' and a dropdown menu showing 'GB'.
- Volume Type :** A dropdown menu showing 'RAID Volume'.

 Below the 'Volume Type' dropdown, there is a note: 'Select RAID Volume for general RAID usage or Backup Volume for backup usage such as the target volume of local clone or remote replication.' At the bottom right of the window are 'Next' and 'Cancel' buttons.

Figure 21 Create a Volume of Auto Tiering Pool Step 1

2. Enter a **Volume Name** for the pool. The maximum length of the volume name is 32 characters. Valid characters are [A~Z | a~z | 0~9 | -_<>].
3. Select a **Pool Name** from the drop-down list. It will also display the available capacity of the pool.
4. Enter required **Capacity**. The unit can be selected from the drop-down list.
5. Select **Volume Type**. The options are **RAID Volume** (for general RAID usage) and **Backup Volume** (for the target volume of local clone or remote replication).
6. Click the **Next** button to continue.

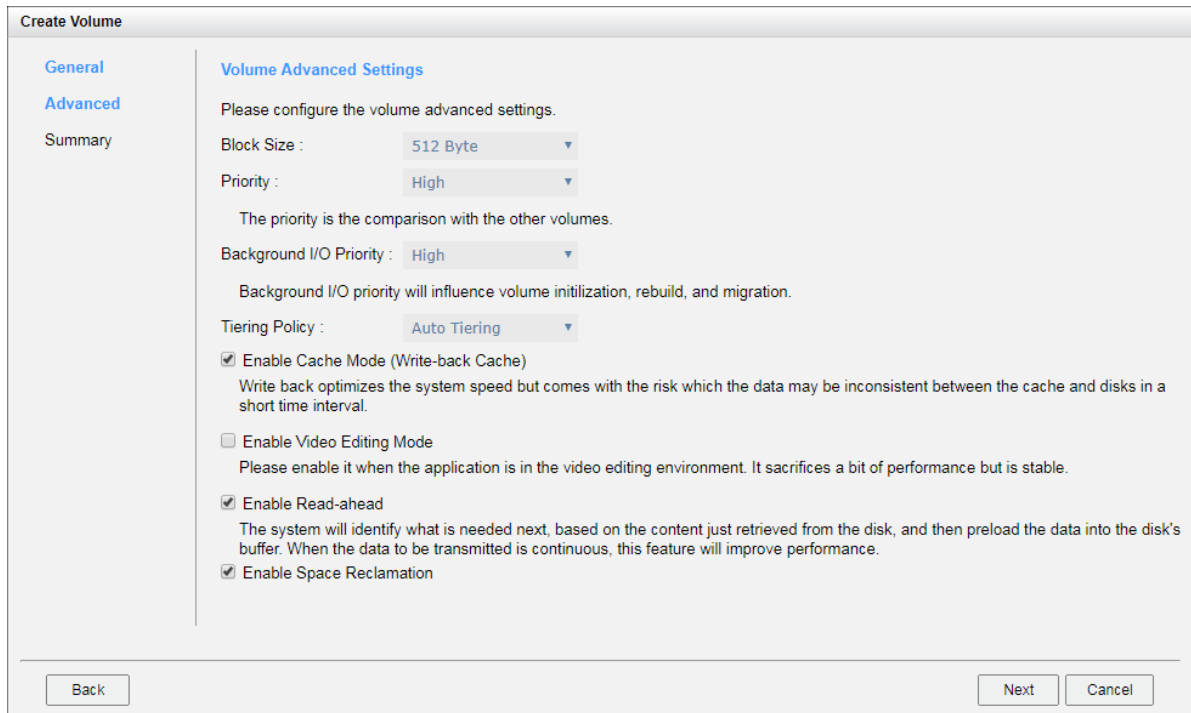


Figure 22 Create a Volume of Auto Tiering Pool Step 2

7. Volume advanced settings can also be configured optionally in this step:
 - **Block Size:** The options are 512 Bytes to 4,096 Bytes.
 - **Priority:** The options are High, Medium, and Low. The priority compares to other volumes. Set it as High if the volume has many I/O.
 - **Background I/O Priority:** The options are High, Medium, and Low. It will influence volume initialization, rebuild, and migration.
 - **Tiering Policy:** The options are Auto Tiering, Start Highest then Auto Tiering, High Available Tier, Lowest Tier, and No Data Movement. Please refer to the [Tiering Policies](#) section for detail.
 - **Enable Cache Mode (Write-back Cache):** Check to enable cache mode function of volume. Write back optimizes the system speed but comes with the risk where the data may be inconsistent between cache and disks in one short time interval.
 - **Enable Video Editing Mode:** Check to enable video editing mode function. It is optimized for video editing usage. Please enable it when your application is in video editing environment. This option provides a more stable performance figure without high and low peaks but slower in average.
 - **Enable Read-ahead:** Check to enable the read ahead function of volume. The system will discern what data will be needed next based on what was just retrieved from

disk and then preload this data into the disk's buffer. This feature will improve performance when the data being retrieved is sequential.

- **Enable Space Reclamation:** Check to enable the space reclamation function of the volume when the pool is auto tiering.

8. Click the Next button to continue.

Figure 23 Create a Volume of Auto Tiering Pool Step 3

9. After confirmation at summary page, click Finish button to create a volume.

10. The volume has been created. It will be initialized in protection RAID level (e.g., RAID 1, 3, 5, 6, 0+1, 10, 30, 50, and 60).

