Synology®

White Paper

Virtualization on Synology NAS with Virtual Machine Manager

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Introduction

Synology NAS and its DiskStation Manager (DSM) operating system offer enterprises an easily maintained, readily scalable, and versatile private cloud solution. Virtual Machine Manager (VMM) is a native hypervisor for DSM that combines the benefits of hardware virtualization with the advantages of Synology NAS, including simplicity, compatibility, and functionality.

Choosing Virtualization for Your Business

When businesses choose their IT setup, they set the conditions for their future growth. A simple IT infrastructure with systems that are easily expandable will not slow down your organization as it changes, and allows you to maintain consistent security and usability as you scale up or change your activities.

Virtualization is an essential technology used by many organizations to achieve these goals. Virtual machines (VM) are operating systems that operate independently and isolated from each other on the same IT hardware. They can be an excellent solution to maximize use of available hardware for different users and tasks.

Flexible, Efficient, and Secure Infrastructure

VMs are typically suitable where a service needs to be run on a different operating system or separate machine, but does not require so many resources as to necessitate its own separate device. If sufficient capacity is available on existing hardware, such an application can be hosted in a virtual machine on devices already in place. This includes on your Synology NAS.

Beside maximizing hardware use, VMs can help you sandbox or isolate threats posed by certain applications, ensuring that other essential functions are not affected. Being hardware-independent and easy to manage, VMs can also ensure easier scaling, backup, replication, and migration, ensuring that changes and failures do not equal costly system downtime.

Synology's Integrated Virtualization Solution

While VMs can help save operational and financial overhead, their implementation has potential downsides. Easy management is offset by the initial complexity of setting up the required virtualization infrastructure. Services hosted on VMs also take a heavier toll on hardware, leading to a significant performance penalty for certain operations.

Synology VMM takes away much of the complexity of setting up virtualization with superior hardware and software integration. Synology NAS servers combine all needed resources on one device, making setting up virtual computing, storage, and networks a breeze. Easy management through one clean application saves time and hassle.

Users can reduce hits to performance and capacity problems with realistic planning and good preparation. This paper helps users choose the right applications and hardware setups to avoid applications that incur outsize performance penalties, as well as setups that do not meet requirements.

Why Use Synology for Virtualization?

+ Extremely easy integration of virtual resources on one or more devices

- Computing, storage, and network resources are integrated on Synology NAS, making professional virtualization setups easy and incredibly fast.
- Avoid setting up complex Storage Area Networks with an automatic management network that needs no configuration.
- Contact a single vendor for all technical software and hardware support, and enjoy Synology's five-year warranty.

+ Smooth browser-based management and exceptionally easy sharing

- Manage your complete virtualization setup from an intuitive management console in DiskStation Manager. Add or remove hosts and resources with a few clicks.
- Directly access VM graphical user interfaces or command lines from any PC or operating system using an IP address or Virtual Machine Manager in DSM.
- Provide access to VMs using share links, with password protection and all the benefits of Synology's QuickConnect referral service.

+ Fast and secure virtual storage on a highly stable hardware platform

- Eliminate network speed as an obstacle between VMs and their virtual disks by hosting both nodes on one Synology NAS.
- VMs, files, and snapshots are kept on storage-optimized systems with advanced RAID or Synology Hybrid RAID configurations and many data recovery options.
- Synology NAS and the DSM operating system are designed for long-term uninterrupted operation and come with long-term support.

+ Highly efficient method to combine Synology and third-party solutions

- Virtualized services can run alongside regular Synology NAS applications and storage processes, as well as on Synology High Availability clusters.
- Virtual DSM allows the creation of many virtual Synology NAS on one machine, alone or alongside virtual Linux and Windows servers.
- VMM High Availability clusters offer hardware and network redundancy without requiring an identical Synology NAS to act as passive server.

- Heavy virtual deployments require high-performance Synology setups

- Synology products are optimized for storage and writing operations, and less suitable for intensive computing or memory-intensive (e.g. graphical) tasks.
- Limited built-in RAM means users who wish to run multiple VM applications on Synology systems will benefit from installing Synology-supported memory extensions and SSD cache.

- Hypervisor competes with other applications on mixed-use platform

- VMM runs on top of DSM, leading to higher resource use and slower performance compared with bare-metal hypervisors.
- If your Synology NAS servers are used intensively for non-virtualization tasks, there might not be sufficient resources for heavy VM applications, and vice versa.
- Resources on Synology NAS are not fully abstracted in line with the principles of hyperconvergence and machines need to be migrated between nodes.

Resource Integration With Synology VMM

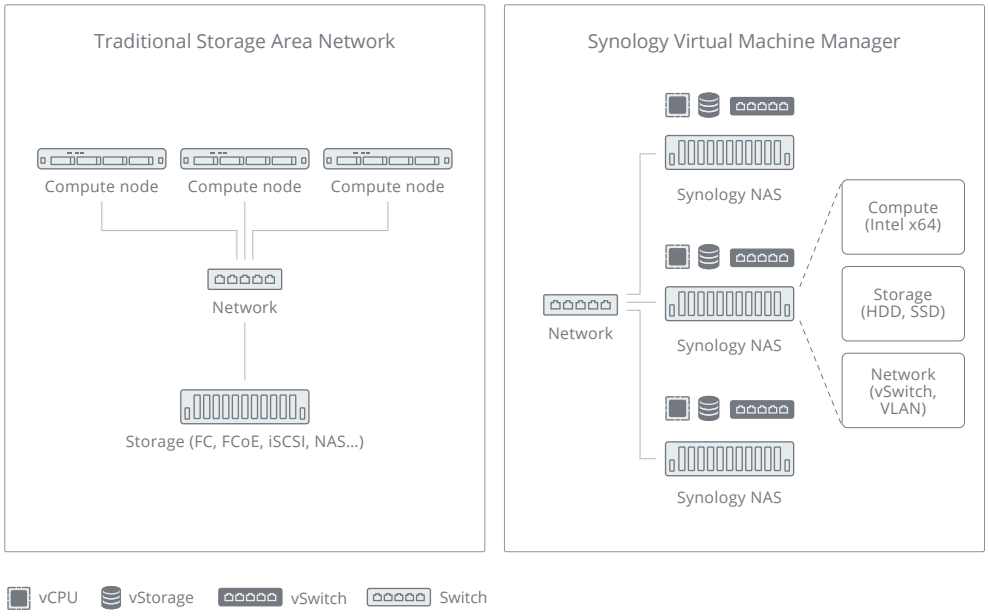


Figure 1: A traditional Storage Area Network (SAN) compared with Synology's virtualization cluster setup. Synology Virtual Machine Manager integrates three types of virtualization resources (computing, storage, and networking) on Synology NAS, removing the need to set up a SAN and deal with multiple suppliers.

Deployment Scenarios

Efficiently Run Multiple Services

Essential office services often depend on specific hardware and software setups, which need to remain stable. This necessitates the use of separate machines to handle each application: email servers, web servers, database servers.

When the resources required by any one service do not require a full server's capacity, it becomes attractive to co-host applications on one physical device. Separate VMs running their own, differently configured, and stable operating systems benefit service continuity and isolate applications from each other.

Current and prospective Synology NAS users, especially those with larger pools of capacity, can use Synology servers as their VM platform, adding value to their Synology setup while avoiding added costs and complexity associated with disparate hardware platforms.

For operationally central applications it is essential to estimate requirements correctly and provision adequate capacity. VMM Pro allows you to run VMs in a cluster of multiple Synology NAS and migrate runing VMs to other devices when hardware needs so require.

Protect Your Host From External Threats

Hosting a VM on your Synology NAS creates an isolated instance of any desired operating system that has no direct access to physical server hardware. This includes Virtual DSM (vDSM), the version of Synology's award-winning operating system designed to run as a virtual machine within VMM.

Running high-risk services that are exposed to the internet on a walled-off instance helps secure the rest of your IT setup. This includes the host's hardware and software, as well as other VMs. This makes virtualization attractive even when the host and guest run the same operating system, such as DSM.

