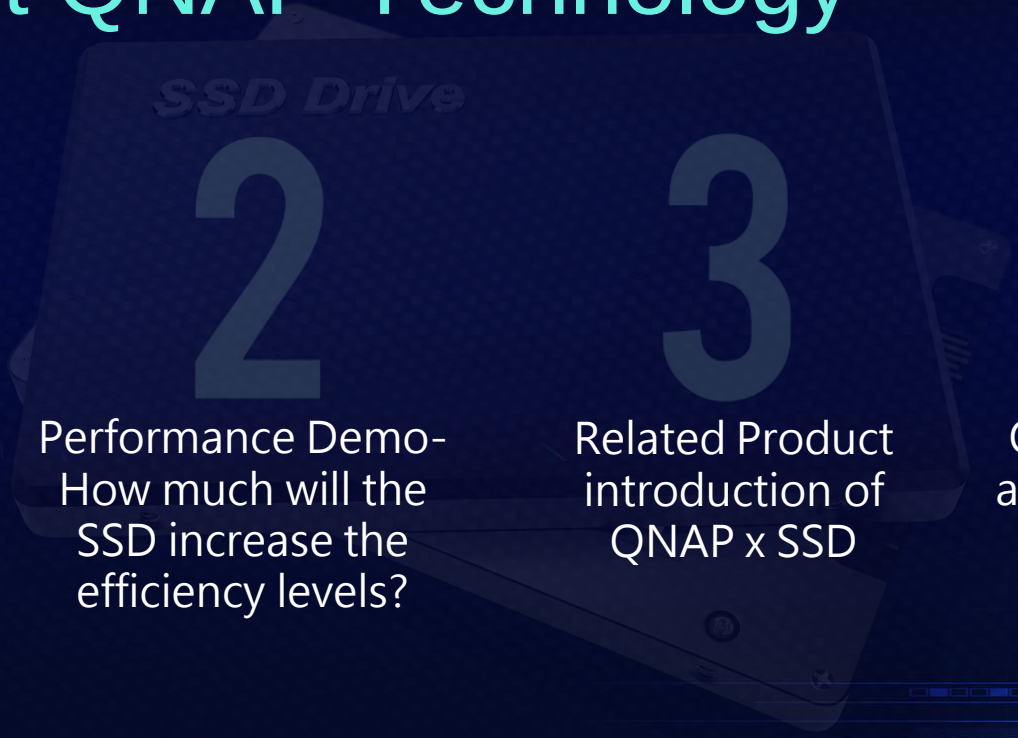
QNAP

SSD

TECHNOLOGY & APPLICATIONS EXPLAINED

QNAP SSD Application

All about QNAP Technology



1. Introduction of SSDs
2. Performance Demo- How much will the SSD increase the efficiency levels?
3. Related Product introduction of QNAP x SSD
4. QNAP Specific SSD application software

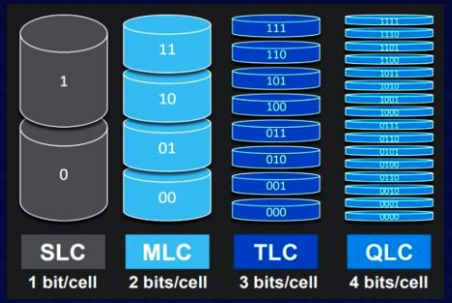
There Are So Many Different SSDs On The Market

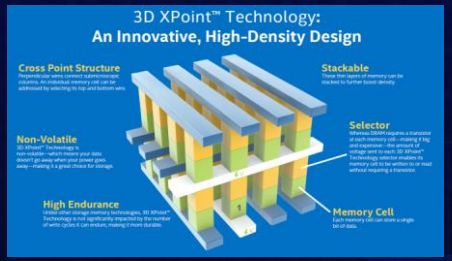
How to choose the right SSD for my application?

SSD NAND Flash Types

SSDs are evolving to store more data.

NAND Flash	Single Level Cell (SLC)	Multi Level Cell (MLC)	Triple Level Cell (TLC)	Quad Level Cell (QLC)
Read/Write Cycles	90,000 – 100,000	8,000 – 10,000	500 - 1000	1000
Bit Per Cell	1	2	3	4
Capacity	★	★★	★★★	★★★★
Writing Speed	★★★★	★★★	★★	★★
Endurance	★★★★	★★★	★★	★★
Cost	★★★★	★★★	★★	★





https://www.anandtech.com/show/12136/the-intel-optane-ssd-900p-480gb-review/5

https://www.kamshin.com/2018/11/what-future-for-intel-optane/

SSD Evolution Trend

Since the SSD already has a high performance, the SATA Port and AHCI Interface still post a limitation to the SSD.

The NVMe Interface, PCIe, M.2, U.2 SSD, and latest technologies such as SSD Over-provisioning and Intel® Optane™ are all continuously contributing to the SSD evolution.

Type	SATA 3	M.2	U.2	PCIe
Speed	6Gbps	10/32Gbps	32Gbps	20/32Gbps
IOPS	60,000	100,000	300,000	1,000,000
Interface	AHCI	NVMe	NVMe	NVMe

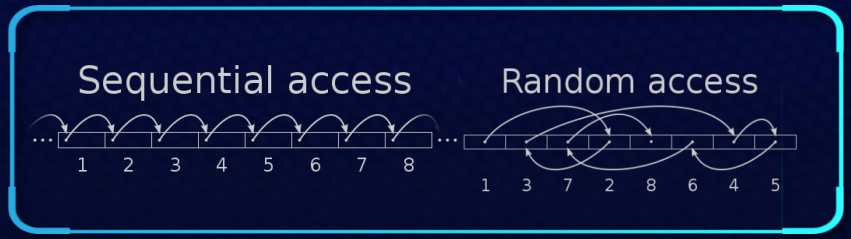
2.5 inch	M.2	PCIe card
SATA	SATA	NVMe
NVMe (U.2)	NVMe	

IOPS performance is measured through general marketing survey
http://www.2cm.com.tw/2cm/zh-tw/magazine/-MarketTrend/F26FE52365E548DFB150B39173AED7D3
https://www.xfastest.com/thread-167519-1-1.html

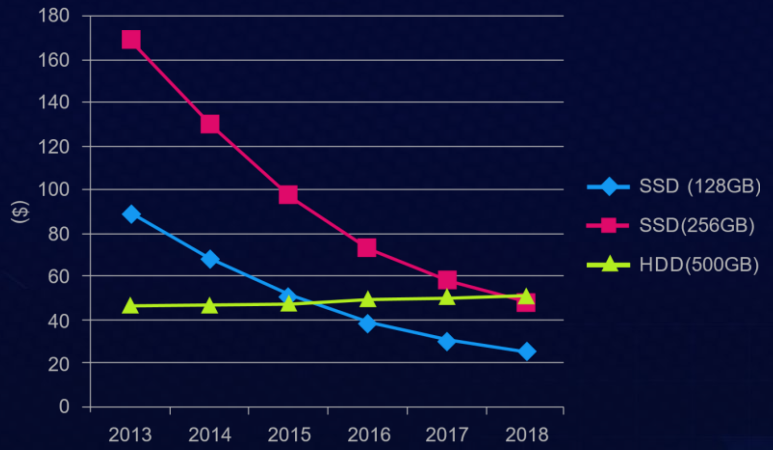
SSD Evolution Trend

As the SSD price keeps falling, smaller SSDs that have been purchased in the past can be replaced with larger SSD.

Disk Type	SW (MB/s)	RW (IOPS)
HDD	100	350
SSD	300	60000



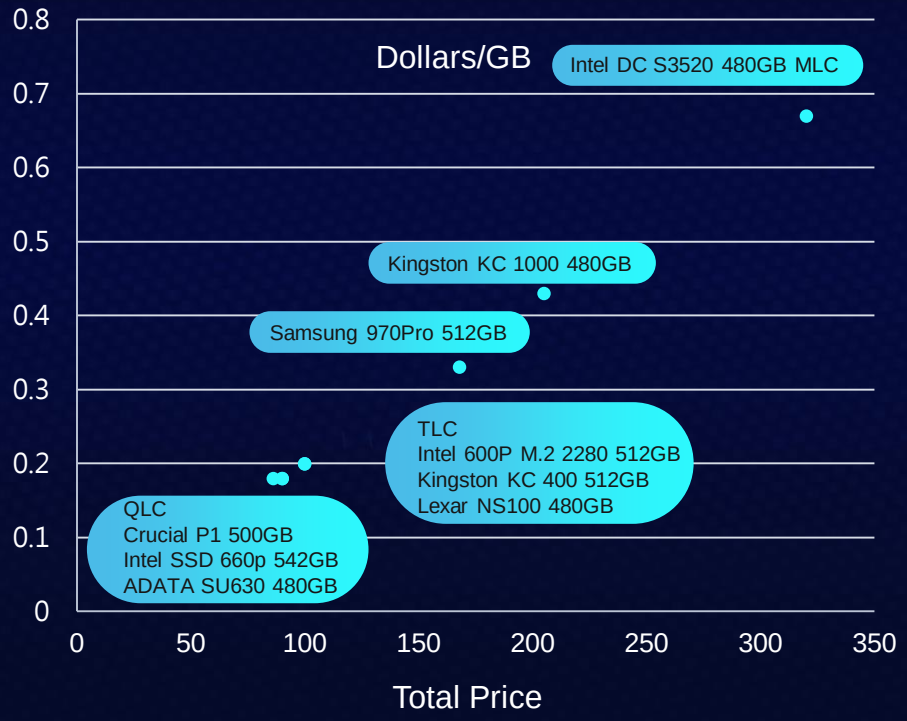
With modern applications it is required higher storage performance, SSD is becoming more popular and is being widely used.



https://www.sandisk.com/business/datacenter/resources/white-papers/the-ssd-enabled-pc-total-cost-of-ownership

SSD Cost Per GB

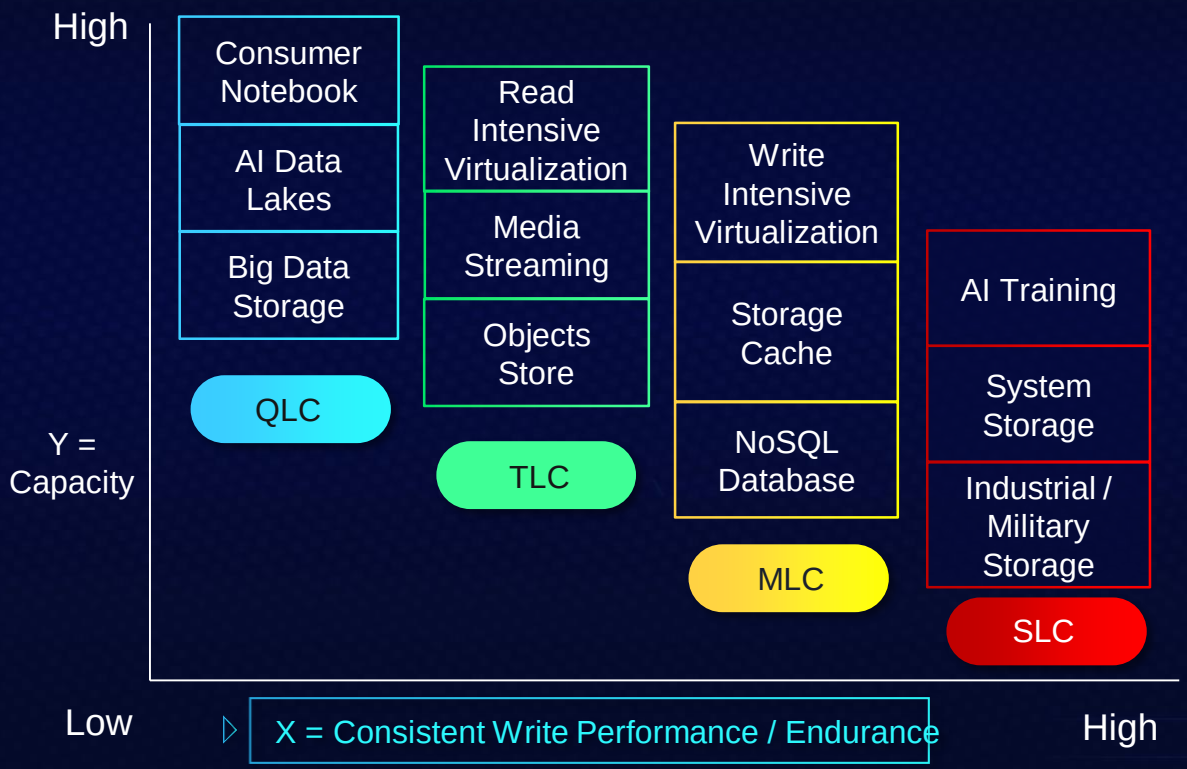
But even the same SSD type, price can have major difference.