<< first < prev **1** next > last >>

	Volume Name	Status	Health	Capacity	Volume Type	SSD Cache	Snapshot Space	Snapshots	Clone	Write	Pool Name
▼	Vol-3	Online	Optimal	100.00 GB	RAID Volume	Disabled	0 MB / 0 MB	0	N/A	WB	Pool-3

<< first < prev **1** next > last >>

Create Volume Local Clone Options

Figure 24 A Volume in Auto Tiering Pool is Created

11. A volume has been created. If necessary, click the Create Volume button to create another.



TIP:

SANOS supports instant RAID volume availability. The volume can be used immediately when it is initializing or rebuilding.



TIP:

If the pool contains some disk drives of 4Kn type, it is not available to set 512, 1024, or 2048 block size. When the case happens, it will pop up a warning message and suggest changing the block size to 4096.

List Volumes and Operations on Volumes

Most operations are described in the chapter 8.5, Configuring Volumes section in the [XCubeSAN SANOS 4.0 User s Manual](#). We describe auto tiering operations below.

Change Volume Properties

Click ▼ -> Change Volume Properties to change the volume properties of the volume.

Change Volume Properties

Volume Name: Vol-3 ⓘ

Priority: High Medium Low

Background I/O Priority: High ▼

Tiering Policy: Auto Tiering ▼

Cache Mode: Write-through Cache Write-back Cache Read-Only ⓘ

Video Editing Mode: Disabled ▼ ⓘ

Read-ahead: Enabled ▼ ⓘ

Space Reclamation: Enabled ▼

Volume Type: RAID Volume ▼ ⓘ

OK Cancel

Figure 25 Change Volume Properties

Reclaim Space with Thin Provisioning Pool

Click ▼ -> Space Reclamation to reclaim space from the volume when the volume is in an auto tiering pool. For more information about space reclamation, please refer to the chapter 9.2.2, Space Reclamation section in the [XCubeSAN SANOS 4.0 User s Manual](#).

Configure LUN Mappings and Connect by Host Initiator

Next step you can configure LUN mapping and connect by host initiator. For more information about LUN mapping, please refer to the chapter 8.6, Configure LUN Mappings section in the [XCubeSAN SANOS 4.0 User s Manual](#) for detail. For more information about host initiator, please refer to the chapter 8.7, Connect by Host Initiator section in the [XCubeSAN SANOS 4.0 User s Manual](#) for detail.

Transfer to Auto Tiering Pool

This section describes thick provisioning pool or thin provisioning pool transfer to auto tiering one. If auto tiering license is enabled, the thick or thin provisioning pool without disk group of mixed disk type can be transferred to the auto tiering pool by **Add Disk Group** option.

Also note that the thick provisioning pool is preconfigured the space, after transferring to the auto tiering, the original disk group in the thick provisioning pool will be the lowest tier. When auto tiering mechanism is running, the hot data are copied to higher tier, but still occupy the space of the original block. If the data is cold, it will return to the original block space. So the total capacity of the pool does not change even adding the capacity of higher tiers.

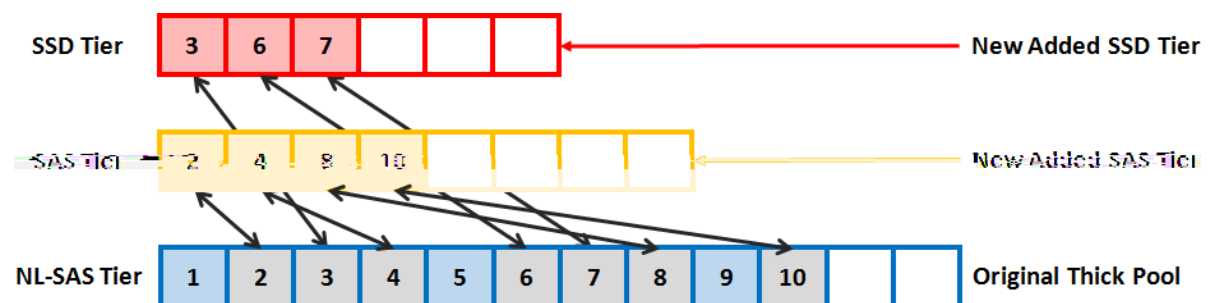


Figure 26 Block Map of Thick Provisioning Pool Transferring to Auto Tiering

- Click ▼ -> Add Disk Group to transfer from a thick provisioning pool to an auto tiering pool. Select Enabled from the Auto Tiering drop-down list. The tier (disk group) must be added one at a time. Select the RAID Level and Select Disks, and then click the OK button.