Virtualize DSM Services and Run Many Synology NAS

Synology users have access to a host of native productivity, networking, and communication tools that communicate with local area networks and the internet. Running such services on Virtual DSM can add an additional layer of security between applications on the one hand, and systems and data on the other.

Create multiple virtual instances of the DSM operating system and web-based interface for different user groups to access remotely. Allow other users to configure, administer, and utilize DSM applications without granting access to core systems of your Synology NAS. Grant easy remote access to others using free share links over the Synology QuickConnect service.

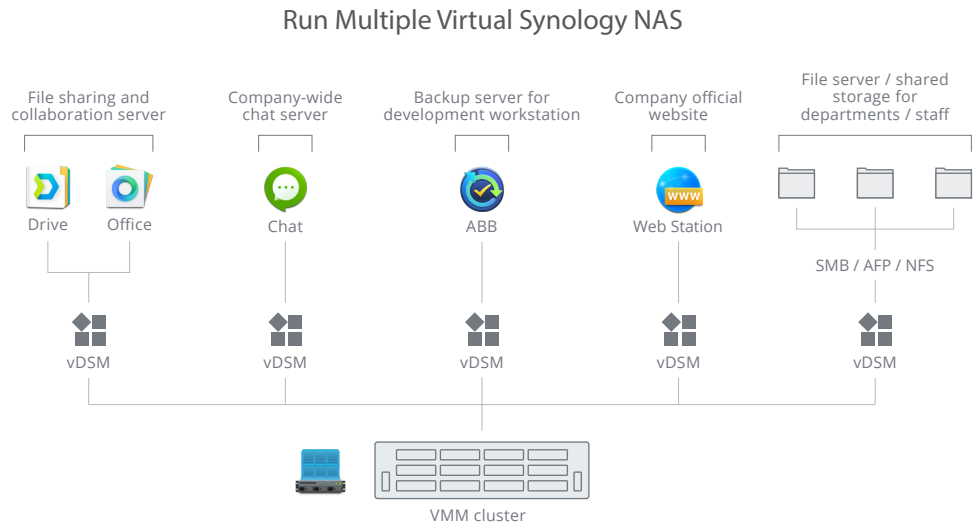


Figure 2: Administrators can run several instances of Virtual DSM on one physical Synology NAS to isolate certain DSM applications, boost service availability, or provide Virtual DSM machines for use by other users. This in essence creates multiple virtual Synology NAS.

Combine DSM With Linux and Windows Services

Among the primary benefits of using Synology VMM is the ability to combine Synology packages running on your Synology NAS' native DSM and Virtual DSM with services that require Linux and Windows servers in a highly flexible and expandable setup.

DSM and Virtual DSM alike offer industry-leading data protection, surveillance, and network management features only available on Synology hardware. Small- and medium businesses that require limited Linux and Windows-based services can leverage VMM to retain a clean Synology setup, while also maintaining high availability

Create Virtualization Clusters and Perform Live Migration

VMM Pro lets you cluster together two to seven Synology NAS, and run and manage VMs across multiple host devices from a single console. Live migration lets you move running VMs from one device to another in their current state, without disconnecting from networks. Applications need not restart and crucial services can be back online in a matter of seconds.

Host virtual servers and storage on separate computing and storage nodes to optimize performance. Adapt to changing workloads and configurations by flexibly managing and moving around virtual machines. Minimize downtime by migrating VMs to another Synology NAS ahead of planned maintenance.

Protect Uptime With a Virtual High-Availability Cluster

For certain applications, guaranteed access is of the essence. Mail servers and databases are prime examples. To keep such systems running around the clock, it is important to protect them from hardware or system failure. A high-availability cluster ensures that services can instantly failover to another hardware host.

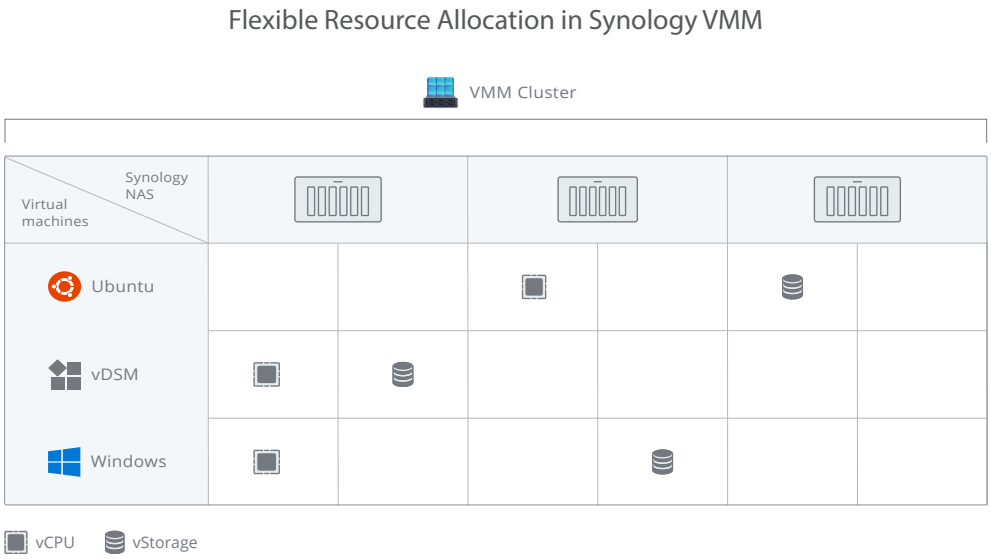


Figure 3: Users can assign Virtual CPUs and VM storage at will to different Synology NAS in a Synology VMM cluster. In a VMM cluster, computing and storage are integrated on one hardware platform. For each VM, each NAS can be designated a computing or storage node, or can be used to fulfil both roles.

When a VMM High Availability cluster detects signs of system malfunction on a Synology NAS, it automatically performs Live Migration of all protected VMs to other hosts. If the original host unexpectedly disconnects or powers down, an identical copy of the VM is started on a passive host to get services running as fast as possible.

Synology High Availability allows a complete Synology NAS to failover to another device. However, a passive device must be running at all times and cannot be used independently. VMM High Availability requires a compatible hardware setup that includes at least three Synology NAS systems, yet each device can be used independently for other applications.

Fully Back Up and Instant Restore Machines

Synology's backup solutions let users maintain full and comprehensive copies of their file systems, ensuring that crucial data is not lost. With VMM, businesses can take their backup plans further by backing up complete virtual servers as they are, including system configuration, and application and system status.

VMs reside on top of your Synology NAS' regular operating system, making it possible to create full system snapshots fast. In addition to restoring systems in their entirety, backing up VMs makes it possible to get a backup copy of a system up and running in seconds, reducing your Recovery Time Objective for resuming services.

Those who use the Active Backup Suite to create emergency copies of physical and virtual machines or operating systems on other computers can use VMM to run a live copy of their backed-up VMs on their Synology NAS to achieve fast service recovery when other devices crash.

Clone Virtual Machines and Sandbox Experimental Setups

Virtual Machines are ideal containers to test the stability of entire systems and applications that require changes to system configuration before their implementation. A VM setup isolates applications from operation-critical services and the corporate network while allowing users to set a variety of hardware and network parameters.

VMM allows you to create large numbers of snapshots and clones of test systems. That means setups can be restored, run in parallel for comparison, and shared. Successful setups can also be multiplied to offer identical services for multiple clients, user groups, or departments.

Synology NAS users can leverage their devices' hardware resources to build and test software setups. Depending on the capacity of your Synology NAS, such setups can be made to run on your Synology hardware permanently, or migrated to other platforms, such as the VMware ecosystem or Microsoft's Hyper-V.

Share VMs With Others the Easy Way

Among the benefits of virtual systems is that they can be accessed remotely and from many desktops. This lets you access system setups remotely and allows you to share machines with other users or administrators. Use this function to give users access to platforms for testing, share and simplify administration duties, demonstrate systems, and more.

VMM relies on Synology QuickConnect to make sharing access to VMs extremely easy. The share link function generates a hyperlink that lets receivers access the operating system's graphical user interface in any browser window.

