Increasing the System Performance of Synology NAS/IP SAN
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Introduction

Synology is dedicated to producing high-quality and reliable NAS/IP SAN. All Synology products are thoroughly fine-tuned, but users can customize settings to further enhance system performance, such as data transmission speed or the system response time when running multitasking applications. This guide covers the four major factors influencing system performance—drive input/output, SSD cache, network configuration, memory upgrade—and provides technical tips on how to increase the performance of your Synology products.
Drive input/output (I/O) plays an important role in determining the performance of a storage system and can vary depending on the installed drive type and the implemented Redundant Array of Independent Drives (RAID) system. The following sections will discuss the main differences between several drive and RAID types to help you select the right system configuration.

**Drive and Interface Type**

Synology has compiled a selection of compatible and tested drives in the Synology Products Compatibility List for users to consult when setting up their Synology NAS/IP SAN. Different brands and specifications are available, but a more fundamental question is whether to invest in hard disk drives (HDDs) or solid-state drives (SSDs). A basic understanding of each drive type should help you make the right decision.

An advantage that traditional HDDs have over SSDs are their cost per gigabyte. Although the cost per gigabyte of SSDs has dropped in recent years, HDDs have also seen considerable improvements: a single HDD now may offer up to 20 TB of raw storage capacity. Therefore, HDDs continue to be favored by the general public and are enough to meet the needs of data storage, cold data archiving, data backup, or surveillance. For more information on selecting a suitable HDD for your Synology product, please refer to this article.

Despite their cost-per-gigabyte advantage, HDDs lose out to SSDs in terms of random input and output operations per second (IOPS). The rotating platters and actuator arms of an HDD pose a mechanical limitation that causes it to offer significantly slower random IOPS access than an SSD, which stores data in flash memory. Therefore, an SSD will be the better choice in an I/O-intensive environment, such as multimedia post-production, enterprise resource planning (ERP), customer relationship management (CRM), or online transaction processing (OLTP). Please refer to Table 1 for a comparison of random IOPS between HDDs and SSDs of different interfaces.
Understanding Drive Input/Output

<table>
<thead>
<tr>
<th>Device</th>
<th>Average Random Read-Write IOPS (4KB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SATA/SAS 7,200 RPM HDD</td>
<td>73 - 79</td>
</tr>
<tr>
<td>SAS 10,000 RPM HDD</td>
<td>142 - 151</td>
</tr>
<tr>
<td>SAS 15,000 RPM HDD</td>
<td>188 - 203</td>
</tr>
<tr>
<td>SATA SSD</td>
<td>61,000</td>
</tr>
<tr>
<td>SAS SSD</td>
<td>120,000</td>
</tr>
<tr>
<td>M.2 NVMe SSD</td>
<td>143,000</td>
</tr>
</tbody>
</table>

**Note**: All values were obtained from official datasheets of HDD/SSD vendors and represent the theoretical and average performance of a single drive. Actual values depend on many factors, including but not limited to CPU performance, operating system (OS), application, drive capacity, RAID configuration, file system, and network bandwidth.

Table 1: Average Random IOPS Comparison of HDDs and SSDs

Drive interfaces are another factor that can affect system performance. Synology products currently support two main types of interfaces for the connection of 2.5 and 3.5-inch drives: SATA and SAS.

- **SATA (Serial ATA, or Serial Advanced Technology Attachment)**: SATA supports a theoretical data transmission bandwidth of 6 Gb/s. This bandwidth is more than enough for traditional HDDs (as shown in Table 1); however, as the manufacturing process of SSDs continues to evolve, this interface can become an impediment to the high-speed data transmission expected of SSDs. SATA SSDs remain a popular and cost-effective solution for general-purpose storage.

- **SAS (Serial Attached SCSI)**: A more accessible version offers a theoretical data transmission bandwidth of 12 Gb/s and provides better fault detection features than SATA interfaces. It has higher data integrity, offers more reliability, and uses duplex operation to enhance the data transmission efficiency. Most SATA drives are compatible with SAS interfaces, but the theoretical data transmission bandwidth will remain at 6 Gb/s. SAS drives, on the other hand, can only be supported by dedicated SAS controllers and are therefore more common for use on an enterprise scale. Click [here](#) to browse Synology products offering SAS drive support.

If budget considerations allow, we recommend SAS drives, as they yield better performance and stability. For mass deployment, SATA drives provide good alternatives with reasonable cost-performance ratios. For more information, please refer to this [article](#) to help you decide between SAS or SATA drives.