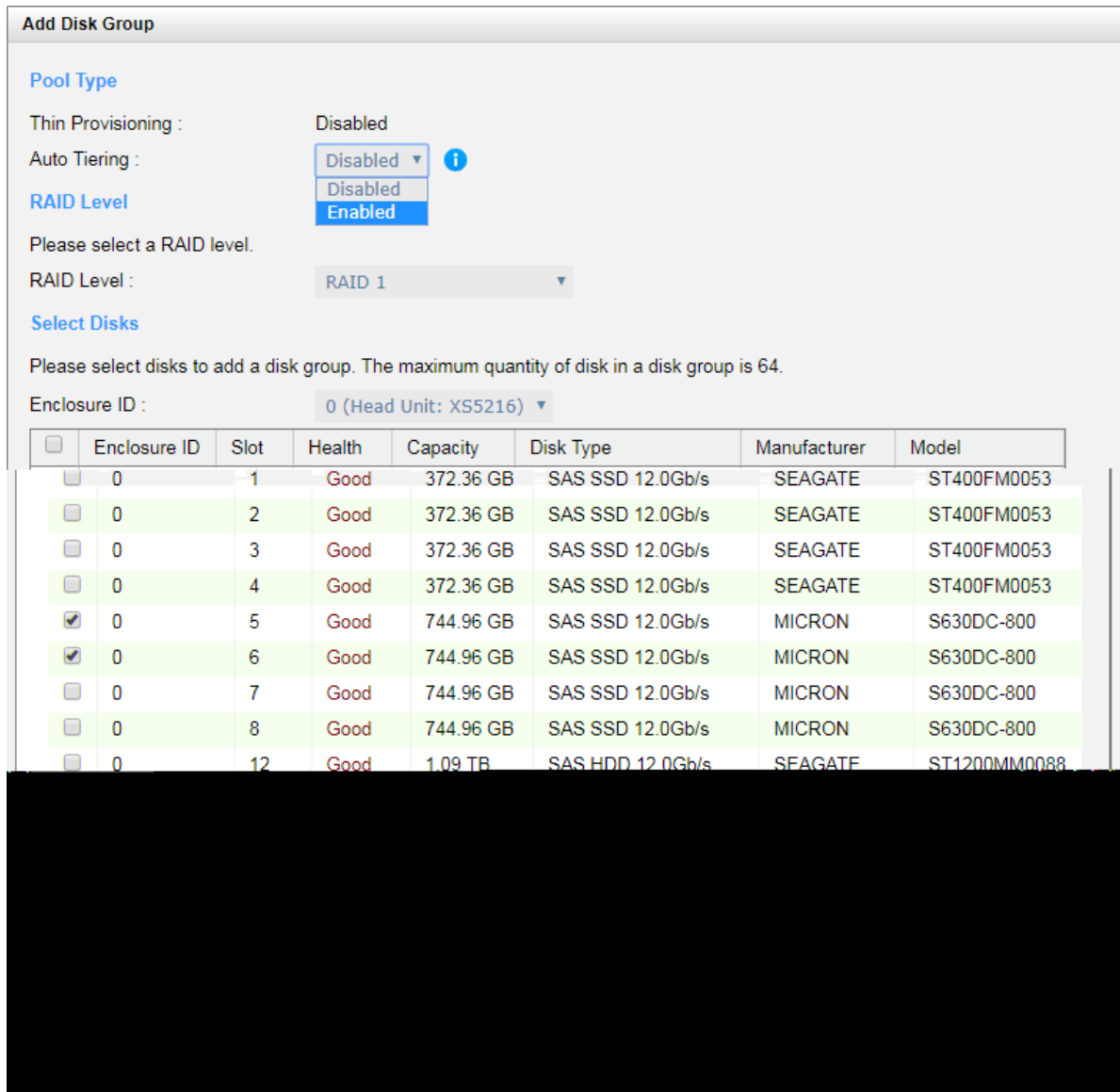


Figure 29 Transfer Thick Provisioning Pool to Auto Tiering Step 2

- Use the same procedure to add another tier if necessary.

	Pool Name	Status	Health	Total	Free	Available	Thin Provisioning	Auto Tiering	Volumes	Current Controller
▼	Pool-1	Online	Good	2.18 TB	2.18 TB	2.18 TB	Disabled	Enabled	0	Controller 1
▼	Pool-2	Online	Good	10.92 TB	10.92 TB	10.92 TB	Enabled	Disabled	0	Controller 1

Disk Groups

	No.	Status	Health	Total	Free	Tier Level	Disks Used	RAID
▼	1	Online	Good	2.18 TB	2.18 TB	SAS	3	RAID 5
▼	2	Online	Good	744.00 GB	744.00 GB	SSD	2	RAID 1

Disks

Enclosure ID	Slot	Status	Health	Capacity	Disk Type	Manufacturer	Model
0	5	Online	Good	744.96 GB	SAS SSD 12.0Gb/s	MICRON	S630DC-800
0	6	Online	Good	744.96 GB	SAS SSD 12.0Gb/s	MICRON	S630DC-800

Create Pool

Figure 30 Transfer Thick Provisioning Pool to Auto Tiering Step 3

- Auto Tiering status is Enabled. The thick provisioning pool has been transferred to auto tiering.



TIP:

The total capacity of the pool does not change even adding the capacity of higher tiers.



CAUTION:

The action of transferring from the thick provisioning pool to auto tiering is irreversible. Please consider carefully all possible consequences before taking this step.

Transfer from Thin Provisioning Pool to Auto Tiering

First of all, make sure the auto tiering license is enabled. For more information about enabling license operation, please refer to the [Enable Auto Tiering License](#) section. And then use **Add Disk Group** function to add another tier (disk group). Here is an example of transfer thin provisioning pool to auto tiering one.

- Create a thin provisioning pool with NL-SAS disk drives. Auto Tiering status is Disabled.