VMM share links eliminate the need to install dedicated software and set port forwarding or other network settings. Sharing account details is not necessary, as separate access passwords can be set for each shared VM. The function is disabled by default and less suitable for operational high-security applications, is an ideal tool to enable collaboration on less critical systems.

Run Older Services in a Legacy Environment

Your office hardware is nearing the end of its lifespan and you plan to upgrade to newer systems. However, reluctance to lose one or more essential services that have been running stably on older platforms prevents you from fully renewing IT infrastructure. Virtualization can help.

Running older systems in a VM allows you to simulate older software environments without the administrative burden of running parallel systems, removing a barrier to hardware consolidation. Services originally created in VMs can be migrated to new systems more easily in the future, lowering the cost of change.

Synology VMM supports various formats for importing and exporting system images. See Selecting and Importing Operating System Images for more information. An up-to-date list of officially supported operating systems can be found on our website.

Configuration Guide

Creating virtualized environments requires detailed hardware planning, whether you intend to set up essential IT infrastructure or a small number of experimental instances. Some virtualization scenarios may require specific add-on components or configurations.

This section guides you through the essential considerations and requirements for different uses of Synology VMM. It also explains how the different elements of a VMM cluster interact.

Please beware that neither minimum requirements nor recommended setups are guaranteed to support your specific use case. We therefore strongly recommend that you test the viability of your plans using VMM's many free features and our free 30-day VMM Pro trial, available for each compatible Synology NAS.

Essential Checks Before You Start

Before you proceed with your virtualization plans, please check whether your hardware meets the minimum requirements for execution. The most up-to-date list of compatible Synology NAS can always be found on the VMM package page. This tells you whether your device can run VMM.

Compatible file system

In addition to the right model number, your prospective host server should have at least one volume configured with the Btrfs file system. VMM does not run on any other file system. Btrfs enables many of the advanced data protection and space reclamation functions for VMs on Synology NAS.

Number of virtual machines

If your Synology system is capable of running VMM, it is now time to check whether your planned applications can be successfully virtualized. Recommended VM instances per host range between 2 and 32 machines for different Synology NAS models. Exact numbers of recommended guests per host can be found in Support Center.

These numbers are based on VMs with 1 virtual CPU (vCPU) and 1GB of RAM each. Many typical applications will require more resources. (Minimum recommended memory for many operating systems is 2GB).

This article provides model calculations to estimate the true number of VMs that can run on your system. Please note that these are based on the parameters you set for each VM. To arrive at a realistic estimation of VM requirements, it is best to test actual virtual resource use of your application in VMM using the actual operating system to be used.

VMM Pro features

For larger applications, you can check whether a VMM Pro license is required for your intended purposes. Refer to the Features Comparison section on the VMM Pro license page.

1. Selecting and Importing Operating System Images

Synology VMM supports a range of popular operating systems for desktop and server use. These currently include Virtual DSM, Windows, Windows Server, multiple versions of the Ubuntu, Fedora, CentOS, Red Hat Enterprise Linux distributions, and limited support for OpenSUSE and Suse Linux Enterprise Desktop.

An updated list of officially supported systems and versions is maintained on the VMM product page. These operating systems function well using VMM's default settings and interfaces. Unsupported distributions and older versions may also run well on VMM, but often require that you select different virtual hardware settings.

Importing images

Operating system installers can be imported from your Synology NAS or computers as an .iso image and installed on VMM as you would on a physical desktop. Existing VMs can be exported and imported as Open Virtual Appliance (.ova) disk images. The .ova format is a .tar archive file that is unpacked to many .vmdk virtual disks.

Other supported VM disk image formats are .vmdk, .vdi, .vhd, .vhdx, .img, and .qcow2 files. When you import these formats, VMM processes them into a disk image that it can run. However, converting other formats to .ova format before importing ensures the best compatibility, as it allows for most of the original configuration to be preserved. VMM currently supports a maximum of eight virtual hard disks per machine.

Guest agent and guest tools

Finally, for supported as for unsupported systems, full functionality is only available if Synology Guest Tool (Windows) or QEMU Guest Agent (Linux) is installed. The agent enables VMM to take file system consistent snapshots, detect virtual machine IP addresses, and shut machines down safely.

2. CPU and Memory Requirements

The two parameters most likely to constrain your virtual ambitions are computing power and available memory. A VM's computing resources consist of virtual CPU cores (vCPU) and virtual RAM (vRAM), whose performance depends on their physical equivalents on the host.

Assigning virtual CPUs

Users can assign more vCPUs than there are physical cores to increase VM density and host utilization. Up to two or four (in VMM Pro) vCPUs can be created per physical CPU thread. However, CPU usage must be closely watched, as insufficient capacity can slow common processes down extremely or even precipitate crashes.

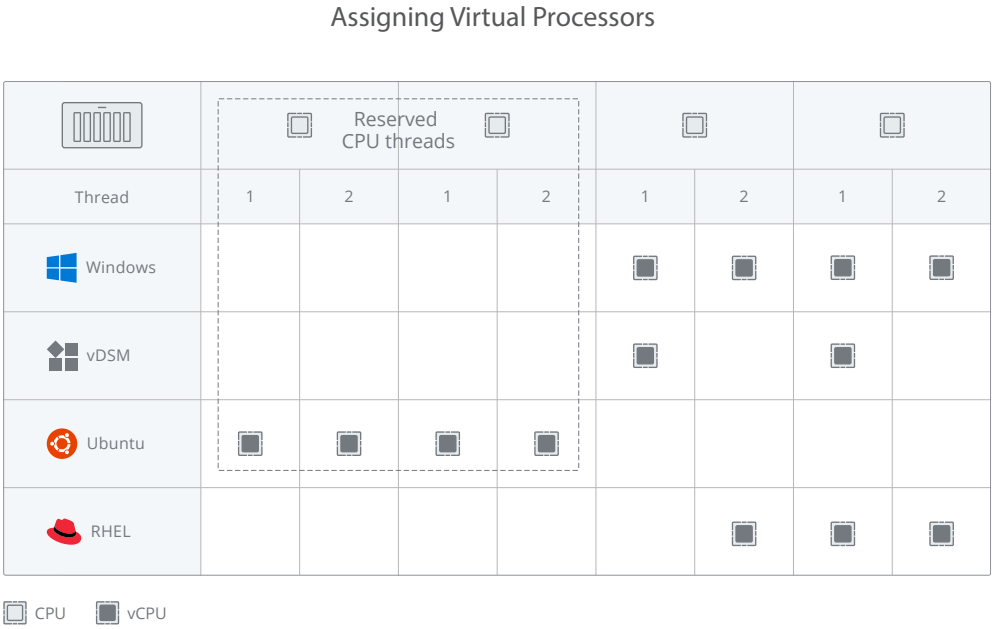


Figure 4: In this example, four CPU threads on two physical CPU cores are reserved for one Ubuntu Linux VM, while Synology VMM divides the other vCPUs over four remaining non-reserved threads based on relative load. Users can specify the number of vCPUs they wish to assign to each VM and whether these are to share physical CPU resources, or run on reserved CPU threads. Virtual Machine Manager automatically balances loads between non-reserved CPU threads.

In VMM Pro, users can assign VMs relative weight, giving important services higher-priority access to the physical CPU. Dedicated physical CPU threads can be reserved for VMs running essential services, ensuring they can use the full capacity of one or more CPU threads.

Higher-spec Synology NAS models, including the XS and FS series, sport higher-performance CPUs that can handle many applications. These are recommended for use as virtual host. In practice, RAM memory will often present the main bottleneck.

Reserving system memory

Unlike CPU capacity, RAM memory is reserved for each VM and for that VM only. That means depending on your VM specifications, RAM may provide a hard upper limit for the number of

machines you can run and your ability to provision for temporary capacity spikes.

Luckily, RAM memory is easily expandable with fully supported DDR3 and DDR4 memory modules for Synology NAS. Adding memory to computing nodes is highly recommended when planning for intensive VMM applications. Meanwhile, users can reduce RAM usage by employing lightweight operating systems and optimizing configurations.