SSD Type	Price Range
MLC	~50%
TLC/QLC	~40%

What has caused these different price levels on SSDs?

SSD Selection Based on Workload



To select the SSD, you need to understand your workload!

SSD Application

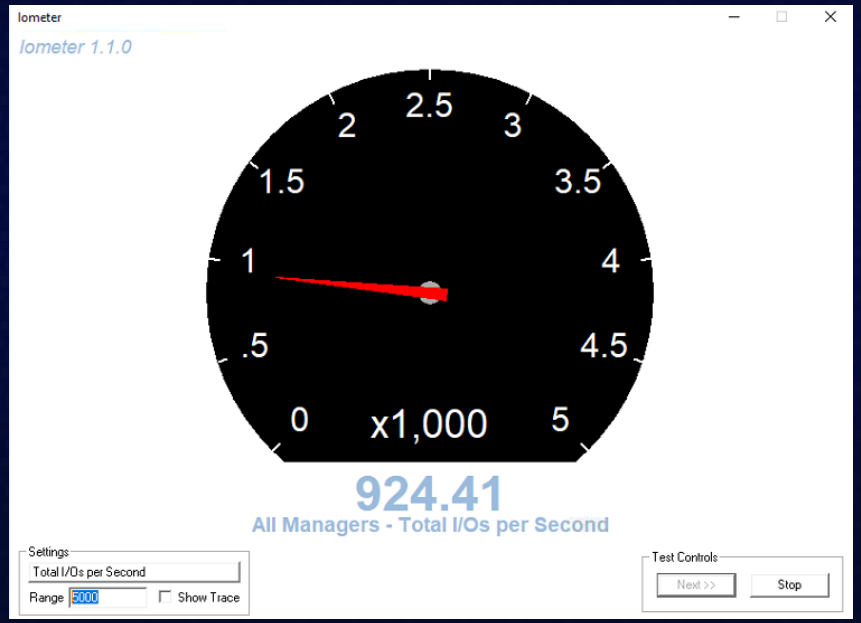
QNAP Is Better Than the Competition

SSD Application		QNAP QTS 4.4.1	Synology DSM 6.2.2
SSD External Over-Provisioning		Yes with Profiling Tool	None
Auto Tiering		Qtier：Auto tiering, Particular unit/LUN, Rebuilding Qtier	None
SSD Cache	Cache	3 types：Read-Only, Write-only, Read and Write	2 types ：Read-Only, Write-only
	Global Settings	Support more than a volume /LUN at the same time	Every SSD Cache only supports one storage space
	Replace Online	No interruption of storage services	Need to suspend the storage service
SSD Management	Health Monitor Tool	Yes	Yes
	Reliability Monitoring	Yes	No
	Supported List Information	Yes	No
	SED encrypting drives	Support Samsung SSD	No
Hardware device	Built-in support	M.2 SATA、M.2 NVMe、U.2 NVMe	NVMe
	PCIe SSD Card	2~4 ports SATA/NVMe、Support 10GbE 、Maximum PCIe Gen 3 x 8	2 ports SATA/NVMe、Support 10GbE Only PCIe 2.0 x 8
	SATA drive bay	Yes, Use two 2.5-inch SATA drives、1-2 M.2 NVMe To U.2 NVMe	No

The Difference Between Using SSD And Not Using SSD

Not Using SSD Cache

Using IOMeter to measure IOPS



Using QNAP SSD Global Cache

Using IOMeter to measure IOPS

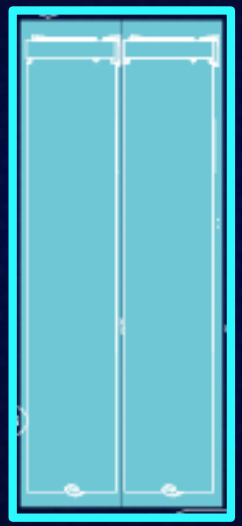
Test Config.: TS-1283XU 16G 8* Seagate 1TB RAID 5, 4* Samsung SSD RAID 10
Windows 10 i7 64G with 10GbE Ethernet SMB. 4k Random Write, 32 Workers, 4 Outstanding

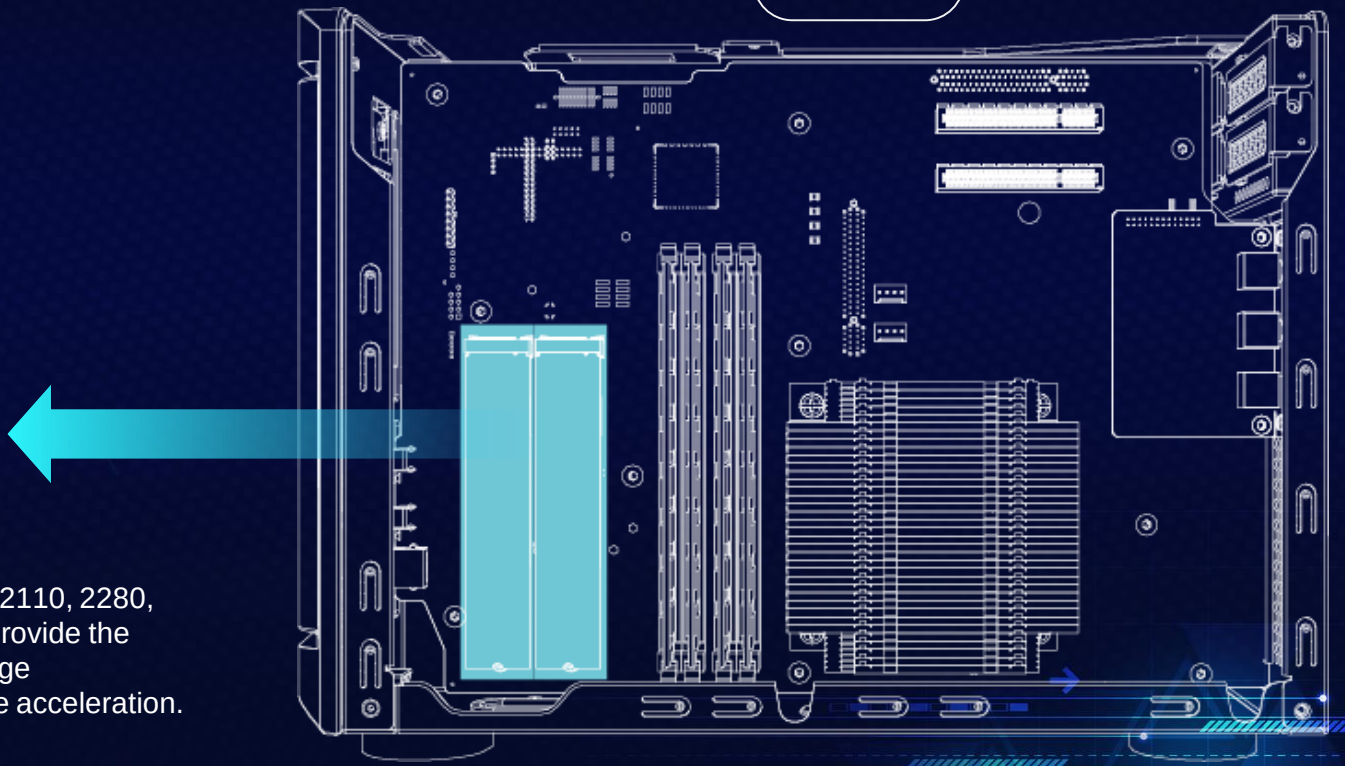
QNAP SSD

HARDWARE TECHNOLOGIES

Build-in M.2 PCIe NVMe Slot

TVS-x72XT Series, TS-x73,TS-x77

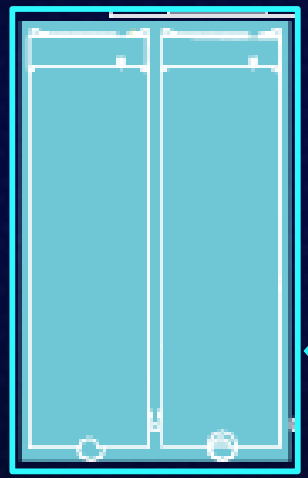


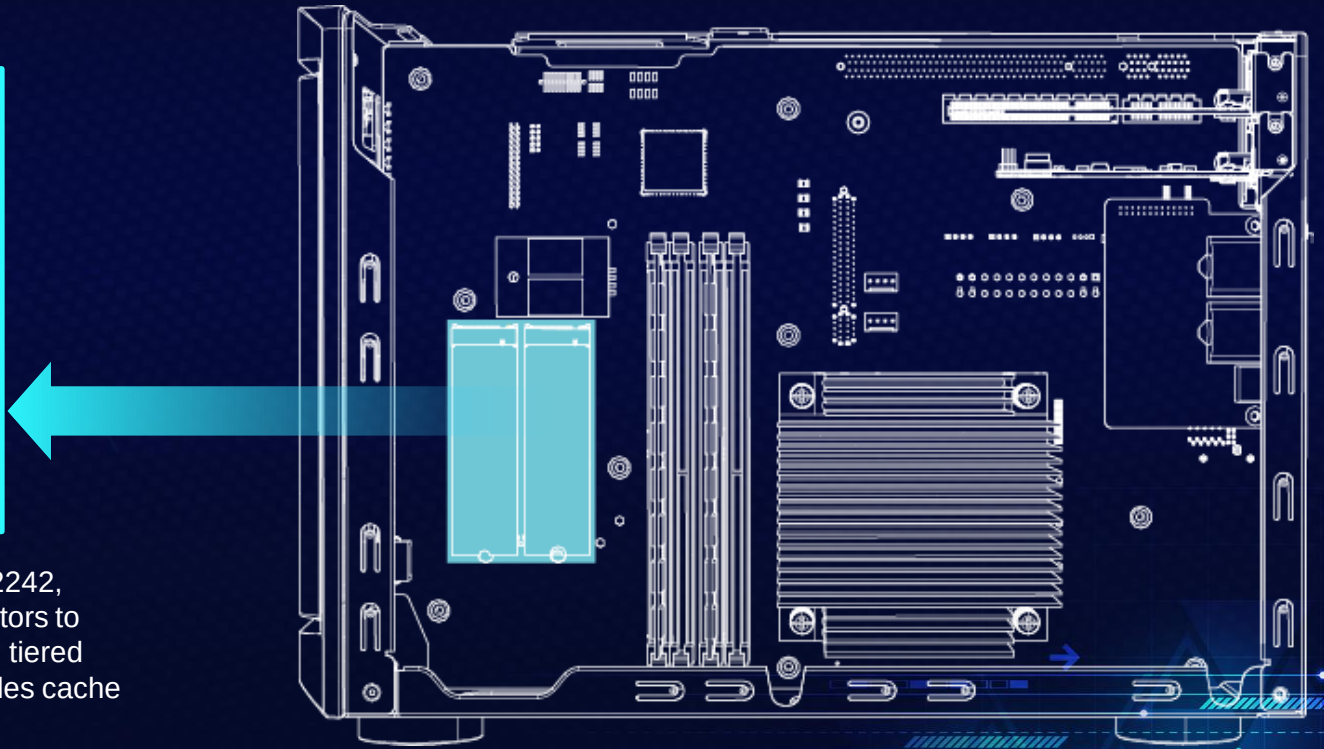


Supports SATA M.2 SSD with 22110, 2280, 2260 and 2242 form factors to provide the greatest flexibility in tiered storage configuration and enables cache acceleration.