	Pool Name	Status	Health	Total	Free	Available	Thin Provisioning	Auto Tiering	Volumes	Current Controller
▼	Pool-1	Online	Good	2.18 TB	2.18 TB	2.18 TB	Disabled	Enabled	0	Controller 1
▼	Pool-2	Online	Good	10.92 TB	10.92 TB	10.92 TB	Enabled	Disabled	0	Controller 1

Disk Groups

No.	Status	Health	Total	Free	Disks Used	RAID
1	Online	Good	10.92 TB	10.92 TB	3	RAID 5

Disks

Type	Manufacturer	Model	Enclosure ID	Slot	Status	Health	Capacity	Disk
AS HDD 12.0Gb/s	SEAGATE	ST6000NM0014	0	13	Online	Good	5.46 TB	NL-S
AS HDD 12.0Gb/s	SEAGATE	ST6000NM0014	0	14	Online	Good	5.46 TB	NL-S
AS HDD 12.0Gb/s	SEAGATE	ST6000NM0014	0	15	Online	Good	5.46 TB	NL-S

Create Pool

Figure 31 Transfer Thin Provisioning Pool to Auto Tiering Step 1

- Click ▼ -> Add Disk Group to transfer from a thin provisioning pool to an auto tiering pool. Select Enabled from the Auto Tiering drop-down list. The tier (disk group) must be added one at a time. Select the RAID Level and Select Disks, and then click the OK button.

	Pool Name	Status	Health	Total	Free	Available	Thin Provisioning	Auto Tiering	Volumes	Current Controller
▼	Pool-1	Online	Good	2.18 TB	2.18 TB	2.18 TB	Disabled	Enabled	0	Controller 1
▼	Pool-2	Online	Good	11.64 TB	11.64 TB	11.64 TB	Enabled	Enabled	0	Controller 1

Disk Groups

	No.	Status	Health	Total	Free	Tier Level	Disks Used	RAID
▼	1	Online	Good	10.92 TB	10.92 TB	NL-SAS	3	RAID 5
▼	2	Online	Good	744.00 GB	744.00 GB	SSD	2	RAID 1

Disks

Enclosure ID	Slot	Status	Health	Capacity	Disk Type	Manufacturer	Model
0	7	Online	Good	744.96 GB	SAS SSD 12.0Gb/s	MICRON	S630DC-800
0	8	Online	Good	744.96 GB	SAS SSD 12.0Gb/s	MICRON	S630DC-800

Create Pool

Figure 33 Transfer Thin Provisioning Pool to Auto Tiering Step 3

- Auto Tiering status is Enabled. The thin provisioning pool has been transferred to auto tiering.



TIP:

The total capacity of the pool is the sum of all tiers.



CAUTION:

The action of transferring from the thin provisioning pool to auto tiering is irreversible. Please consider carefully all possible consequences before taking this step.

SSD Cache vs. Auto Tiering

The SSD cache and auto tiering solutions can work together and compliment each other. A key difference between tiering and cache is that tiering moves data to SSD instead of simply caching it. Tiering can also move data both from slower storage to faster storage and vice versa. However, SSD cache is essentially a one-way transaction. When the cache is done with the data it was accelerating it simply nullifies it instead of copying it back to HDD. The important difference between moves and copies is that a cache does not need to have the

Best Practice

Auto tiering technology provides a solution to achieve optimal storage efficiency and improved performance, making it the most cost effective storage solution for data center environments with dynamic workload changes.

If your applications are belongs to sequential I/O from beginning to end, such as surveillance or backup, or their access profiles are very random in the large address range, a homogeneous pool is recommended for your applications. In a homogeneous pool, only one drive type (SSD, SAS, or NL-SAS) is selected during pool creation. If using auto tiering technology in these applications, the data will move up and down frequently without any benefit.



TIP:

Homogeneous pool is suitable for the application of sequential I/O from beginning to end or very random in the large address range. In addition, auto tiering is suitable for the data which has a lifecycle.

Configuration Planning Advice

SSD / SAS / NL-SAS Tier RAID Level and Capacity Ratio

The following is a general guide to the auto tiering pool planning. The user can fine-tune according to the actual situation.

- SSD Tier (\$\$\$)

Suggest SSD tier using at least 4 disks with RAID 10 (better) or 2 disks with RAID 1 for extreme performance. Prepare SSD storage capacity in 10% to 15% of the total pool capacity to fulfill the requirements of critical high I/O applications.

- SAS Tier (\$\$)

Suggest SAS HDD tier configuring with RAID 6 (better) or RAID 5. Prepare about 30% of the total storage capacity.

- NL-SAS Tier (\$)

For capacity tier, suggest NL-SAS HDD using RAID 5 level to store cold data. This tier occupies the rest of the storage capacity.