The following parameters contribute to RAM memory use:

Virtual Machine Memory Use	
1.5 GB 10% of RAM	Memory reserved for Synology host - If host memory is 15 GB or smaller - If host memory exceeds 15 GB
250 MB	Virtual machine
80 MB	Virtual CPU
2 GB 2 GB 1 GB 1 GB	Operating system - Windows 10 (64-bit) - Ubuntu 16.10 (64-bit) - CentOS 7.3 - Virtual DSM

Memory approaching capacity

When memory use on one virtual host appears to approach the limit, users running a VMM cluster with several hosts can perform live migration of VMs to a host with more available memory. However, it can pay to take a close look at the resource use reported by your guest operating system before concluding it is short on RAM.

While a VM is running, all of the memory you assigned to it in VMM is permanently shown as in use in your DSM Resource Monitor. In reality, the guest operating system may not be using much of its memory quota.

Linux operating systems tend to report that almost all their memory is in use. A closer look (for instance, using the "top" command) might show that most excess RAM is used as temporary cache. That means it is available for applications, or you could reassign RAM to other VMs.

Upgrading system memory

A full list of compatible RAM modules for Synology NAS can be found on our compatibility pages. Depending on the CPU platform of your Synology NAS, there might be different requirements for expanding system memory. This article provides general guidance, while more specific information can be found in your device's Hardware Installation Guide.

3. Appropriate Storage Setups

Using Synology NAS for virtualization simplifies virtual storage configuration significantly. At the same time, advanced choices are available for those eyeing professional, large-scale

implementations. These include high-performance drives, cache expansions, connectivity enhancements, as well as virtual interface choices that can speed up processes.

Hard drives and SSDs

The physical drives on your VM's storage node are the most important predictor of virtual drive performance.

Different VMs are stored in different locations on physical disks, and running several VMs concurrently can require a large number of random read and write input-output operations per second (IOPS). Traditional HDDs, which have a rotating platter design, may struggle to perform such operations efficiently.

Using all-SSD storage for the storage node is recommended and can significantly speed up VM operations. Compatible SSD drives are available for FlashStation, as well as DiskStation and RackStation models. Alternatively, adding SSD cache to your HDD-based setup will significantly speed up virtualized operations.

Adding an SSD cache

Some Synology NAS models have internal slots for additional SSD cache. For other models, the Synology M2D18 and M2D20 SSD adapters offer an effective way to expand cache memory.

Full updated lists of supported SSD modules for each interface are available on our compatibility pages. Consult our Support Center to find out which Synology NAS models support adding SSD cache and using which protocol.

Virtual disk interfaces

Users have a choice of three virtual disk controllers. In order of rising average speed, users have a choice of IDE, SATA, and VirtIO SCSI.

IDE is compatible with almost all operating systems and SATA works with most modern operating systems (released after 2003). VirtIO, the fastest option, is supported in most Linux distributions, while Microsoft Windows requires separate installation of VirtIO drivers.

The VirtIO interface is included in the Synology Guest Tool .iso image for Windows available in VMM.

A comparison of disk controller performance can be found in Comparing Configurations below. Storage IOPS performance statistics for the latest and older Synology NAS models are constantly updated on our performance pages.

Virtual disk space reclamation

VMM version 2.3.0 and DSM 6.2 and above support virtual disk space reclamation. With the SCSI UNMAP or ATA TRIM commands available in Windows and most Linux distros, space held by virtual disks in host HDD and SSD storage can be released after files are deleted or disks are formatted. Space reclamation may affect system or disk performance.

For more information on remote disk performance, refer to Storage nodes.

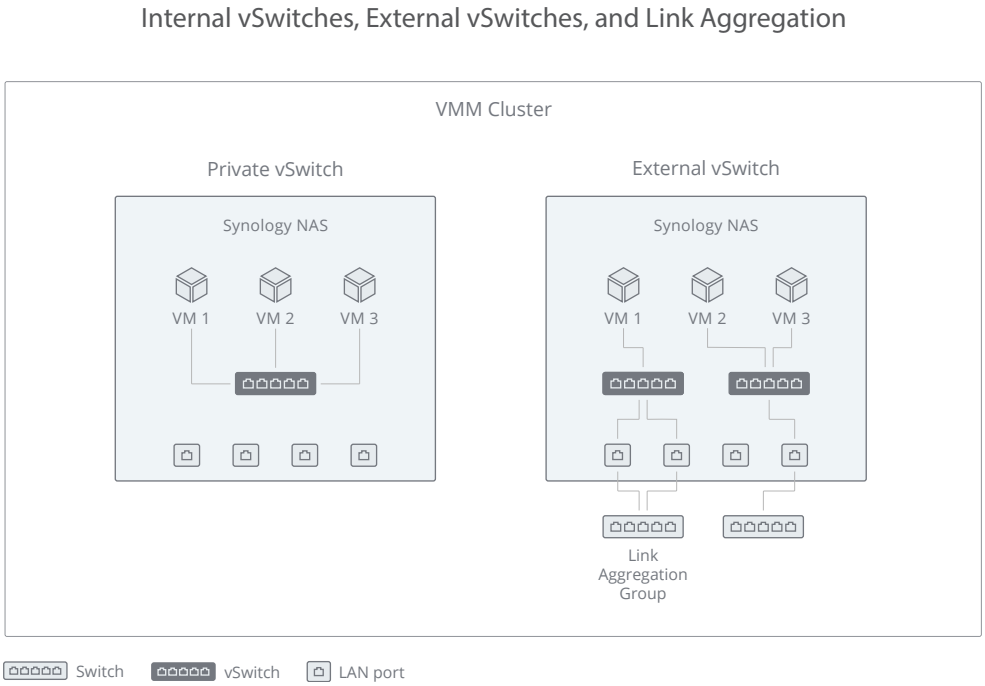


Figure 5: Virtual switches (vSwitches) can be configured to create an internal network between virtual machines, or they can be matched with LAN ports on your network interface card and connected to external networks. In the setup on the left, the three VMs can connect only to each other. On the right, one VM uses two LAN ports for better external connectivity (link aggregation), while two other VMs are conected to each other and to the network using only one LAN port and one external vSwitch

4. Network Connections

A management network (connecting hypervisor and VMs) and cluster network (connecting hosts) are automatically created on VMM and do not need to be configured separately, as with certain other virtualization solutions. While you cannot manage these networks or disconnect your VMs, they are purely used to manage your machines and cluster.

Virtual switches

Each instance of VMM creates at least one virtual switch (vSwitch) on its host Synology NAS called "Default VM Network" and connected to all active physical LAN ports. You can edit this switch or create new vSwitches and attach these to one or several LAN ports. However, you do not need to connect VMs to any vSwitch if they do not require network access.

An external vSwitch connects VMs to your LAN and the internet, using one or several of the physical LAN ports or logical network interfaces of your Synology NAS' network card. Machines connected to an external switch have direct access to your LAN and the internet using the host's connection.

A private vSwitch connects VMs only with other VMs running on the same host, creating an internal host network similar to a local LAN.

Network addresses

Virtual machine IP addresses with LAN access are assigned like other IP addresses by your

local network, either via DHCP or manual configuration. If connected to a private vSwitch, they are (also) assigned a local IP address on the host network.

Creating a Virtual DSM instance allows you to manually configure an IP address. However, VMM can only detect guest IP addresses on other operating systems if the QEMU agent is installed and running.

Virtual network interfaces

VMs connect to the network with virtual network interfaces. Four types of interface are supported in VMM: e1000, rtl8139, VirtIO, and SR-IOV. The first two standards offer the widest compatibility. VirtIO supports faster connections and is recommended, but requires separate installation on Microsoft Windows VMs using the Synology Guest Tool.

SR-IOV (Single Root I/O Virtualization) is a high-performance interface that can drive down I/O latency and CPU use, but requires hardware with built-in support. It allows several VMs to share PCI hardware resources and performs almost as well as a physical network card, but does not support VM suspension, live migration, and VMM High Availability.

Network bonding

Link Aggregation, also called network bonding, is a recommended function that raises expected cluster availability. Each host combines at least two active LAN interfaces into a single Bond network interface. The LAN ports in a Bond connect to the same network and provide fault tolerance in addition to more bandwidth.