Build-in M.2 SSD SATA Slot

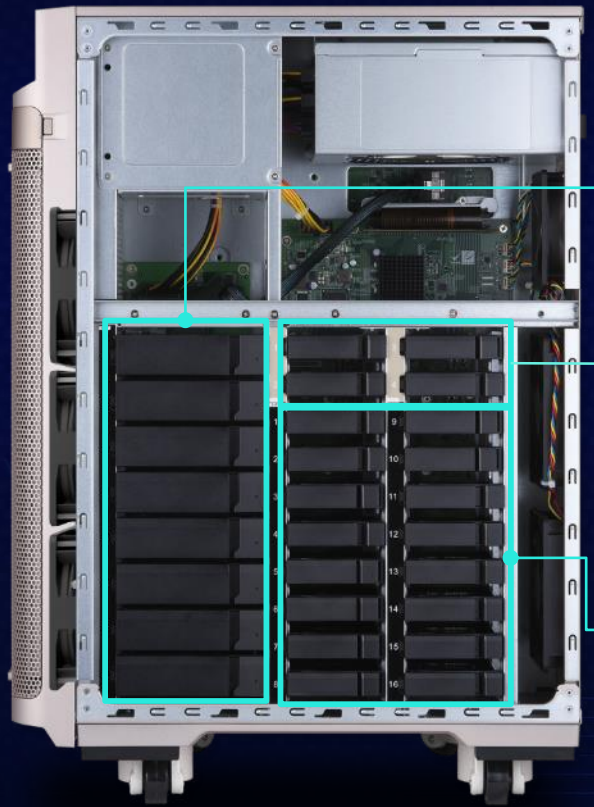
TVS-x82, TS-x73U, 453BT3, TS-1685





Supports SATA M.2 SSD with 2242, 2260, 2280 and 22110 form factors to provide the greatest flexibility in tiered storage configuration and enables cache acceleration.

Build-in U.2 PCIe NVMe Slot TS-2888X



QNAP Technology

Built-in U.2 NVMe

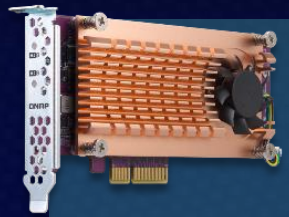
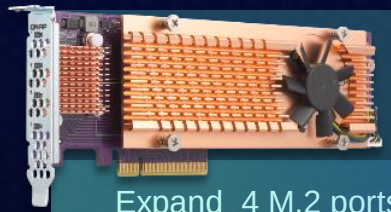
8 x 3.5” /2.5” SATA 6Gb/s HDD Slot

4 x 2.5” U.2 NVMe Gen3 x4 SSD port

Use QDA-UMP or QDA-U2MP to add up to 8 x M.2 2280 NVMe SSDs

16 x 2.5” SATA 6Gb/s SSD Slot

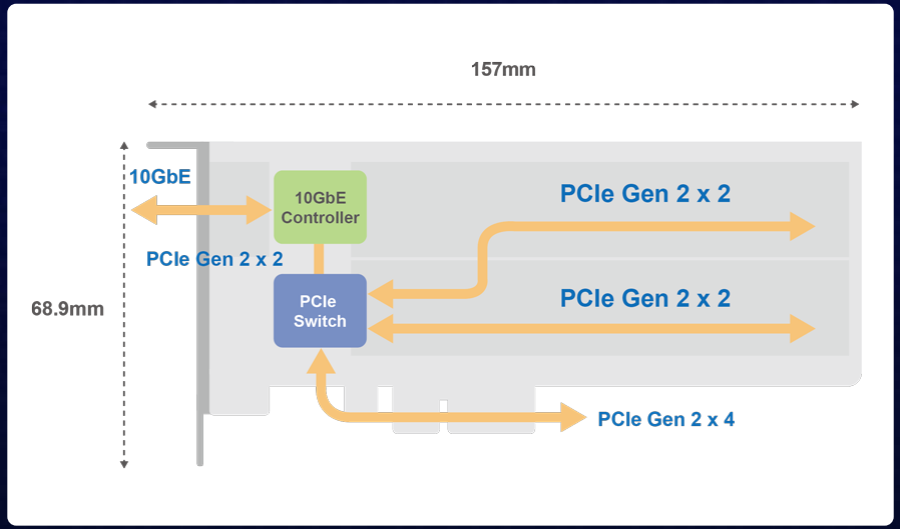
Select The QM2 Card You Need

	M.2 SATA	M.2 PCIe Gen 2	M.2 PCIe Gen 3
	QM2-2S-220A	QM2-2P-244A	QM2-2P-344 QM2-2P-384
NEW  Support 10GBASE-T port	QM2-2S10G1TA	QM2-2P10G1TA	
 Expand 4 M.2 ports	QM2-4S-240	QM2-4P-284	QM2-4P-342 QM2-4P-384

SSD cache and 10GbE in one card

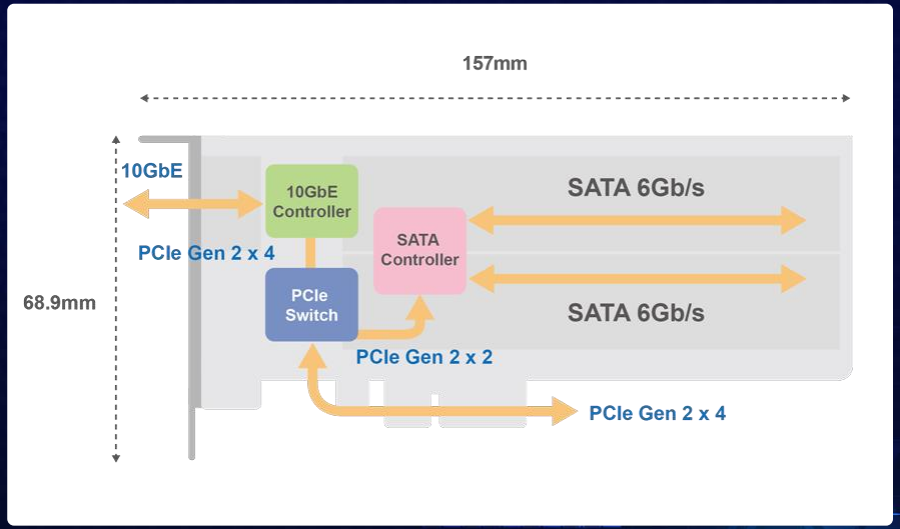
QM2-2P10G1TA

Supports maximum 2 x PCIe NVMe SSD (M-key), provides Gen2 x2 on each slot



QM2-2S10G1TA

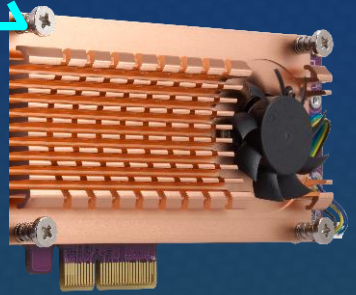
Supports maximum 2 x SATA M.2 SSD, provides 6Gb/s on each slot



3rd party operating system support

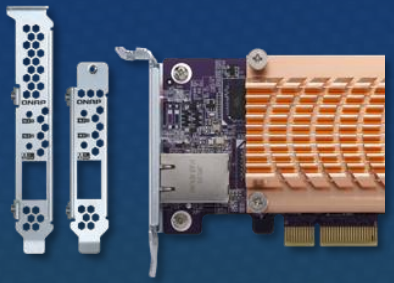
QNAP Technology

Active cooling module



Self-monitored with thermal sensors to control the speed of smart fan modules.

Compliant with PCIe standards



Low-profile PCIe add-on cards, bundled with full-height bracket.

AQC-107S

AQUANTIA

Linux & Windows
Dual platform supported

QNAP NAS don't need to install Driver, Windows/Linux platforms please visit QNAP website to download the driver

Note: M.2 SSD compatibility and function supported depends on the hardware design and platform. Please check with your motherboard manufacturer for details.

Leave the 3.5” slots for huge capacity HDDs

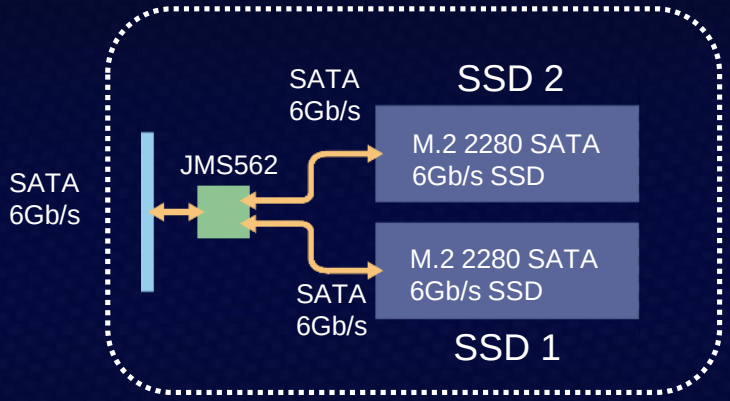
Without changing existing configurations

NAS

Freely upgrade a normal pool to a Qtier pool without starting over

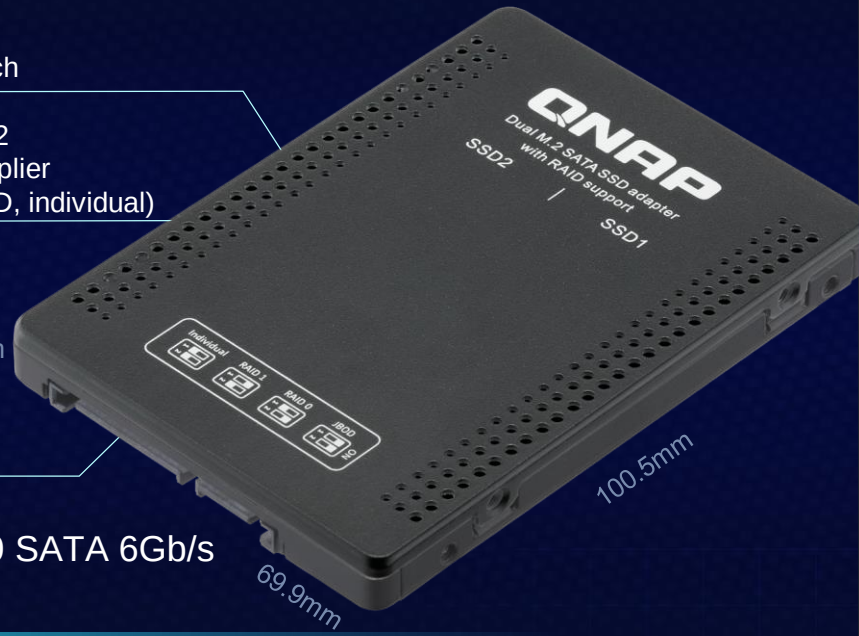
PC

2.5” SATA to dual M.2 SATA adapter QDA-A2MAR



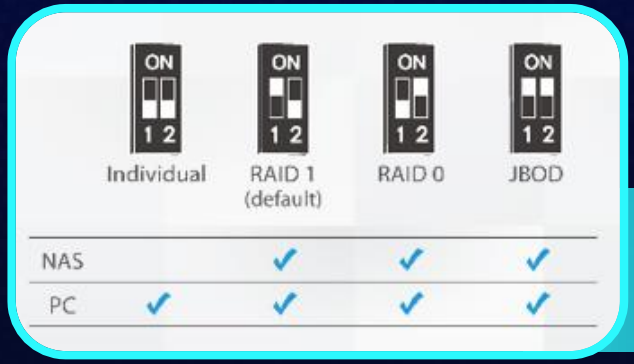
Disk mode switch

Jmicron JMS562
SATA port multiplier
(RAID 0/1, JBOD, individual)