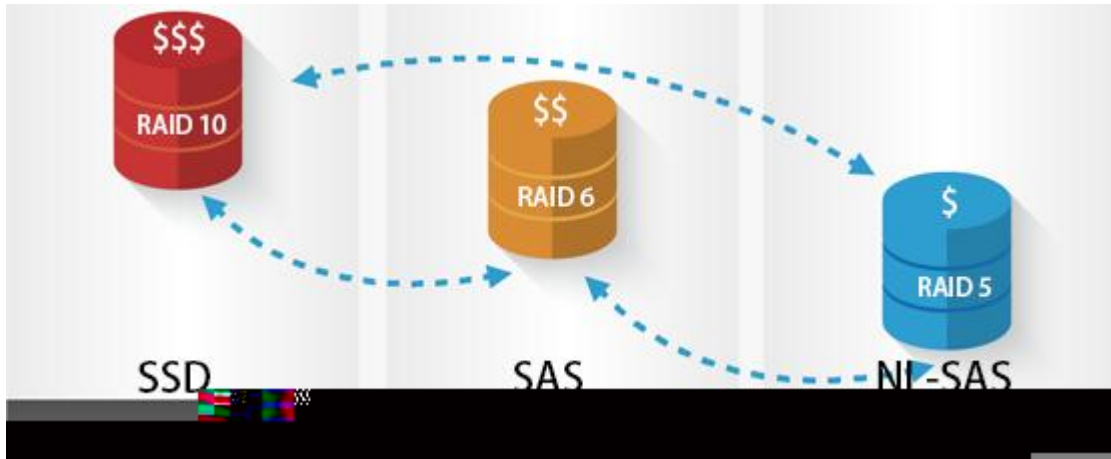


Figure 35 Best Practice of Auto Tiering

Take an example for reference. First, you can estimate the total capacity used, and estimate how much hot data or high I/O your application uses every day. Assuming 666GB per day, the recommended SSD tier capacity is at least 1.5 times, $1.5 \times 666\text{GB} = 1\text{TB}$, as a conservative estimate. Then, calculate the SAS HDD tier capacity about 3 times of the SSD tier capacity, $3 \times 1\text{TB} = 3\text{TB}$, as if the SSD tier full of the buffer, so that the performance does not drop too much. This tier is optional. The remaining space is left for NL-SAS HDD tier. The following table is the summary for reference.

Table 8 Tier RAID Level and Capacity Ratio

Tier	Capacity per Drive	Quantity	RAID Level	Capacity per Tier	Capacity Ratio
SAS SSD Tier	500GB	4	RAID 10	$(4/2) \times 500\text{GB} = 1\text{TB}$	10%
SAS HDD Tier	1TB	5	RAID 6	$(5-2) \times 1\text{TB} = 3\text{TB}$	30%
NL-SAS HDD Tier	3TB	3	RAID 5	$(3-1) \times 3\text{TB} = 6\text{TB}$	60%

This is a rough planning proposal. Whether to meet customer requirements also requires users to calculate the performance and necessary capacity. Of course, if more capacity is needed, you can also add a disk group to any tier.

Relocation and Its Effect

In the [Intelligent Auto Tiering Mechanism](#) section, we introduce there are three major functions in auto tiering technology. Statistics collection and ranking operate automatically, but relocation can be configurable manually. We would like to suggest that users can set the schedule relocation at midnight every day (Daily 00:00), the relocation period sets to 8

7. After an hour, the system analyzes the data automatically, and the data will be relocated at midnight. The figure shows that 18GB data in SSD tier will be moved down to the SAS tier.

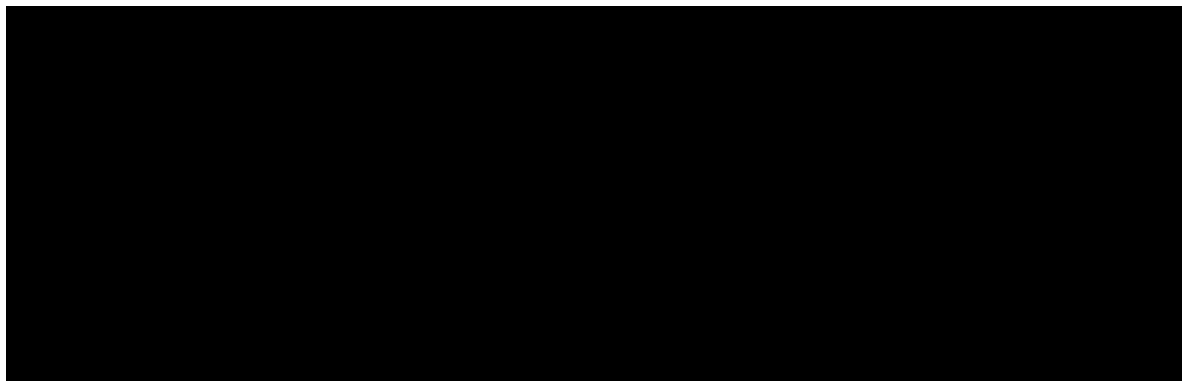


Figure 43 Statistic Collection and Ranking

8. At the next day, 18GB data in SSD tier has been moved down to the SAS tier. And the event log records how much data is moved. You can see that SSD tier reserved about 10% of the capacity for incoming data.



Figure 44 Complete Relocation

9. Continue copying the third 100GB file into the volume. It spends 3 minutes and 8 seconds to complete. The transmission speed is around 460 ~ 500 MB/s. The file is copied to the SAS tier.

- Last, copy the first file back to the source volume and observe the transmission speed. You can also compare the performance monitor of disks in the web UI and observe which tier the data is located.