Even without bonding, users can add several LAN ports to each vSwitch to increase redundancy. In that case, VMM will automatically choose between ports to achieve load balancing and switch over to an alternate port in case of network failure.

5. Share Links and External Access

Virtual machines running on Virtual Machine Manager can be accessed remotely in four ways: through the VMM interface on your Synology NAS, with easy-to-use share links, through remote desktop software, and using the command line over Secure Shell (SSH).

Access via Synology VMM

As long as your Synology NAS is online, you can power on, power off, and access any virtual machine running on it directly in VMM in your browser. You can also enable direct access to a machine in any browser by creating one or more VMM share links. Both methods work regardless of whether VMs are connected to the internet.

Remote access protocols

VMs that are connected to the internet and have their own IP address can also be accessed using conventional remote access protocols. Remote Desktop Protocol (RDP) and Virtual Network Computing (VNC) client applications let you operate your virtual machine's desktop graphically. With SSH, you can control active machines using the command line.

All of these solutions let you control VMs that are online and running. However, only Virtual Machine Manager and VMM share links provide access to machines without network

connection. Access through VMM on Synology NAS is also required to boot machines that are powered off, install and update operating systems, change BIOS settings, or guarantee successful reboots.

Synology VMM API

The Synology VMM API allows you to perform some of these routine management operations without accessing the DSM user interface. For more information on API requests and syntax, see the Synology VMM API Guide.

6. Running Regular or High-Availability Clusters

Clusters allow you to boost efficiency and availability by separate computing and storage nodes, migrating machines between nodes, and creating failover mechanisms. The hosts in a cluster have the ability to monitor each other.

Setting up a VMM virtualization cluster has consequences for network infrastructure, computing power, and storage performance, which are reflected in our recommendations for cluster network configurations and cluster nodes.

Providing nodes with the right resources is essential to creating an optimal cluster. Ideal clusters feature different nodes that are optimized for their specific roles. The below sections explore the best ways to optimize your Synology NAS and network for cluster use.

a. Computing nodes

Computing nodes run your VMs, and handle communication with the local network and the internet. Their configuration determines the maximum number and speed of your VMs. Higher-spec CPUs, RAM, and network interface cards are recommended on compute nodes.

Adding the maximum amount of RAM to computing nodes and using multiple network interfaces boosts performance. Using all-SSD storage likewise speeds up VM operations. Performance comparisons can be found under Comparing Configurations.

An essential feature of any cluster (VMM High Availability and regular) is the ability to migrate VMs to another node ahead of expected downtime or to balance workloads. Ideally, two or more Synology NAS with very similar capabilities should be configured as computing nodes.

Less demanding services can also temporarily be migrated to weaker nodes, such as storage nodes. At a minimum, this requires that the nodes share the same CPU architecture. We maintain a comprehensive list of CPU and RAM configurations in Support Center.

b. Processor compatibility

Different CPUs come with different instruction set architecture features that significantly boost performance for certain processes. Operating systems and applications detect such features when booting or launching, and adjust their operations to the host CPU.

Moving a running VM (live migration) or a VM in a saved state (failover) to a node with a different processor architecture without rebooting can cause machines and applications to fail or crash. CPU compatibility mode is a functionality that allows live migration between two hosts with different processors.

When CPU compatibility mode is activated, VMM will hide CPU features that are not common to most processors from the VM. In effect, it will simulate the performance of an Intel Core 2 Duo processor. This allows running applications to continue successfully with a different processor. However, enabling the function can sharply reduce CPU performance.

Among the functions most reliant on special CPU features are AES-256 encryption and compression processes, which can be heavily impacted when compatibility mode is enabled. In other words, performance penalties do not only depend on CPU speed, but also on the specific features included.

Test results in the Comparing Configurations section compare the impact of CPU Compatibility Mode on cryptography, as well as on operations that rely less on special CPU features.

For CPU compatibility mode to work, processors need to be from the same manufacturer. The option needs to be enabled before booting the VM's operating system. Enabling CPU compatibility mode is not necessary if you plan to shut down a VM and reboot it on another node.

For a complete list of CPUs used in our products, refer to this up-to-date list.

c. Storage nodes

On storage nodes, compatible SSD cache can be utilized to significantly enhance read/write performance. Random writes, especially, can benefit from a memory buffer. Using all-SSD Synology NAS for storage nodes is highly recommended to speed up I/O-intensive applications.

An IOPS performance comparison for an HDD-based storage node with and without SSD-cache can be found under Comparing Configurations. Learn more about installing additional SSD cache on your Synology NAS in Support Center.

Synology supports a large number of SATA and SAS flash drives. In a previous white paper, we discussed how to increase the performance of Synology NAS and IP SAN. Keeping virtual disks and VMs on the same host Synology NAS achieves the best storage performance.

d. Cluster networks

When you configure separate computing and storage nodes, a cluster network is created. If it has to share its physical network with other hosts and applications, that can increase data transfer latency. Cluster networks have several other essential functions that can also be hampered by saturated network connections.

A virtualization cluster ideally consists of an uneven number of nodes, which can then make decisions and monitor cluster health collectively by majority, or "quorum." A fast heartbeat connection allows nodes to do this and to properly order events in time.

Delays on the network that affect the heartbeat can slow down all processes. Cluster networks should therefore ideally be isolated physically (using separate infrastructure) or logically (using VLAN and vSwitches). Each host Synology NAS must be assigned a static IP address.

Cluster Network Communications	
• Cluster heartbeat • Cluster metadata • VM to iSCSI storage • VM live migration	• Storage live migration • Image transmission • VM remote replication

e. Cluster network communications

Replicating, backing up, and migrating VMs and their disks between hosts increases data traffic. Network cards of 10GbE or above are recommended if such operations are performed often. Fast connectivity for the cluster network reduces I/O latency.

If your VMs are expected to require larger bandwidth, we maintain a complete list of compatible and available 10GbE, 25GbE, and 40GbE network cards on our website.

f. High-availability clusters

VMM High Availability clusters require more resources than normal virtualization clusters, but do not demand the dedicated setup necessary for a Synology High Availability (SHA) cluster. They require more Synology NAS nodes, but allow for more flexible network configurations and device use.

VMM High Availability vs. Synology High Availability	
Synology High Availability	VMM High Availability
Synology NAS x 2	Synology NAS x 3
Dedicated passive server	Failover host(s) with sufficient capacity
Physical heartbeat network	Fast enough shared network
Identical devices and configuration	Identical CPUs on two nodes
Incompatible DSM packages removed	DSM packages not affected

Major technical differences between SHA and VMM High Availability clusters include the number of nodes in a cluster, the nodes' utilization, and how nodes are connected.

An SHA cluster is made up of two Synology NAS, one of which acts as a dedicated passive server and is not available for use. The two nodes are directly connected using a dedicated Ethernet cable. Their configuration is fully identical. DSM packages that are not SHA-compatible cannot be used.

VMM High Availability clusters require at least three hosts and can accommodate up to seven, all of which can run their own independent DSM applications and VMs. In the minimum setup, two Synology NAS function as computing nodes, while a third serves as a shared storage node. VMs can failover between the computing nodes.