SATA 6Gb/s

2 x M.2 2280 SATA 6Gb/s



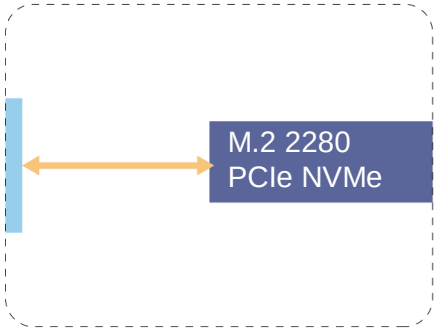
	Individual	RAID 1 (default)	RAID 0	JBOD
NAS		✓	✓	✓
PC	✓	✓	✓	✓

QDA hardware RAID disk mode switch：Creating or deleting RAID is only supported by the hardware-based disk mode switch.

U.2 NVMe to dual M.2 PCIe NVMe adapter

QDA-UMP

U.2 PCIe NVMe Gen3 x4

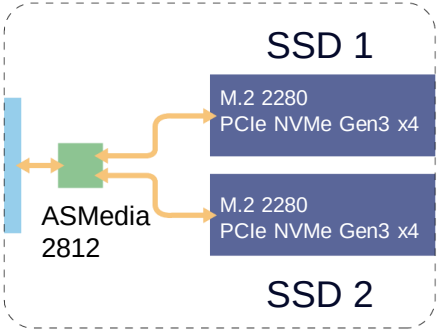


M.2 2280 PCIe NVMe Gen3 x4

U.2 PCIe NVMe Gen3 x4

QDA-U2MP

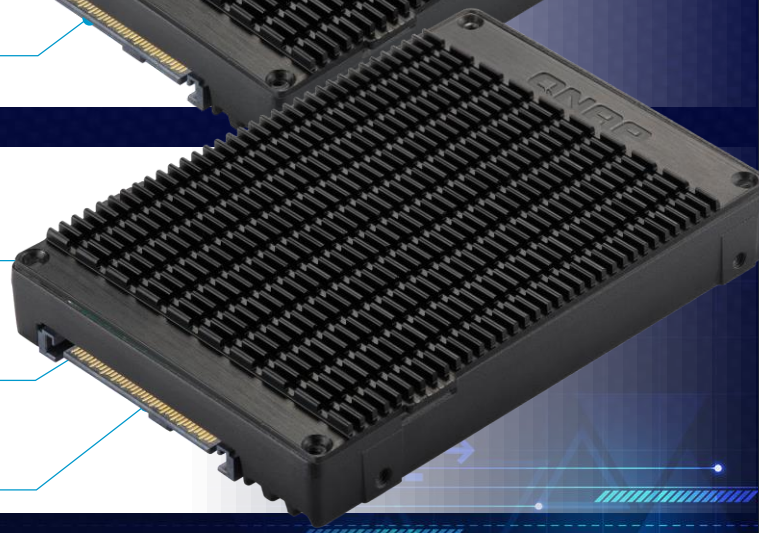
U.2 PCIe NVMe Gen3 x4



Asmedia 2812 Gen3 PCIe switch

2 x M.2 2280 PCIe NVMe Gen3 x4

U.2 PCIe NVMe Gen3 x4



Effects of Temperature on SSD Endurance

The SSD endurance specification can change dramatically when used at extreme temperatures such as those commonly seen in industrial and embedded applications.

$$\text{Acceleration Factor} = e^{(-E_a/k\,(1/T_2 - 1/T_1))}$$

Where
- E_a = Activation energy (1.1 eV for SSD flash)
- k = Boltzmann's constant (8.623 x 10-5 eV/°K)
- T_1 = Baseline temperature (°K), typically 313°K
- T_2 = Application storage temperature (°K)

Storage Temperature		Acceleration Factor	Max storage duration at end of drive life
(°C)	(°K)		
85	358	168	2 days
80	353	101	4 days
75	348	60	6 days
70	343	35	10 days
65	338	20	18 days
60	333	11.5	32 days
55	328	6.5	56 days
50	323	3.5	104 days
45	318	1.9	192 days
40	313	1	365 days
35	308	0.52	1.9 years
30	303	0.26	3.8 years
25	298	0.13	7.8 years
20	293	0.062	16 years
15	288	0.029	34 years
10	293	0.013	75 years

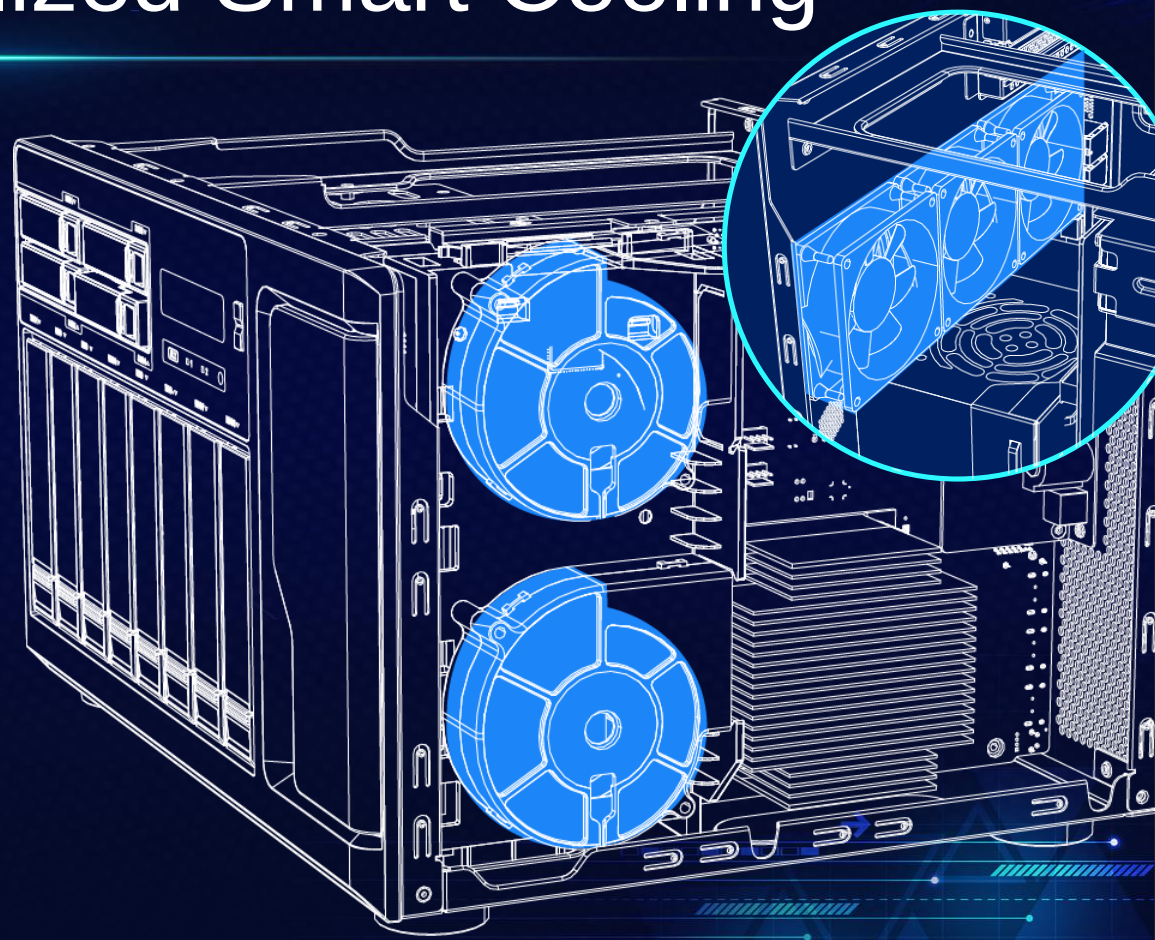
http://www.ni.com/product-documentation/54864/en/

High Quality Metal Construction For Better Heat Dissipation

The included M.2 SSD thermal pads and **Aluminum-alloy Metal Frame** provide excellent heat induction and keeps the SSDs cooler.

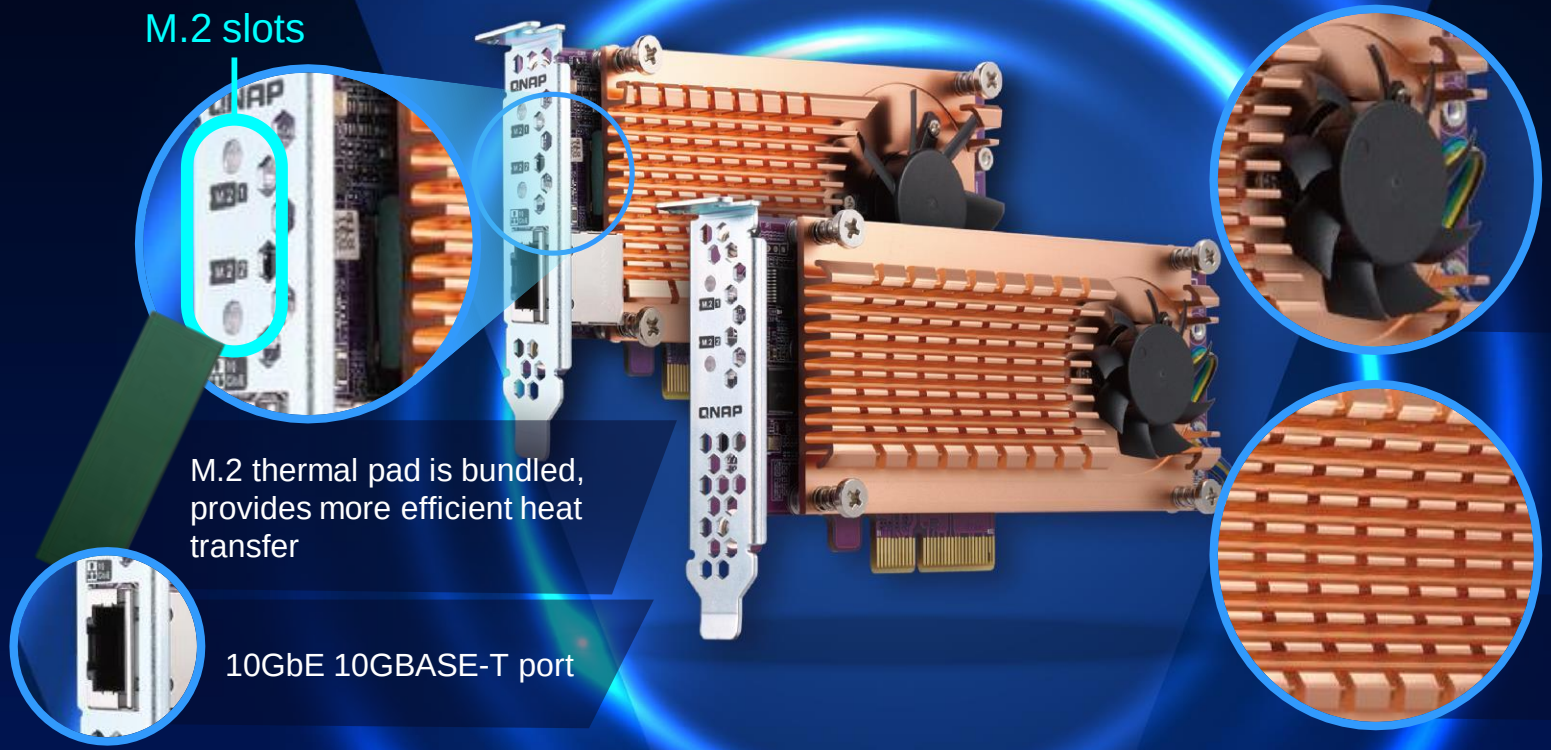
Compartmentalized Smart Cooling

QNAP NAS implements ventilation design and actively detect the SSD temperature to increase system fan speed when the SSD is reporting higher temperature.