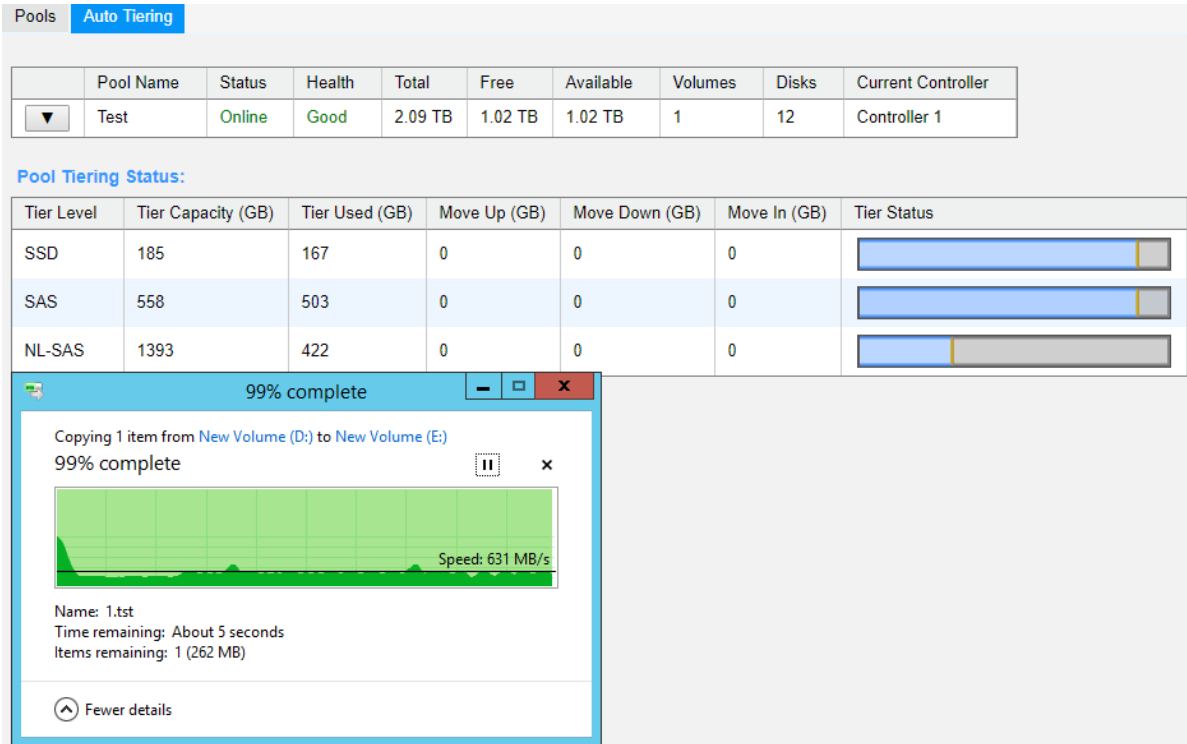


Figure 50 Test the Performance

Summary

In case 1, the data locates at the SSD tier first because we set the auto-tiering policy as Start Highest then Auto Tiering. When user edits a new video, the video remains at the SSD tier and performs extreme performance. After the editing is complete, the video moves to the HDD tier and leaves the space for the next video. The scenario meets the expectations of video editing.

Case 2: VMware

We simulate 8 VMs (Virtual Machines) running on a server, assume that they have different I/O queue depths and possess intensive I/O flows. We recommend setting the auto-tiering policy as Auto Tiering. After working a while, we assume that the data with heavy I/O will be relocated to the higher tier for better performance.

Test Equipments and Configurations

- Server
 - Model: ASUS RS700-E6/PS4 (CPU: Intel Xeon E2620 2.0GHz / RAM: 20GB)
10GbE HBA: Intel Ethernet CNA X710-DA4 FH
OS: VMware ESXi 6.5
- Storage
 - Model: QSAN XCubeSAN XS3224
Memory: 8GB (2 x 4GB in bank 1 & 3) per controller
Firmware 1.2.1
SAS SSD: 4 x HGST Ultrastar SSD800MH.B, HUSMH8010BSS200, 100GB, SAS 12Gb/s
SAS HDD: 4 x HGST Ultrastar C15K600, HUC156030CS4200, 300GB, SAS 12Gb/s
NL-SAS HDD: 4 x Seagate Constellation ES.3, ST1000NM0023, 1TB, SAS 6Gb/s
 - Auto Tiering Pool: 3.45TB
SSD Tier: RAID 10 with 4 x SAS SSD, 185GB
SAS Tier: RAID 6 with 4 x SAS HDD, 558GB
NL-SAS Tier: RAID 5 with 4 x NL-SAS SSD, 2.73TB
 - Volume: 1 x 3.45TB in Auto Tiering Pool, 8 x VMs in the Volume
 - Auto Tiering Policy: **Auto Tiering**
- I/O Pattern
 - Tool: IOmeter V1.1.0
 - Workers: 1
 - Access Specifications:
 - VM1: 256KB, 100% Write, 100% Random, Outstanding 128, Maximum Disk Size 10GB
 - VM2: 256KB, 100% Write, 100% Random, Outstanding 16, Maximum Disk Size 20GB
 - VM3: 256KB, 100% Write, 100% Random, Outstanding 32, Maximum Disk Size 10GB
 - VM4: 256KB, 100% Write, 100% Random, Outstanding 48, Maximum Disk Size 20GB
 - VM5: 256KB, 100% Write, 100% Random, Outstanding 64, Maximum Disk Size 10GB
 - VM6: 256KB, 100% Write, 100% Random, Outstanding 80, Maximum Disk Size 20GB
 - VM7: 256KB, 100% Write, 100% Random, Outstanding 96, Maximum Disk Size 10GB
 - VM8: 256KB, 100% Write, 100% Random, Outstanding 112, Maximum Disk Size 20GB

Test Scenario and Result

1. Create an auto tiering pool with the following configurations.
 - Auto Tiering Pool: 3.45TB

SSD Tier: RAID 10 with 4 x SAS SSD, 185GB
 SAS Tier: RAID 6 with 4 x SAS HDD, 558GB
 NL-SAS Tier: RAID 5 with 4 x NL-SAS SSD, 2.73TB

Pools		Auto Tiering						
	Pool Name	Status	Health	Total	Free	Available	Thin Provisioning	Auto Tiering
▼	test	Online	Good	3.45 TB	3.10 TB	3.10 TB	Enabled	Enabled

Disk Groups								
	No.	Status	Health	Total	Free	Tier Level	Disks Used	RAID
▼	1	Online	Good	2.73 TB	2.73 TB	NL-SAS	4	RAID 5
▼	2	Online	Good	558.00 GB	558.00 GB	SAS	4	RAID 6
▼	3	Online	Good	185.00 GB	185.00 GB	SSD	4	RAID 10

Create Pool

Figure 51 Create an Auto Tiering Pool

2. Create a volume of the capacity 3.45TB, and sets the tiering policy as Auto Tiering.

Create Volume

General
 Advanced
 Summary

Volume Advanced Settings

Please configure the volume advanced settings.