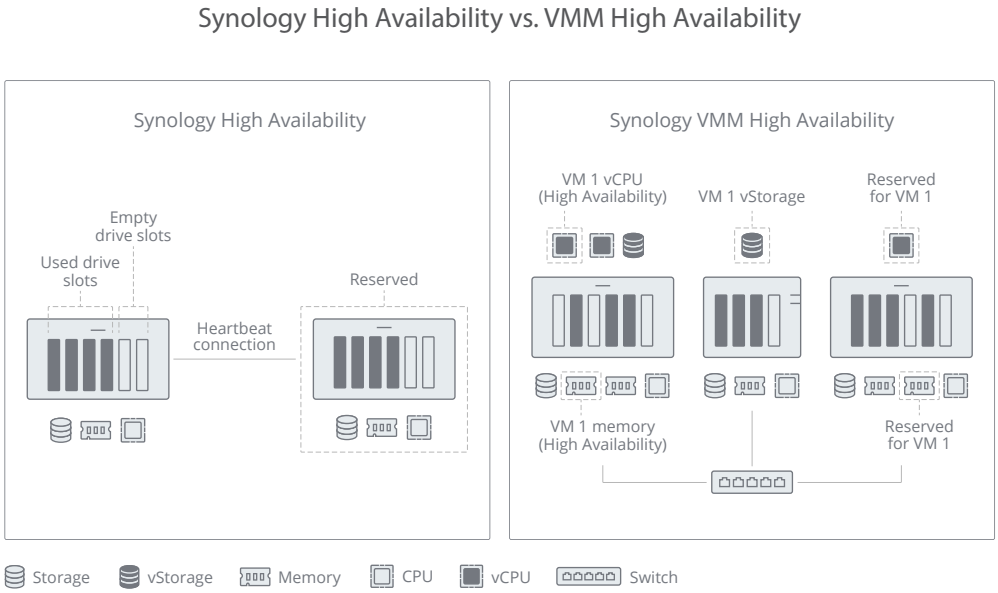


Figure 6: Synology High Availability and VMM High Availability require different hardware setups. While Synology High Availability relies on an identical passive server and physical heartbeat connection, VMM High Availability only reserves specific system resources, uses a regular LAN connection, and can work with different models or differently configured Synology NAS.

All VMM High Availability nodes are connected over a virtual cluster network that can share the same network with other VLANs. Nodes do not need to be dedicated to one role. However, designated failover hosts need to have similar capabilities to the original host and the resources of each highly available VM will be permanently reserved on the failover target.

Network connectivity must be fast, stable, and redundant, preferably using all available LAN interfaces and configuring network bonding using Link Aggregation. For instance, four LAN ports can be joined into two bonds and connected to two network switches.

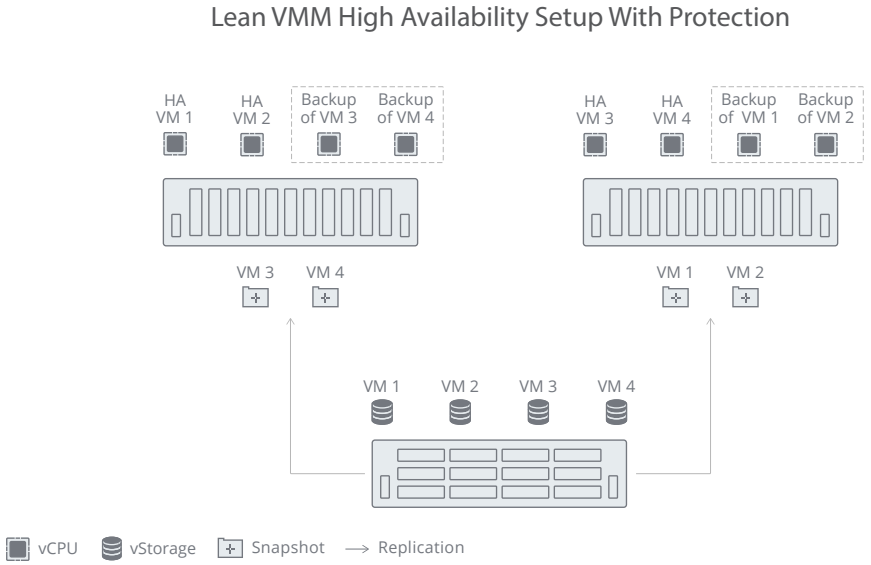


Figure 7: A full VMM High Availability cluster with a replication plan can be created with three Synology NAS. In this example, two devices both host two virtual machines and serve as failover destinations for two more VMs. Data from the single VM storage node are replicated to the two computing nodes, providing extra redundancy.

Case Studies

Der SwelTzer, Switzerland

Virtualized and non-virtualized solutions on Synology NAS were used together to set up complete digital office infrastructure for a medium-sized service provider.

The new setup is highly scalable and combines multiple disparate IT services, yet is easily managed. It also maximizes uptime by combining a VMM High Availability cluster, redundant network configuration, and advanced security features — all on four Synology NAS.

Four RS3617xs+ were set up as a cluster. Two were configured both as MailPlus servers and as VMM computing nodes, with RAM expansions to 64GB in addition to SSD cache. The other two were configured as VMM storage nodes and fitted with SSD cache in addition to HDD to speed up storage operations.

For the network, a central stack with two switches and a cluster with two firewalls were used. Two of the four LAN ports on each NAS were redundantly connected to each of the two switches using Link Aggregation. The network was separated by VLAN on layer 2 and routing firewall on layer 3 to protect the Synology NAS from unforeseen events.

The two VMM computing nodes were set up to operate five VMs, of which four run on Virtual DSM and one on Linux, while simultaneously operating a non-virtualized MailPlus Server cluster.

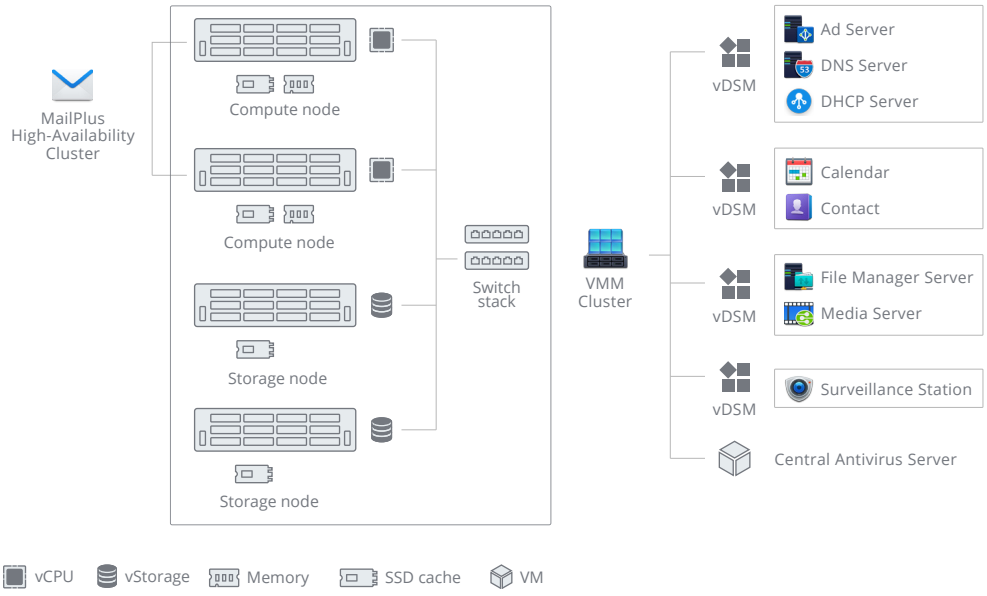


Figure 8: Four Synology RS series devices are used to to run four Virtual DSM servers and one Linux VM on a VMM High Avalability cluster, as well as a Mailplus high-availability cluster.

In this design, the first Virtual DSM instance provides administrative services, the second acts as a file server, a third one is used for Calendar and Contacts, and the forth runs Surveillance Station. One Linux VM works as centralized antivirus server to protect clients.

The separation of the services through multiple VMs makes the best use of available resources. When events or errors occur, one of the storage nodes can take over administrative services, such as CMS and HyperBackup Vault, for all physical and virtual DSM instances to ensure service continuity.

Synology, Taiwan

Synology Virtual Machine Manager is used extensively at Synology Headquarters. The native hypervisor is used to virtualize and protect DSM services that are essential to our day-to-day operations. Multiple Virtual DSM machines are used to boost flexibility of deployment, increase redundancy, and simplify recovery in two elegant setups.

Employees across seven company offices and on the move worldwide make intensive use of Synology Chat and other DSM applications for communication and cooperation. In addition to busy network traffic, these applications depend on sizable databases and archives that continue to grow on a daily basis. This presents both expansion and recovery challenges.