In addition to SATA and SAS, some Synology products also support system cache with M.2 NVMe SSDs. This is further explained in the “Utilizing SSD Cache” section.
**RAID Type**

The number of drives and how they are configured in a storage system like Synology NAS/IP SAN can also influence the system’s overall performance. You can take advantage of RAID technology and combine multiple physical drives into one or more logical groups to realize data redundancy, performance improvement, or both.

Each RAID type can tolerate up to a certain number of defective drives before data loss occurs. To ensure the stored data can be safely recovered in the event of a drive failure, RAID requires the system to calculate parity whenever data is written to the drives. This protective mechanism consumes resources and can influence the overall write performance of the RAID volume. Table 2 shows a brief overview of the different RAID types supported by Synology servers, including the minimum drive requirement, number of tolerable drive failures, capacity utilization, and their characteristics.

<table>
<thead>
<tr>
<th>RAID Type</th>
<th>Min. Number of Drives Required</th>
<th>Tolerable Drive Failures</th>
<th>Capacity Utilization</th>
<th>Pros</th>
<th>Cons</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>2</td>
<td>None</td>
<td>N</td>
<td>Data are divided into equal shares and distributed to all drives in the RAID set. As no data parity calculation is required, RAID 0 utilizes all drives in the RAID set and delivers the highest performance among all RAID types.</td>
<td>No drive redundancy is provided. All data in the RAID set are lost if one drive fails, and data will need to be restored from additional backup.</td>
</tr>
<tr>
<td>1</td>
<td>2</td>
<td>N - 1</td>
<td>Single drive capacity</td>
<td>Data are mirrored to all drives. Data integrity will not be affected if one drive fails.</td>
<td>Only half of the total drive storage capacity is available for use.</td>
</tr>
<tr>
<td>5</td>
<td>3</td>
<td>1</td>
<td>N - 1</td>
<td>One drive redundancy is offered. Data are striped across multiple drives alongside the parity check bit. Data integrity is ensured by the parity check bit.</td>
<td>Available volume size is affected because the storage capacity of one drive is reserved for data integrity checks. In order to calculate an extra parity bit for each set of data, CPU utilization is higher than RAID 1.</td>
</tr>
</tbody>
</table>
### Understanding Drive Input/Output

<table>
<thead>
<tr>
<th>RAID Type</th>
<th>Min. Number of Drives Required</th>
<th>Tolerable Drive Failures</th>
<th>Capacity Utilization</th>
<th>Pros</th>
<th>Cons</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>4</td>
<td>2</td>
<td>N - 2</td>
<td>Two drive redundancy is offered. Data are striped across multiple disks alongside the parity check bit. Data integrity is ensured by the parity check bit.</td>
<td>The storage capacity of two drives is reserved for data integrity checks and therefore the available volume size is affected. In order to calculate two extra parity bit for each set of data, CPU utilization is higher than RAID 5.</td>
</tr>
<tr>
<td>10</td>
<td>4</td>
<td>1 in each sub RAID</td>
<td>N / 2</td>
<td>It offers the benefit of both RAID 0 and RAID 1 – data access efficiency and mirroring protection.</td>
<td>Only half of the total drive storage capacity is available for use.</td>
</tr>
</tbody>
</table>

N = Total number of drives

Table 2: RAID types comparison

Because drive performance and capacity vary with each RAID type, it is important to know whether your computing environment prioritizes data protection or system performance before proceeding to configure a suitable RAID system. Apart from the RAID types mentioned already, some Synology products also work with proprietary RAID types, such as Synology Hybrid RAID (SHR) and Synology RAID F1. Please refer to the links below to learn more:

- [What is Synology Hybrid RAID (SHR)](#)
- [Which Synology server models support RAID F1?](#)
- [Synology RAID F1 White Paper](#)
Utilizing SSD Cache

In the previous sections, we recommended SSD over HDD for the former’s higher IOPS performance. Especially for computing environments that commonly use applications (such as email services) that are random I/O sensitive, we further recommend deploying Synology's all-flash FS-series to boost business productivity. However, if budget constraints do not allow an all-SSD setup, you can utilize Synology SSD Cache technology to reduce I/O latency and improve system performance.

Synology SSD Cache can be enabled by mounting an SSD cache to a single storage volume or iSCSI LUN (Block-Level). This also works for an iSCSI LUN (File-Level) created on a volume with SSD cache enabled. What Synology SSD Cache does is that it creates a hot data buffer that greatly enhances the system performance of your Synology products. Applications on the system that can benefit from this increased performance include virtual machine deployments, database processing, video editing, file indexing, and Synology packages like Snapshot Replication, Synology MailPlus, and Web Station.