Efficient cooling dissipation

QM2 series



QNAP SSD

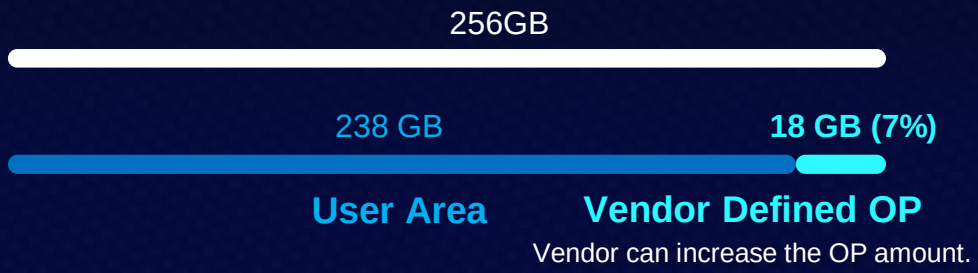
SOFTWARE TECHNOLOGIES

What is SSD Over-Provisioning

SSD as Flash storage, its capacity should be presented in Gibibyte (GiB)
2^30 = 1,073,741,824 Bytes。

As storage device, SSD actually reports its capacity back with Gigabyte (GB)
10^9 = 1,000,000,000 Bytes。

Every GB in SSD contain 73,741,824 Bytes(7.37%) for the Garbage Collection operation, and enterprise SSD may reserved more.

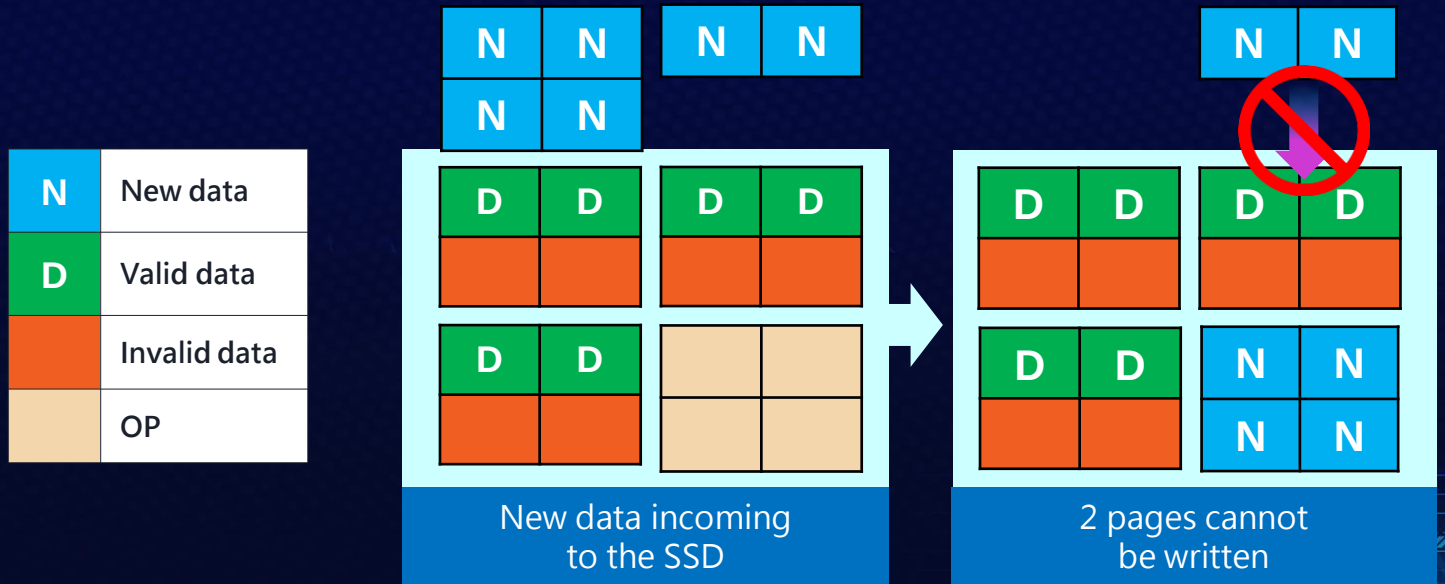


SSD actual size (GiB)	SSD present size (GB)	Vendor designed OP %	Actual internal OP %	Size show in the NAS (GiB)
256 GiB	256 GB	0%	7%	238 GB
256 GiB	240 GB	7%	15%	223 GB
256 GiB	200 GB	28%	37%	186 GB

How Over-provisioning can Affect SSD Performance and Endurance

Below: A simplified example, SSD contains 1 block as OP and 3 blocks contain both valid and invalid data.

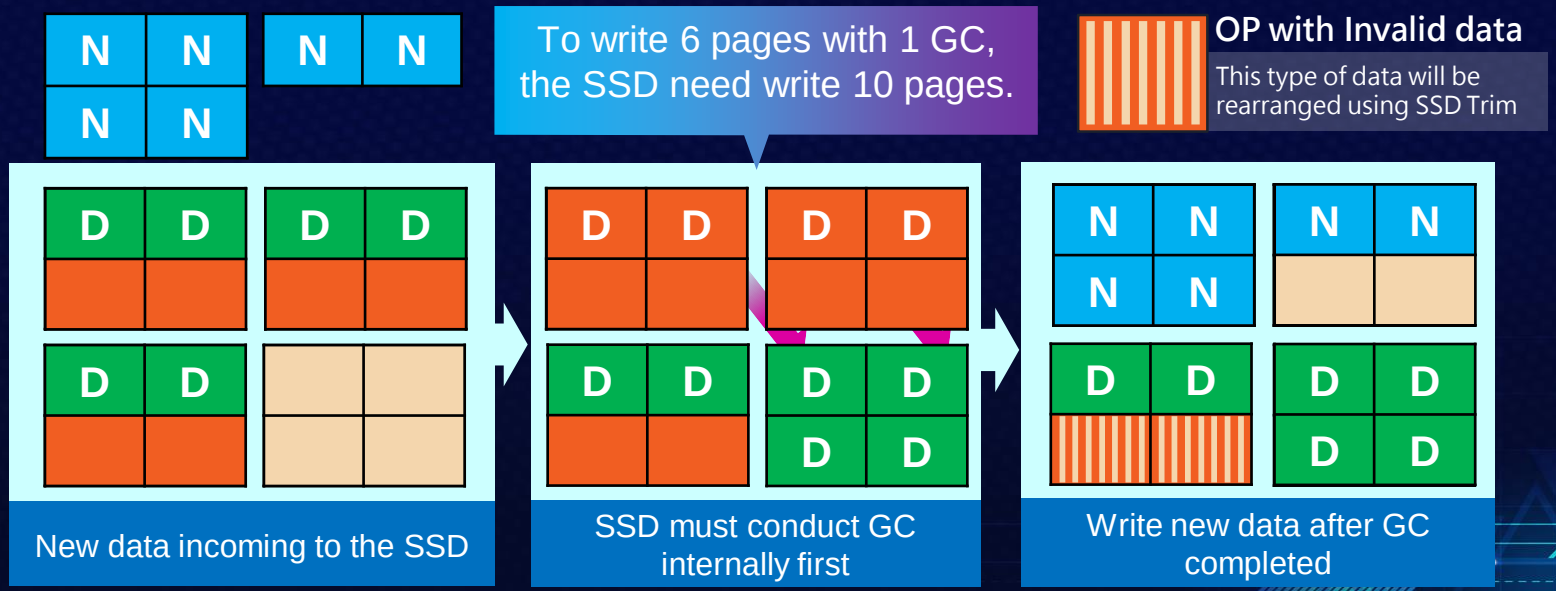
If 4 pages of new data are directly written to the last OP block first, the remaining 2 pages cannot be written anymore.



How Over-provisioning can Affect SSD Performance and Endurance

To write all new data into SSD, the SSD must conduct GC first. During the GC, more write actions need to be taken, and this is known as “Write Amplification.”

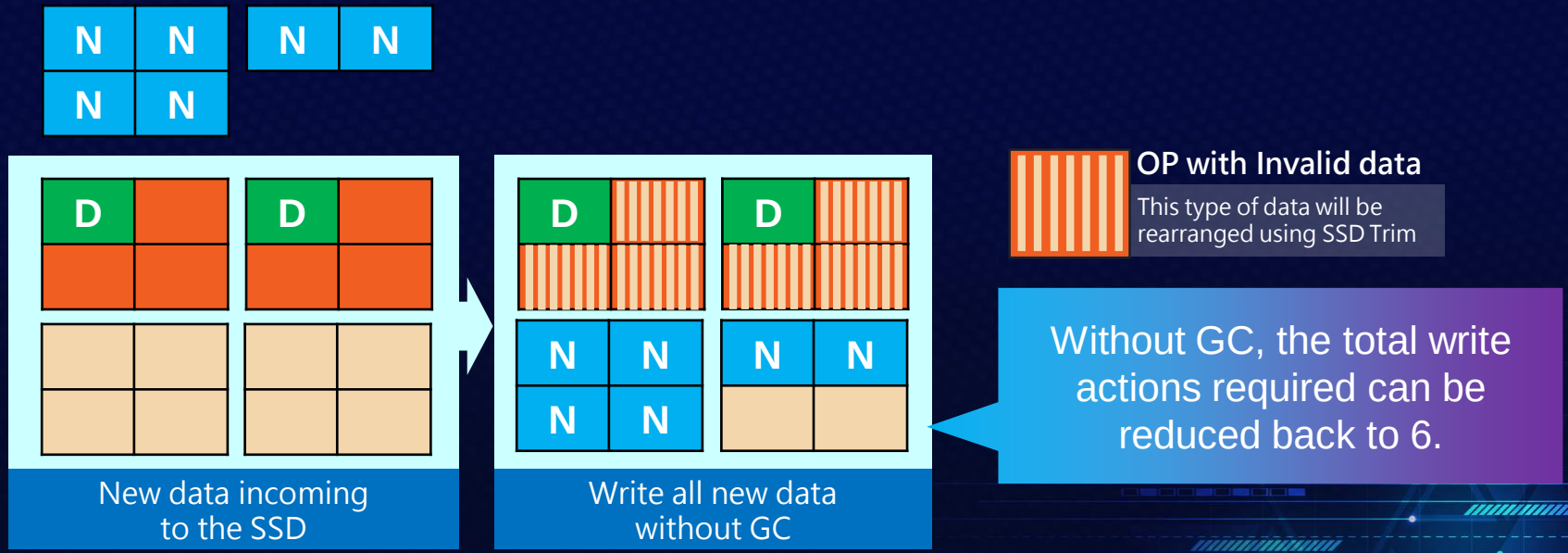
$$WAF = \frac{\text{Bytes written to NAND}}{\text{Bytes written from Host}}$$



https://en.wikipedia.org/wiki/Write_amplification

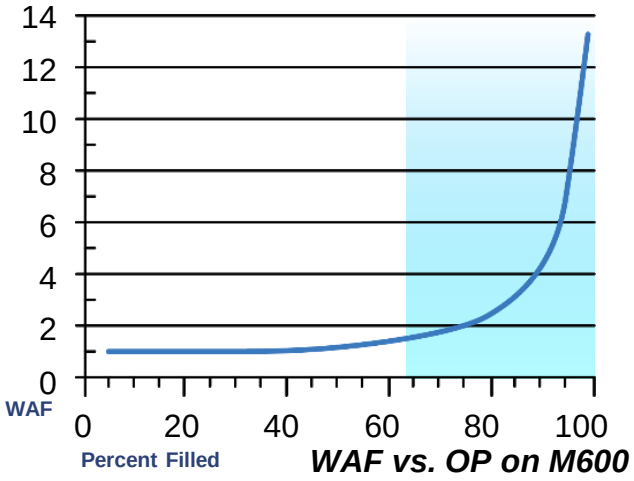
How Over-provisioning can Affect SSD Performance and Endurance

- When more space is reserved for Over-provisioning, data can be written directly without Garbage collection.
- Write Amplification has been reduced.