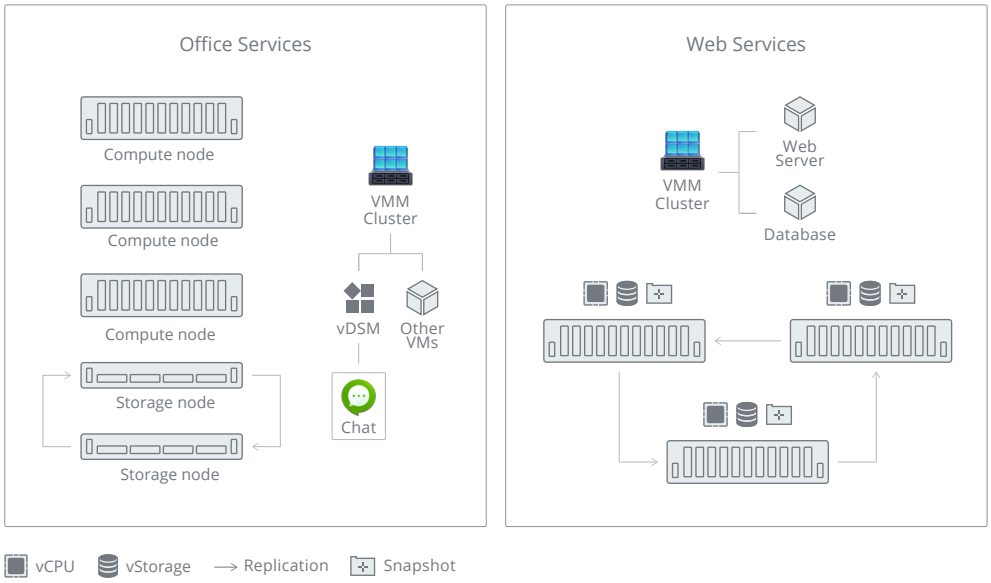


Figure 9: In the example on the left, a regular VMM cluster is used to run and back up essential office services at Synology headquarters. On the right, Synology set up a lean VMM cluster configuration in a remote location to run web services, with all devices serving as computing, storage, and backup nodes.

A Synology VMM cluster provides the uptime, flexibility, and protection options that dynamic services need. A Virtual DSM machine over 2 TB in size (and growing) hosts Synology Chat Server. It runs alongside other VMs on three powerful FS series all-flash computing nodes. Mass storage is provided by two RS series storage nodes in all-flash configuration, each of which replicates to the other for added redundancy using a dedicated network.

In this recommended setup, an even number of storage nodes enables two-way replication

of virtual machines. An uneven total number of nodes ensures that the cluster can reach a quorum (majority) for decision-making and allows one computing node to be taken offline for maintenance without losing redundancy.

A very different, lean setup was chosen to run webservices for the Synology website. Three FS series compute nodes in an all-flash configuration each fulfil both computing and storage roles for various VMs. The minimum recommended number of three nodes provides a measure of redundancy, while recovery demands are met by having each node replicate its data to one other node.

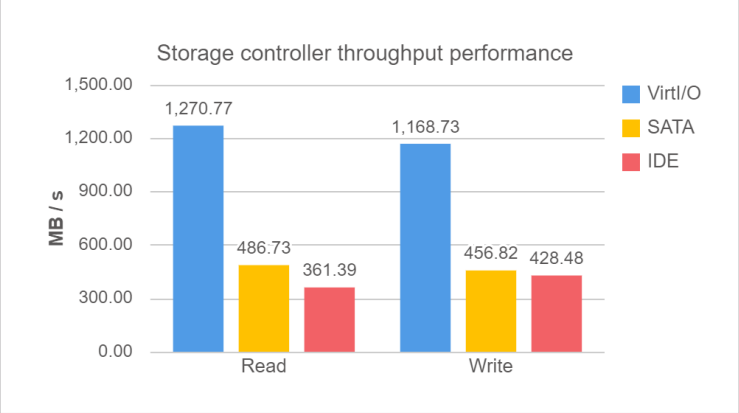
Comparing Configurations

Below we present comparisons of different physical and virtual hardware configurations to help you assess the feasibility of your virtualization setup. The data provided here supplement the general performance statistics we provide for our hardware products on our performance pages.

Storage Controller Throughput Performance

A comparison of virtual drive controllers using the Synology DS3617xs shows a moderate performance gain when using SATA over IDE drivers. Meanwhile, using VirtIO SCSI drivers more than doubles performance as measured by speed of data throughput.

Throughput performance (megabytes per second)			
DS3617xs	VirtI/O	SATA	IDE
Read	1,270.77	486.73	361.39
Write	1,168.73	456.82	428.48

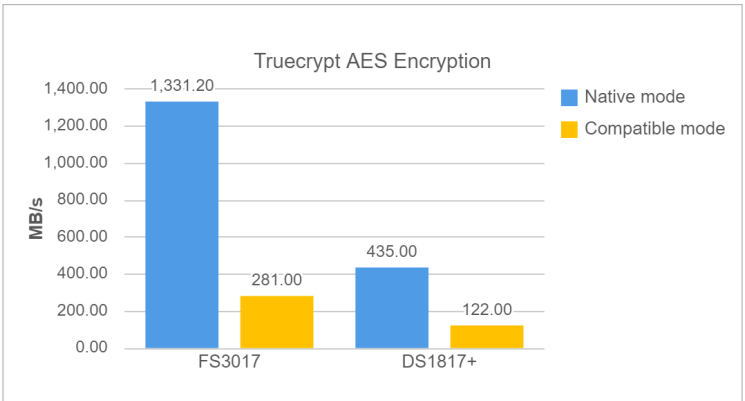


CPU Compatibility Mode

To illustrate the significant difference in general system performance between setups with CPU Compatibility Mode enabled and disabled, we measured the speed of AES-256 cryptography operations on the all-flash Synology FS3017 and the DS1817+, which has slower I/O performance. We also tested an operation less affected by CPU Compatibility Mode.

The AES-256 cryptography figures represent the mean of encryption and decryption speeds. They show a marked decrease in performance to less than one-third the speed on the DS1817+ and almost one-fifth the performance on the faster FS3017. The penalty is more pronounced on the higher-spec model with more hardware support for encryption.

Mean encryption / decryption speed (megabytes per second)		
Model	Native mode	Compatible mode
FS3017	1,331.20 MB/s	281 MB/s
DS1817+	435 MB/s	122 MB/s

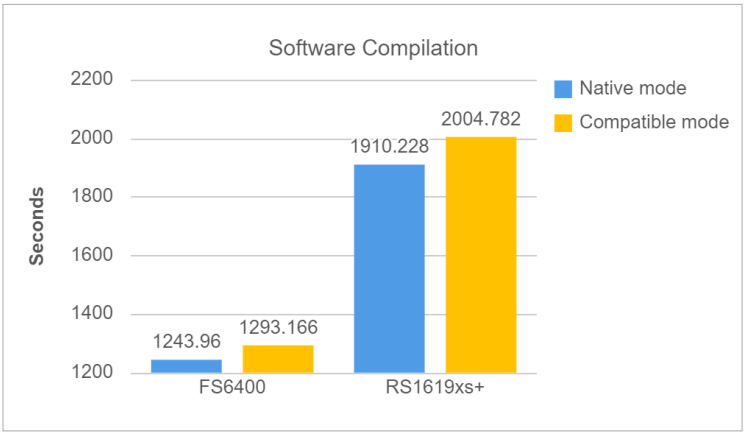


Encryption speed provides only one measure of CPU performance. For other operations, enabling compatibility mode may not yield speed differences of the same magnitude. This includes software compilation, regular backup tasks, and other operations that rely on regular computing features. We illustrate this case with a compilation speed comparison.

Virtual machines on two Synology NAS were used to compile the Virtual Machine Manager software package. The results show only a slight decrease in compile performance when CPU Compatibility Mode is enabled. They also show a large difference between models, with the XS+ series model having a more powerful processor unit.

For a complete list of CPUs used in our products, refer to this up-to-date list.