The objective of enabling SSD cache is to increase the performance of random access to a small portion of frequently accessed (hot) data in the storage space. Please keep in mind that other data operations may not benefit from the use of SSD cache. There will not be a significant increase in performance for large sequential read or write operations, such as high-definition video streaming, or data reading that is entirely random and lacks rereading patterns.

Synology products support two types of SSD cache:

- **Read-only cache** only stores frequently accessed data to increase random read speed. This type of cache requires one or two identical SSDs configured as RAID 0 to provide optimal performance.

- **Read-write cache** writes data into at least two SSDs simultaneously to speed up data access. This type of cache requires at least two SSDs configured as RAID 1 to ensure data security and integrity.

Depending on the size of the storage volumes or iSCSI LUNs to be accelerated, you can create several SSD caches on the volumes of a Synology NAS/IP SAN. You can refer to the specifications of your Synology products to see if the SSD cache requires 2.5-inch SAS or SATA SSD installed into the system drive trays. Certain Synology products are equipped with M.2 slots or even support an optional M.2 SSD adapter card to facilitate the creation of an SSD cache volume. To see a complete list of Synology products that support SSD cache, please refer to this article.

As a best practice for Synology SSD Cache technology, we recommend using the SSD Cache Advisor feature in Storage Manager. As a properly sized-cache is required to store the most frequently accessed data, you can use SSD Cache Advisor to calculate the total size and number of recently accessed files on a selected volume within a specific period, and then determine a proper cache size for that volume. For more technical information on Synology's SSD Cache technology, please refer to the white paper on Synology SSD Technology or to our FAQ article.
Many Synology products (see product list) come with multiple 1GbE and 10GbE LAN ports built-in to provide high-speed network connections. As Synology NAS/IP SAN often serves as a centralized storage system and offers simultaneous data transmission to multiple clients, you may want to set up Link Aggregation to optimize your network. Link Aggregation combines multiple LAN interfaces to increase network bandwidth and throughput, and to keep the network connected via traffic failover in the event of network failure. For more instructions on configuring Link Aggregation, please click here.

If you do not find the network bandwidth provided by the built-in LAN ports to be sufficient, certain Synology models (see product list) also come with one or more empty PCIe expansion slots. You can opt to install additional 10GbE/25GbE/40GbE network interface cards (NICs) to considerably enhance the overall bandwidth for multiple client connections and data transmission performance. You can find a detailed list of compatible NICs here.

For the latest performance figures on Synology products, please refer to our Performance page where data transmission speeds, system IOPS, and other relevant information are available to help enterprises, as well as private users. You may also refer to the following articles for troubleshooting steps if you are experiencing slow network transmission:

- How can I troubleshoot a low data transfer rate?
- What can I do when the file transfer via Windows (SMB/CIFS) is slow?
- How can I troubleshoot iSCSI storage performance issues?
Upgrading memory capacity of your Synology NAS/IP SAN to form a dual-channel or multi-channel memory configuration can enhance overall system performance, including data transmission speed and the system response time when running multitasking applications. The following tables display the performance difference between a single channel (factory default) memory configuration and a dual-channel memory configuration on selected Synology products that are tested in an SMB environment of 10GbE:

### RS3617xs+

<table>
<thead>
<tr>
<th></th>
<th>8 GB (Factory Default)</th>
<th>16 GB (Dual Channel)</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sequential Throughput</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Read</td>
<td>4,952.6 MB/s</td>
<td>5,415.72 MB/s</td>
<td>+ 8.55%</td>
</tr>
<tr>
<td>Write</td>
<td>1,604.5 MB/s</td>
<td>2,477.71 MB/s</td>
<td>+ 35.24%</td>
</tr>
<tr>
<td><strong>Sequential Throughput via Encrypted Shared Folder</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Read</td>
<td>2,323.67 MB/s</td>
<td>3,251.99 MB/s</td>
<td>+ 28.55%</td>
</tr>
<tr>
<td>Write</td>
<td>1,230.7 MB/s</td>
<td>1,735.88 MB/s</td>
<td>+ 29.10%</td>
</tr>
</tbody>
</table>