Block Size : 512 Byte

Priority : High

The priority is the comparison with the other volumes.

Background I/O Priority : High

Background I/O priority will influence volume initialization, rebuild, and migration.

Tiering Policy : Auto Tiering

Enable Cache Mode (V) Write back optimizes the short time interval. risk which the data may be inconsistent between the cache and disks in

Enable Video Editing Mode

Enable Read-ahead The system will identify what is needed next, based on the content just retrieved from the disk, and then preload the data into the disk's buffer. When the data to be transmitted is continuous, this feature will improve performance.

Enable Space Reclamation

Cancel Back Next

Figure 52 Create a Volume and Set the Tiering Policy as Auto Tiering

- VM2: 256KB, 100% Write, 100% Random, Outstanding 16, Maximum Disk Size 20GB, the throughput is 4.78 MB/s
- VM3: 256KB, 100% Write, 100% Random, Outstanding 32, Maximum Disk Size 10GB, the throughput is 4.41 MB/s
- VM4: 256KB, 100% Write, 100% Random, Outstanding 48, Maximum Disk Size 20GB, the throughput is 4.13 MB/s
- VM5: 256KB, 100% Write, 100% Random, Outstanding 64, Maximum Disk Size 10GB, the throughput is 3.98 MB/s
- VM6: 256KB, 100% Write, 100% Random, Outstanding 80, Maximum Disk Size 20GB, the throughput is 3.79 MB/s
- VM7: 256KB, 100% Write, 100% Random, Outstanding 96, Maximum Disk Size 10GB, the throughput is 3.70 MB/s
- VM8: 256KB, 100% Write, 100% Random, Outstanding 112, Maximum Disk Size 20GB, the throughput is 3.61 MB/s