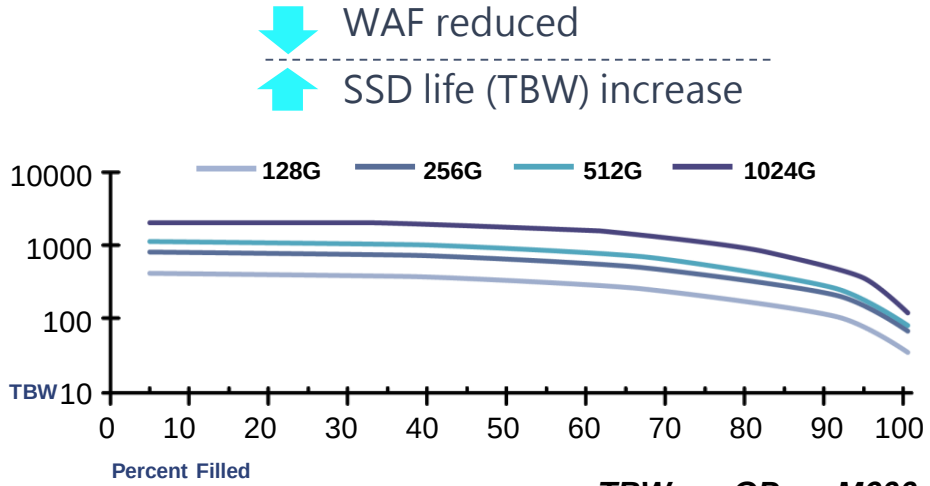


How Over-provisioning can Affect SSD Performance and Endurance

With the additional Over-provisioning, the Write Amplification can be reduced dramatically. And with reduced write actions, SSD's endurance can be increased.



WAF vs. OP on M600



TBW vs. OP on M600

資料來源: https://www.micron.com/~/media/documents/products/technical-marketing-brief/over_provisioning_m600_for_data_center_tech_brief.pdf

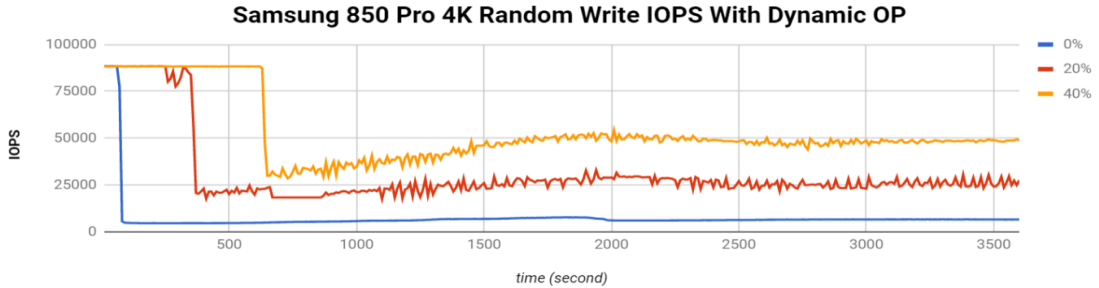
The Advantage of Software-defined SSD Extra Over-provisioning

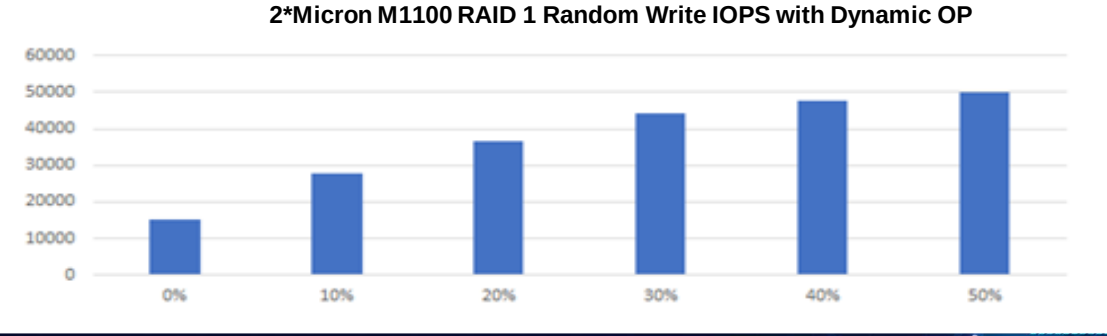
QNAP Technology

- With QTS, users can allocate more space for OP (1%~60%) to the SSD RAID.
- At QNAP Lab, the effect of over-provisioning besides observing single consumer-level as with Samsung SSD gain the same performance as the data center SSD, but also be seen on SSDs as a RAID.

Above: Samsung 850 Pro as Single Disk
Below: Micron M1100 as RAID 1

Test conditions:
FIO configuration: runtime=1800
ioengine=libaio direct=1 rw=randwrite
bs=4k numjobs=1 iodepth=32

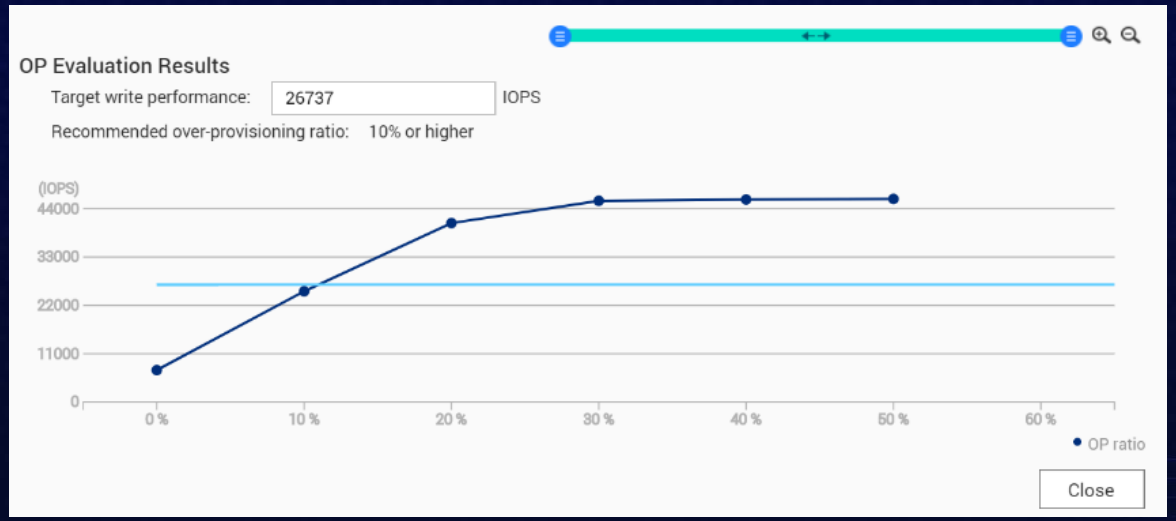




Choosing an SSD is Difficult
Choosing QNAP is Easy!

IT managers' biggest challenge in deploying SSD is to measure the SSD performance and how it can solve the storage bottleneck.

With QNAP SSD Profiling Tool, users can not only set OP, but further test SSD RAID performance with different OP amount.



IT managers can decide the best practice directly on production site

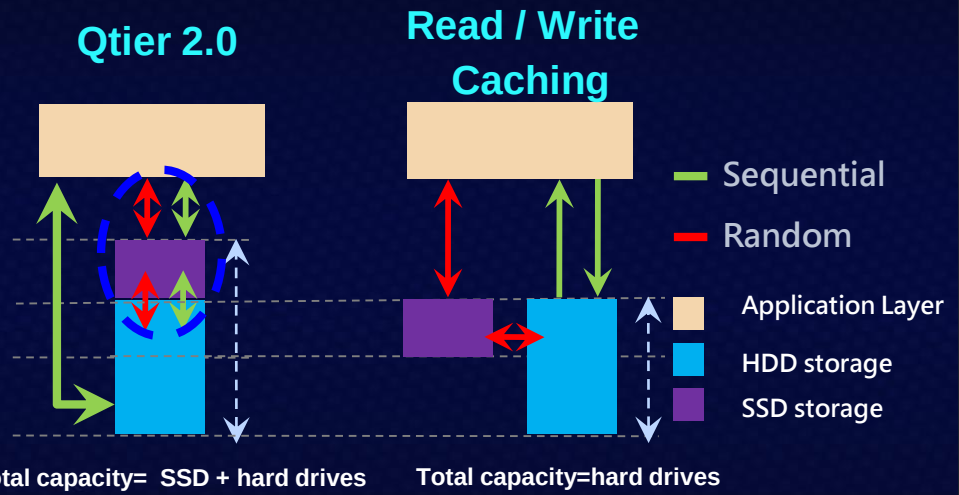
Io-aware Feature Automatically Moves Data

Storage space and SSD caching

Keep flexibility for accelerating performance of key data and increase cost/performance ratio

I/O Aware

Tiering on Demand

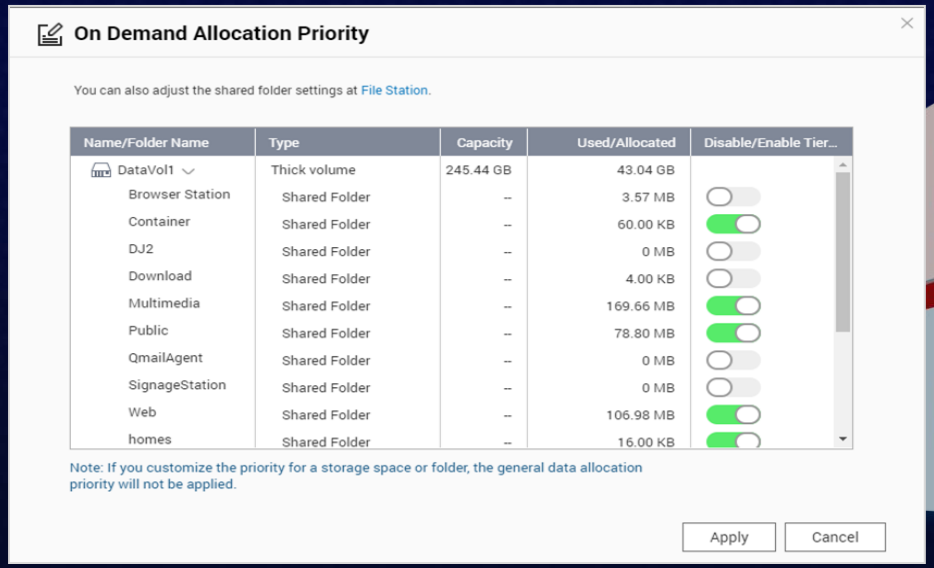


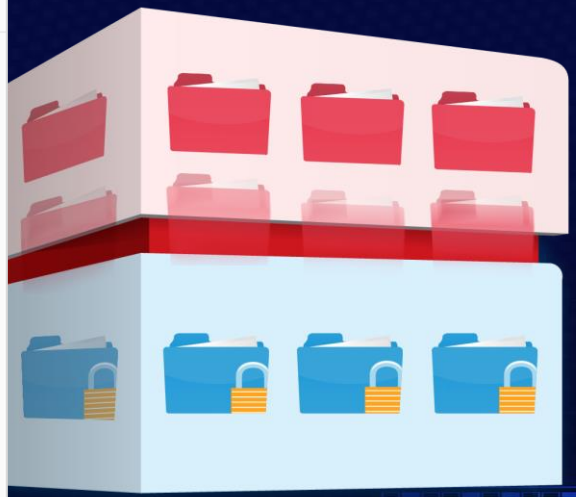
Hot adata & Reserved block (Tier on Demand)