Software compile time (seconds to completion)		
Model	Native mode	Compatible mode
DS1619xs+	1243.96	1293.166
FS6400	791.413	826.382

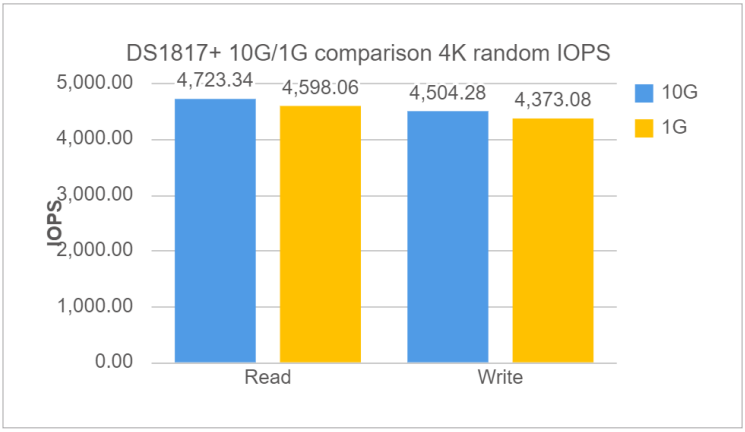


Fast and Slow Network for Storage

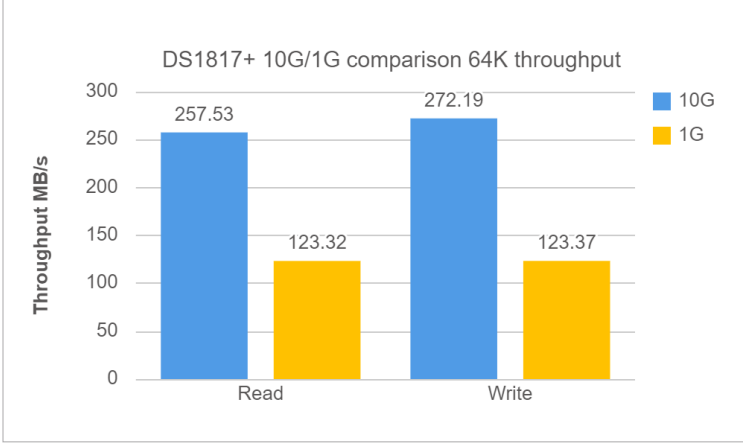
We tested the influence of network speed on storage operations by looking at maximum random IOPS and maximum data throughput using 1 Gigabit and 10 Gigabit Ethernet connections.

The results show a relatively small effect on the maximum number of random 4KB IOPS, but a clear difference when transmitting larger files, where the nominal transmission limit of 125 MB/s for 1G Ethernet is reached.

Remote storage performance (4KB block random IOPS)		
DS1817+	10 Gigabit	1 Gigabit
Read	4723.34	4598.06
Write	4504.28	4373.08



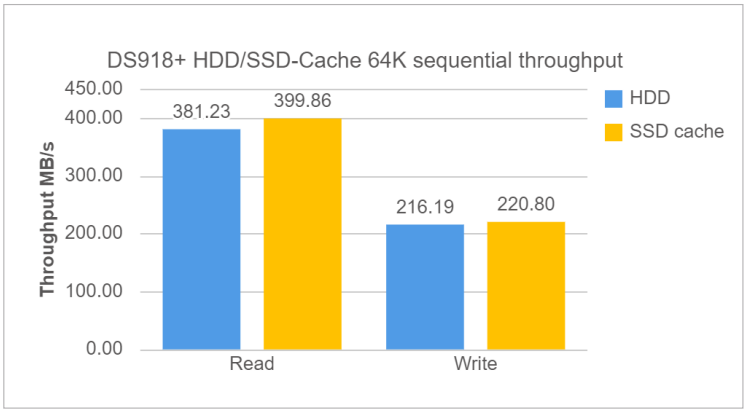
Remote storage performance (64KB block throughput in MB per second)		
DS1817+	10 Gigabit	1 Gigabit
Read	257.53	123.32
Write	272.19	123.37



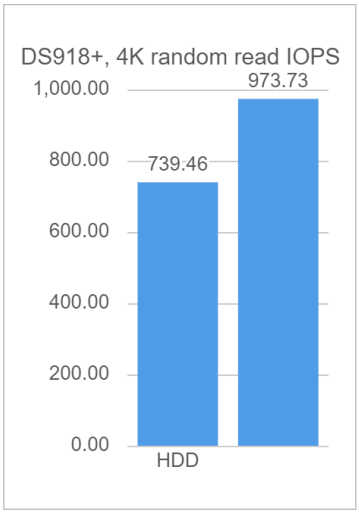
Benefits of SSD Cache on Storage Node

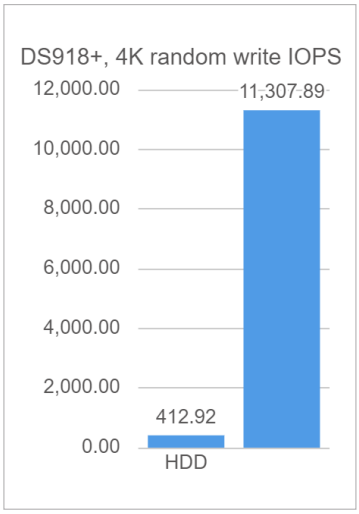
The data provided below show a significant, but limited effect of SSD cache on data throughput volume, whether write or read. However, a large improvement can be seen in processing speed for small random IOPS, and adding SSD cache gives an outsize boost to random write performance, as long as there is enough space left for the write buffer. (At high data volumes or large packages sizes, performance might not benefit as much.)

Storage performance (64KB block sequential throughput in MB per second)		
DS918+	HDD	HDD + SSD Cache
Read	381.23	399.86 (+4.9%)
Write	216.19	220.8 (+2.1%)



Storage performance (4KB block data random IOPS)		
DS918+	HDD	HDD + SSD Cache
Read	739.46	973.73 (+32%)
Write	412.92	11307.89 (+2645%)





Conclusion

Synology Virtual Machine Manager allows you to combine virtual services with Synology's vast software ecosystem on the same hardware platform. Run any of the services available in Synology's award-winning DSM operating system alongside virtual machines, or create multiple virtual Synology NAS with Virtual DSM to accommodate different services or users.

Virtual Machine Manager makes it easy to set up virtual machines or virtualized infrastructure for small and large deployments. Synology's native hypervisor helps you boost hardware utilization and flexibility of deployment. It also offers a more flexible way to make services highly available, implement third-party security solutions, and protect your data and processes — all on Synology NAS.

Prospective users are advised to take advantage of the possibilities to test all functions of Synology VMM that they wish to employ in a real-world configuration. A 30-day free trial of VMM Pro, available for each Synology NAS, helps you unlock full cluster functionality for test purposes. One Virtual DSM license is included with each VMM instance and is always free.

Specific hardware and configuration improvements may drastically increase the capacity of your configuration for your application. This guide provides detailed suggestions on how to optimize VMM setups. Would you like to discuss specific needs or advanced configurations? Contact our sales team for custom advise or find a Synology partner in your region.

SYNOLOGY
INC.

9F, No. 1, Yuan Dong Rd.
Banqiao, New Taipei 220545
Taiwan
Tel: +886 2 2955 1814

SYNOLOGY
AMERICA CORP.

3535 Factoria Blvd SE, Suite #200,
Bellevue, WA 98006
USA
Tel: +1 425 818 1587

SYNOLOGY
UK LTD.

Unit 5 Danbury Court, Linford Wood,
Milton Keynes, MK14 6PL,
United Kingdom
Tel.: +44 (0)1908048029

SYNOLOGY
FRANCE SARL

102 Terrasse Boieldieu (TOUR W)
92800 Puteaux
France
Tel: +33 147 176288

SYNOLOGY
GMBH

Grafenberger Allee 295
40237 Düsseldorf
Deutschland
Tel: +49 211 9666 9666

SYNOLOGY
SHANGHAI

200070, Room 201,
No. 511 Tianmu W. Rd.,
Jingan Dist., Shanghai,
China

SYNOLOGY
JAPAN CO., LTD.

4F, No. 3-1-2, Higashikanda
Chiyoda-ku, Tokyo, 101-0031
Japan

Synology®

synology.com