5. Stop VM2~VM8 I/O but keep VM1 running I/O, the throughput of VM1 is up to 40.98 MB/s.

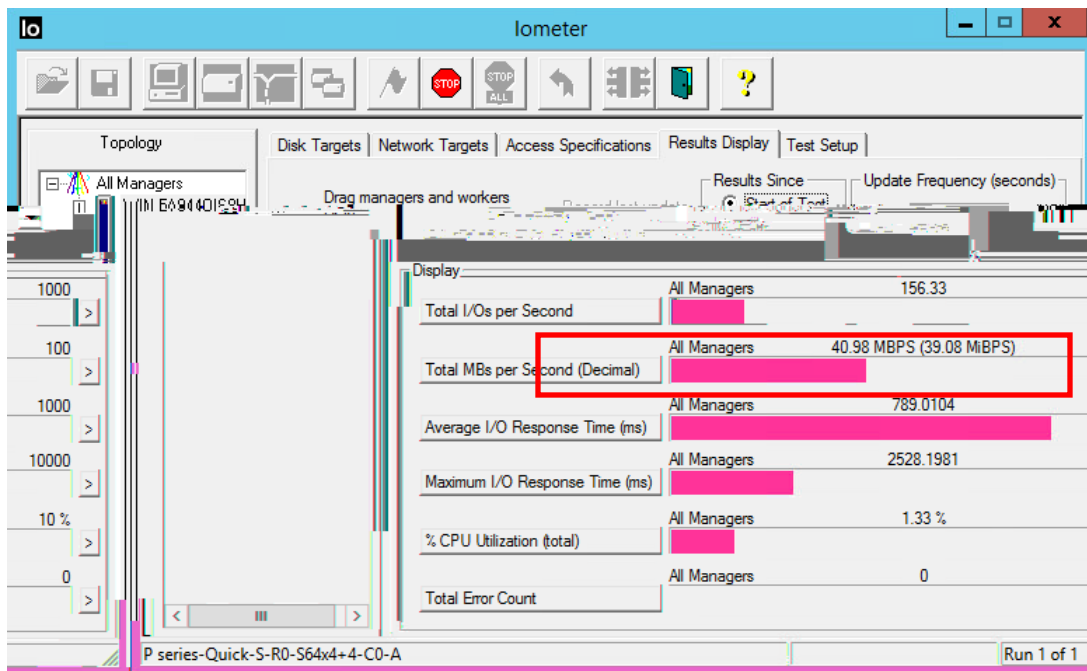


Figure 55 Throughput of VM1 when Stop VM2~VM8 I/O

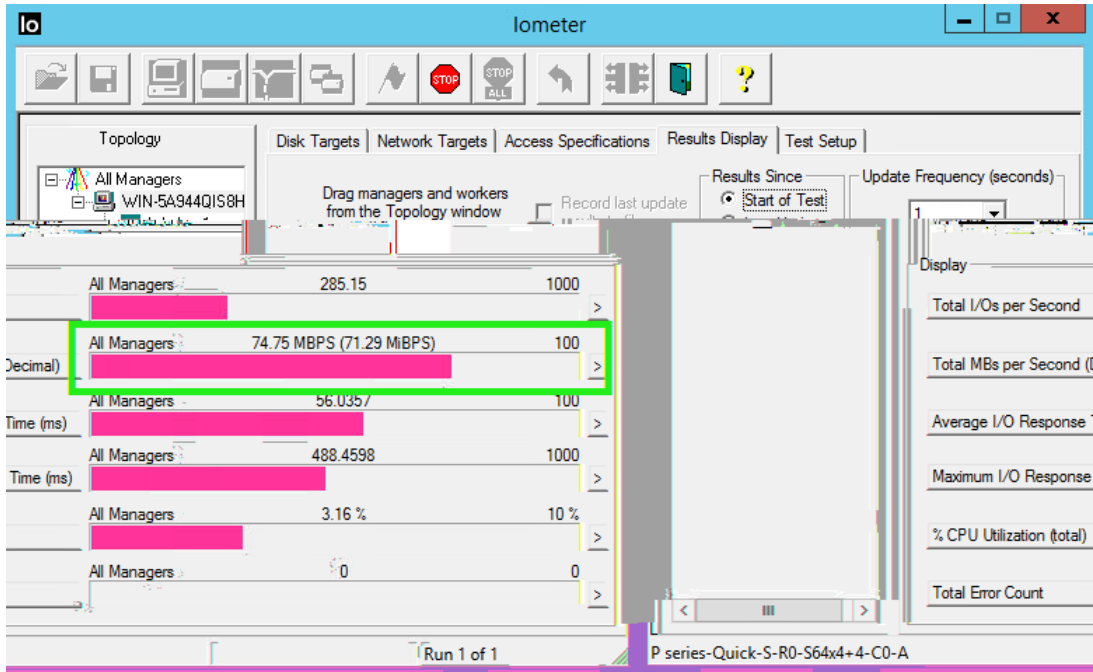


Figure 57 Throughput of VM2

- VM3: 256KB, 100% Write, 100% Random, Outstanding 32, Maximum Disk Size 10GB, the throughput is 68.78 MB/s
- VM4: 256KB, 100% Write, 100% Random, Outstanding 48, Maximum Disk Size 20GB, the throughput is 63.59 MB/s
- VM5: 256KB, 100% Write, 100% Random, Outstanding 64, Maximum Disk Size 10GB, the throughput is 60.03 MB/s
- VM6: 256KB, 100% Write, 100% Random, Outstanding 80, Maximum Disk Size 20GB, the throughput is 57.12 MB/s
- VM7: 256KB, 100% Write, 100% Random, Outstanding 96, Maximum Disk Size 10GB, the throughput is 54.90 MB/s
- VM8: 256KB, 100% Write, 100% Random, Outstanding 112, Maximum Disk Size 20GB, the throughput is 54.18 MB/s

Summary

In case 2, although the auto-tiering policy sets to Auto Tiering, the data is allocated in the tier which is healthier and has more free capacity than other tiers at the beginning. Then the data with frequently accessed I/O will be relocated to the higher tier for better performance. The following table summarizes the throughput before and after the relocation and an improvement percentage calculation as a reference. This verifies the scenario and meets the expectations of VMware.

Pools **Auto Tiering**

	Pool Name	Status	Health	Total	Free	Available	Volumes	Disks	Current Controller
▼	Teat	Online	Good	2.09 TB	2.04 TB	2.04 TB	1	12	Controller 1

Pool Tiering Status:

Tier Level	Tier Capacity (GB)	Tier Used (GB)	Move Up (GB)	Move Down (GB)	Move In (GB)	Tier Status
SSD	185	0	0	0	52	
SAS	557	0	0	0	0	
NL-SAS	1395	52	52	0	0	

Relocate Now

Pool Name: **Teat**

Relocation Period (hh:mm): 00 : 00 (Set as 00:00 to let relocation process run until it finishes.)

Relocation Rate: **Medium**

OK Cancel

Figure 63 Execute Relocation Now Manually

6. The relocation completes. The data has been moved to the SSD tier.



Figure 64 Complete Relocation

Conclusion

With auto tiering technology, the XCubeSAN series can help you put the right data in the right place at the right time for optimal use of all storage tiers and allow you to reduce storage costs and management overhead while increasing performance and capacity.

Intelligent algorithm behind auto tiering manages the data relocation and monitors the data hotness ratio using half-life coefficient and advanced ranking mathematics. Relocations can occur on the user-defined relocation schedule, making auto tiering a truly automated offering.

Apply To

- XCubeSAN XS5200 / XS3200 / XS1200 FW 1.2.0 and later

Reference

- SSD Cache 2.0 White Paper
- [SSD Cache 2.0 White Paper](#)

Appendix

Related Documents

There are related documents which can be downloaded from the website.

- [All XCubeSAN Documents](#)
- [XCubeSAN QIG \(Quick Installation Guide\)](#)
- [XCubeSAN Hardware Owner's Manual](#)
- [XCubeSAN Configuration Worksheet](#)
- [XCubeSAN SANOS 4.0 User's Manual](#)
- [Compatibility Matrix](#)
- [White Papers](#)
- [Application Notes](#)

Technical Support

Do you have any questions or need help trouble-shooting a problem? Please contact QSAN Support, we will reply to you as soon as possible.

- Via the Web: <https://qsan.com/support>
- Via Telephone: +886-2-7720-2118 extension 136
(Service hours: 09:30 - 18:00, Monday - Friday, UTC+8)
- Via Skype Chat, Skype ID: qsan.support
(Service hours: 09:30 - 02:00, Monday - Friday, UTC+8, Summer time: 09:30 - 01:00)
- Via Email: support@qsan.com