Cold data & Disable Qtier

Qtier 2.0 Tiering On Demand

- SSD only has limited capacity that can be used on key applications
- Enable or disable auto-tiering for individual shared folder or iSCSI LUN





Hot data and reserved block

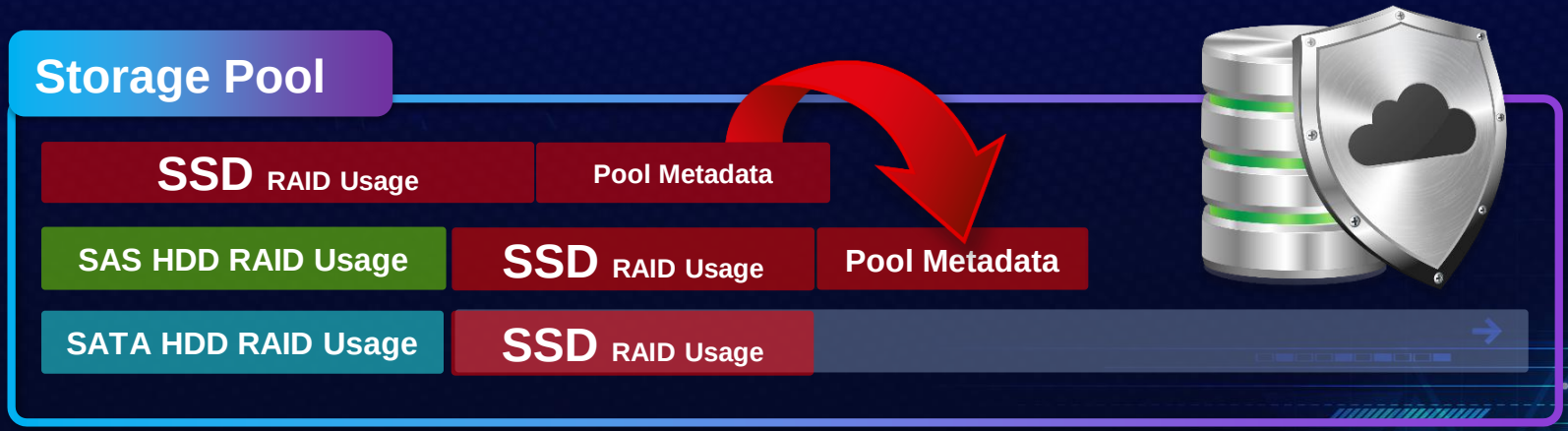
Cold and archived data

QTS 4.4.1 Supports Rebuilding Qtier SSD Pool, **Upgrade Qtier capacity**

QNAP Technology

QNAP QTS 4.4.1 supports remove Qtier SSD Tier, the users can remove then re-create SSD tier as required.

When Removing SSD Tier, it will move data and metadata to the rest of the RAIDs Group, and stop the pool's service. All the storage pool data will be retained.



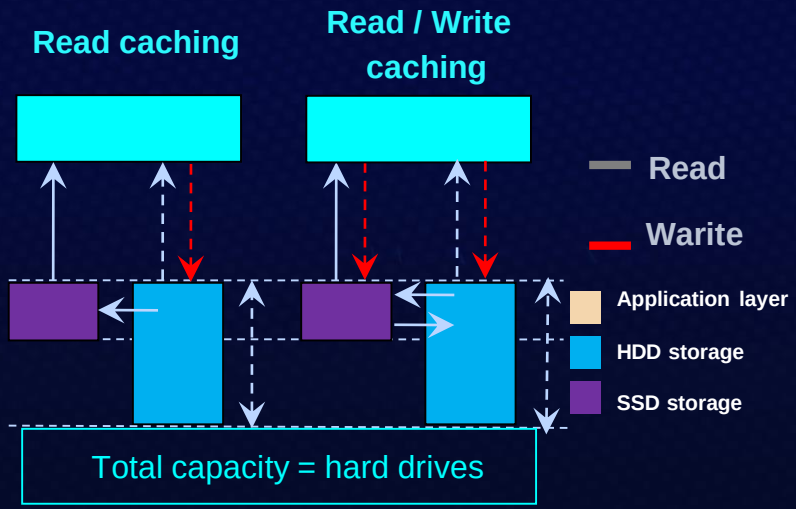
QTS Supports Cache Acceleration

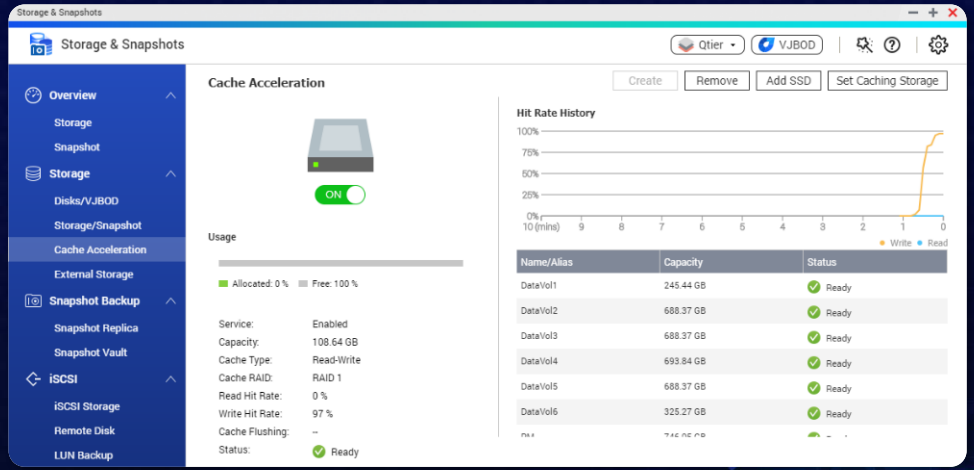
Reduce I/O latency

Accelerates IOPS performance

Global read-write cache

Applies SSD cache to all volumes and LUNs with a single setup process, or specified volumes only





QNAP Global SSD Cache

The QNAP SSD Cache can be applied to multiple volume / LUN

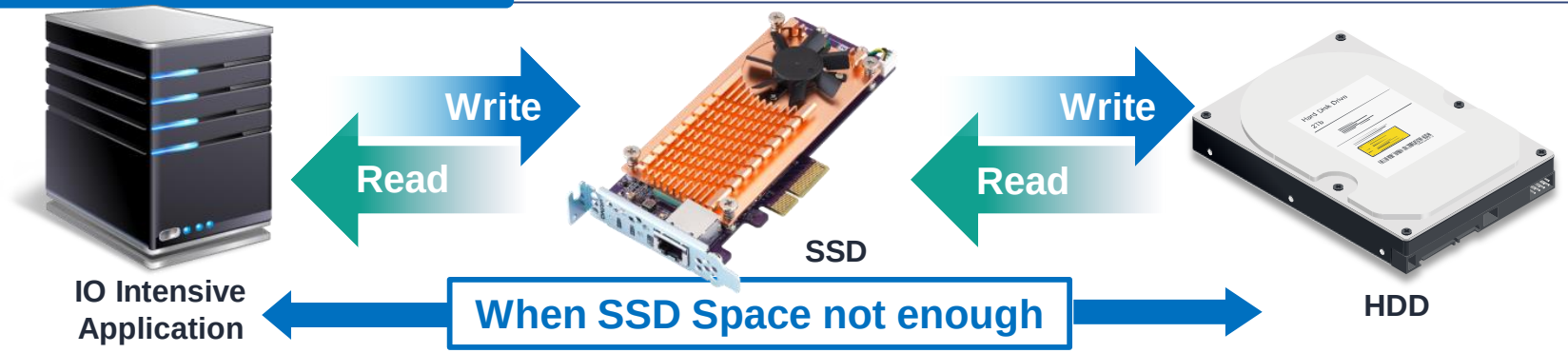
- Cache Type:

- Copy frequently used data to SSD (Read-Cache)
- Not only copy data, new data can also be temporarily stored in SSD (Read-write Cache)
- Only new data will be written into the cache (Write-Cache)

- RAID configuration: Single, RAID 0, RAID 1, RAID 10
- SSD type: SATA, SAS, M.2, PCIe SSD

How Read-write Cache work

Data from clients and storage will both be cached

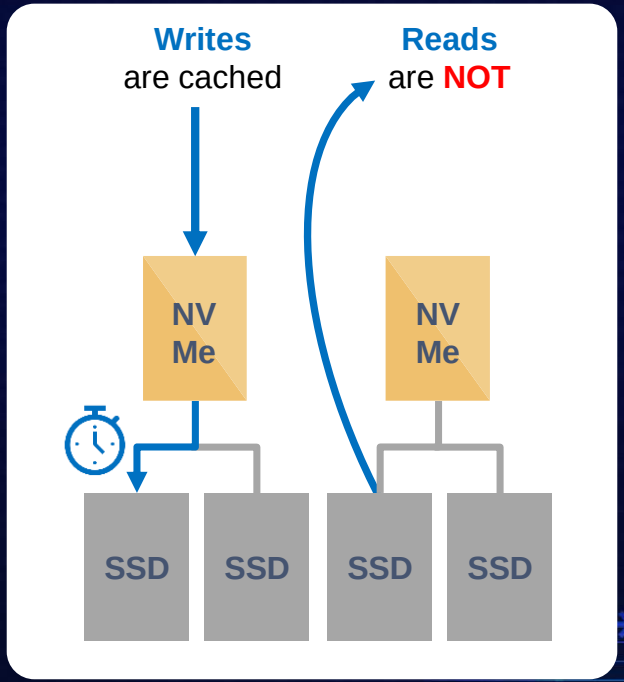


The Write-only Cache Increase ROI of SSD Cache with high Writing Demand

Write-only cache is promoted by Microsoft for endurance control.