### SA3400

<table>
<thead>
<tr>
<th></th>
<th>16 GB (Factory Default)</th>
<th>32 GB (Dual Channel)</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sequential Throughput</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Read</td>
<td>5,464.99 MB/s</td>
<td>5,520.05 MB/s</td>
<td>+ 1%</td>
</tr>
<tr>
<td>Write</td>
<td>1,432.76 MB/s</td>
<td>2,731.02 MB/s</td>
<td>+ 47.54%</td>
</tr>
<tr>
<td><strong>Sequential Throughput via Encrypted Shared Folder</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Read</td>
<td>3,136.89 MB/s</td>
<td>4,093.15 MB/s</td>
<td>+ 23.36%</td>
</tr>
<tr>
<td>Write</td>
<td>1,145.09 MB/s</td>
<td>1,734.42 MB/s</td>
<td>+ 33.98%</td>
</tr>
</tbody>
</table>
Upgrading Memory Capacity

<table>
<thead>
<tr>
<th></th>
<th>FS6400</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>32 GB</td>
<td>64 GB</td>
<td>Difference</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(Factory Default)</td>
<td>(Dual Channel)</td>
<td></td>
</tr>
<tr>
<td>Sequential</td>
<td>Read</td>
<td>7,054.56 MB/s</td>
<td>7,036.09 MB/s</td>
<td>- 0.26%</td>
</tr>
<tr>
<td>Throughput</td>
<td>Write</td>
<td>2,870.59 MB/s</td>
<td>4,665.86 MB/s</td>
<td>+ 38.48%</td>
</tr>
<tr>
<td>Sequential</td>
<td>Read</td>
<td>5,047.64 MB/s</td>
<td>5,887.91 MB/s</td>
<td>+ 14.27%</td>
</tr>
<tr>
<td>Throughput via</td>
<td>Write</td>
<td>2,007.52 MB/s</td>
<td>2,877.61 MB/s</td>
<td>+ 30.24%</td>
</tr>
<tr>
<td>Encrypted Shared</td>
<td></td>
<td>Folder</td>
<td>Folder</td>
<td></td>
</tr>
</tbody>
</table>

The results show that write performance benefits the most from a dual-channel memory configuration. If you have installed high-speed NICs and wish to improve the data transmission speed of your Synology product, you might consider a multi-channel memory configuration. For additional information, please refer to this [article](#) for the recommended memory configuration for Synology products, or click [here](#) to learn more about the limitations and requirements of performing a memory upgrade.

Data transmission speed is not the sole benefit of upgrading the system memory capacity. Other benefits include:

- The system response time of many Synology services can be greatly improved, such as Synology Chat, Synology MailPlus, Synology Drive, Synology Office, or Active Backup for Business.

- More virtual machines using higher memory capacity can be run on the Synology product.

- Several Synology products can support a maximum single volume size of 200 TB with at least 32 GB of memory installed (the complete model list can be found [here](#)).
This guide covered the key aspects of system performance to help users optimize and unleash the full potential of their Synology NAS/IP SAN.

- HDDs and SSDs offer significantly different IOPS and throughput performance, so it is important to select a suitable drive type. Another aspect crucial to the planning of system architecture is configuring a RAID type that balances I/O performance and data integrity protection.

- For those on a limited budget who needs to run capacity-oriented applications, Synology SSD Cache technology can be enabled to reduce the I/O latency of HDD volumes and improve system performance.

- To optimize network performance, installing high-speed NICs or enabling Link Aggregation are both viable options to increase the network bandwidth, improve data transmission, and accommodate multi-client connections.

- Upgrading system memory to form dual-channel or multi-channel configurations can enhance the system response to multitasking applications.

Depending on the workload and demands, there are different ways to customize a storage system to increase performance. For further information about increasing the system performance of Synology products, please visit https://www.synology.com/support.
Drives

• How to choose a suitable HDD for my Synology NAS/IP SAN
• Should I choose SAS or SATA solid-state drives for Synology FlashStation?
• What is Synology Hybrid RAID (SHR)
• Which Synology server models support RAID F1?

SSD Cache

• Which Synology NAS models support SSD cache?
• Frequently asked questions about using Synology SSD cache

Network

• Link Aggregation
• How can I troubleshoot a low data transfer rate?
• What can I do when the file transfer via Windows (SMB/CIFS) is slow?
• How can I troubleshoot iSCSI storage performance issues?

Memory

• How to expand the memory on my Synology server for better performance
• Are there any requirements for installing or expanding system memory capacity?
• How many virtual machines can I run on my Synology NAS?
• What is the maximum single volume size of my Synology NAS?
Products List

Synology Products Compatibility List

- HDD/SSD
- PCIe Network Interface Cards

Synology Products

- With SAS Drive Support
- With 10GbE Built-In
- With 10GbE Optional
- Performance

White Paper

- Using Synology SSD Technology to Enhance System Performance
- Synology RAID F1 White Paper

External Site

- Tom's Hardware: SSD Prices to Fall Below 10 Cents Per GB