The Write-only Cache can also increase the ROI of purchasing SSD in below scenario:

1. File Server focusing on write operations
2. Database with more write operation (Such as IoT monitoring server)
3. Use high endurance SSD (Intel Optane™) with other SSD



QNAP Technology

https://docs.microsoft.com/en-us/windows-server/storage/storage-spaces/understand-the-cache

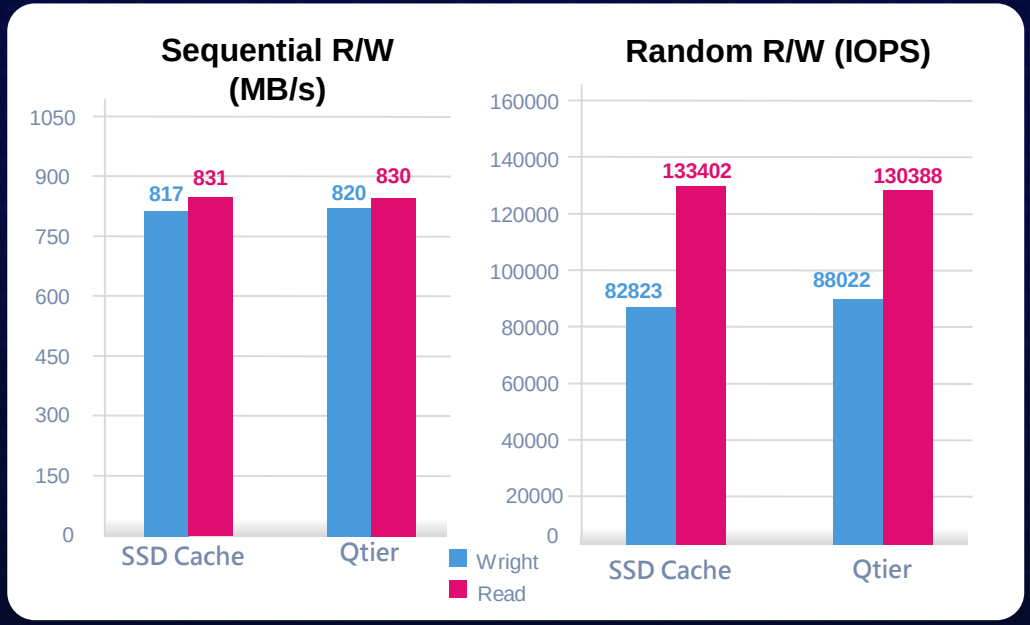
Seamless SSD Cache

- When configuring SSD Cache RAID, storage pool operations will not stop.
- When configuring Qtier, storage pool operations will not stop.

QNAP Technology

SSD Cache or Qtier™, Which is Better?

The best SSD configuration may only be measurable once it is configured. The SSD Cache and Qtier have different advantages.



Global SSD Cache

Real time performance boost

1. Burst read and write requirement such as news editing.
2. The cache can be disabled and adjusted at any time.

Qtier 2.0

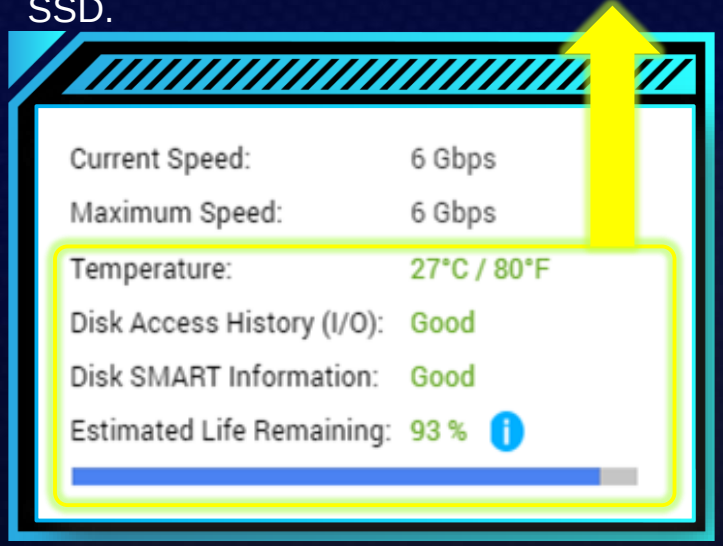
Fully utilize the SSD capacity

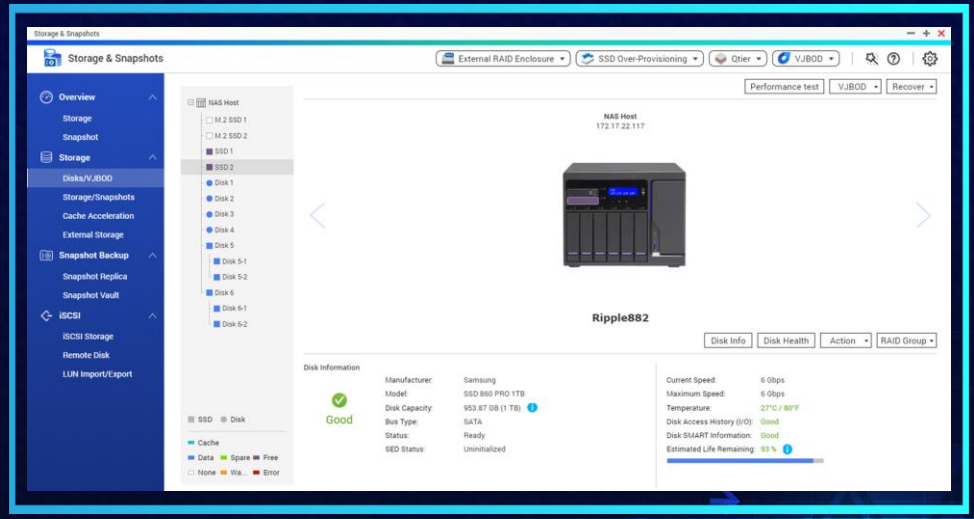
1. For data with hot and cold access pattern to conduct tiering
2. Pair with Qtier IO-aware can also be used on databases.

SSD Health Monitoring Tool

QTS tracks **the SSD Estimated Life Remaining** with Device Statistics Log (Log Address 04h Percentage Used Endurance Indicator) provided by the SSD.

This log address is defined by American National Standard of Accredited Standards Committee in SSD ATA/ATAPI Command Set.

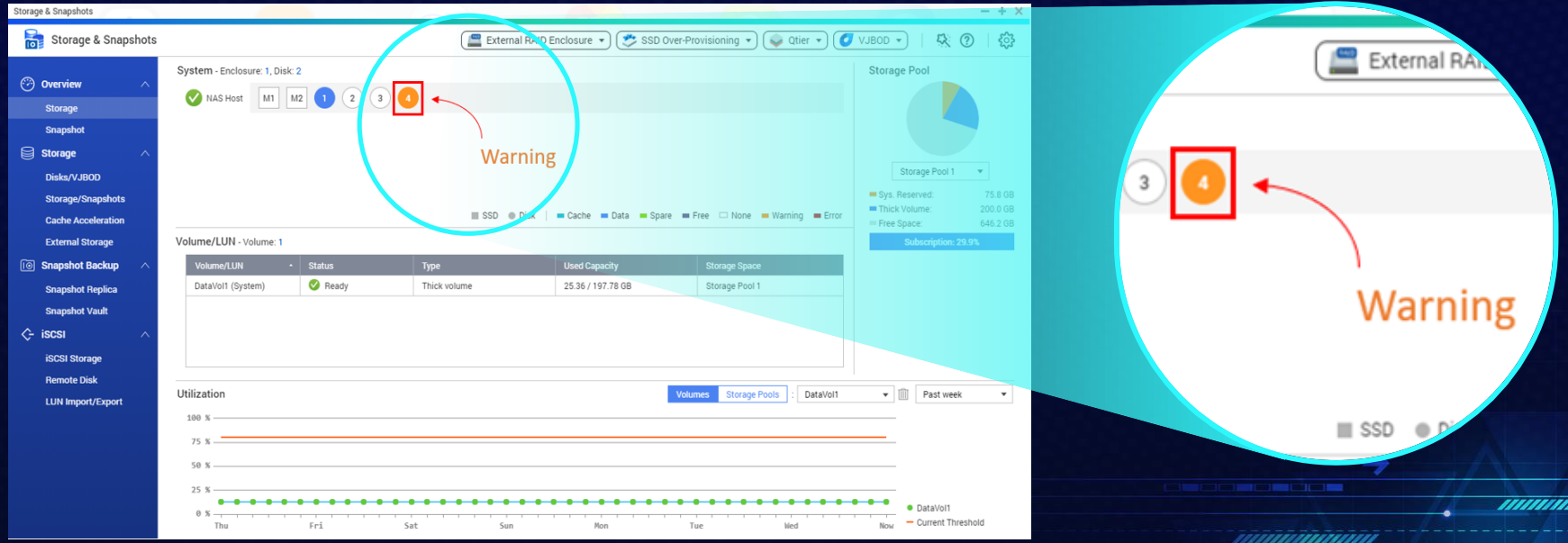




http://www.t13.org/documents/UploadedDocuments/docs2016/di529r14-ATAATAPI_Command_Set_-_4.pdf

SSD Reliability Active Notification

When the SSD remaining life is 0, it does not mean the SSD can no longer be used. The system will issue notifications to warn the user. The system log will be further sent through email, SMS text message, Push notification, etc.



SSD Features Support List

The ATA/ATAPI Command Set can also be used to identify the SSD support features, which include S.M.A.R.T. monitoring, SSD Secure Erase, SSD Trim and Opal SED encryption.

Disk Health

Monitor disk health, temperature, and usage status using the disk S.M.A.R.T. mechanism.

NAS Host | SSD 2

- Summary
- SSD Features
- SMART Information
- Test
- Settings

Disk model: Samsung SSD 860 PRO 1TB RVM01B6Q
Firmware version: RVM01B6Q
ATA version: 8
ATA standard: 94

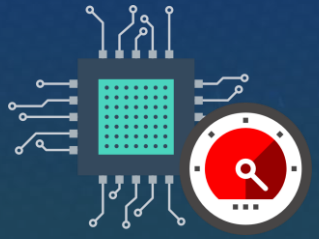
Feature	Status
S.M.A.R.T. Monitoring	Support
S.M.A.R.T. Self-Test	Support
SSD Secure Erase	Support
SSD Trim	Support
SSD Estimated Life Remaining	Support
Deterministic Zeros After Trim (DZAT)	Support
SED	Support

QNAP x Samsung SSD SED hardware encryption technology

QNAP Technology

The SED encrypting engine is in the ASIC controller, and each disk is with dedicated encrypting engine. The management function is built in the disk, the encrypting key is in the disk all the time.

Hardware encryption won't slow down the performance



Solve the problem caused by software encryption

You can decide not to use password to protect the SED pool

While the data is not important anymore, you can stop the password protection.

PSID Erase make sure the data deleted completely

Solve the problem of high costs on deleting data.

QNAP NAS with SSD Multiple Configurations

In addition to acting as a backup server, SSD Over-provisioning, Global Cache and Qtier let QNAP NAS be deployed as production server

Scenario	File Server	Web, Application, Virtualization Server	Synchroni-zation, Vi-deo Editing	Surveillance, Backup, Log Server	Business-Critical Database
SSD Config	Qtier™	Qtier™	Read-Write Cache	Write-Only Cache	SSD RAID
SSD RAID	RAID 6	RAID 10	RAID 5	RAID 10	RAID 10
SSD OP	10%	20%	20%	30%	30%

QNAP

QNAP

Is Your Best Choice

Fast

Safe

Easy

QNAP Is Your Best Choice

Fast

- Set up SSD OP to boost SSD performance
- 3 types：Read-Only 、Write-only、Read and Write
- Qtier Auto Tiering
- Re-create Qtier
- PCIe SSD Card

Safe

Easy

QNAP Is Your Best Choice

Safe

- SSD OP Increases your SSD’s Lifespan
- SED encrypting drives
- Health Monitor Tool
- Auto SSD Reliability Notification

Fast

Easy

QNAP Is Your Best Choice

Easy

- Support more than one Volume/LUN
- Replace online
- No interruption of storage service
- IO-aware feature automatically moves data
- Qtier Particular unit/LUN
- SSD drive bay
- PCIe SSD Card

Fast

Safe