

QNAP



QNAP NAS Solution Virtualization Station White Paper

Abstract

With the constant state of hardware development, the functions of NAS (Network-attached Storage) devices have moved beyond being simple storage servers. With high-speed I/O, high potential storage capacity, and integrated virtualization technology modern NAS can easily accommodate storage, computing, virtualization, and services in a single device to provide the best solution for corporate flexibility and cost considerations.

This article is written with the perspective of the solution provider in mind to explore what virtualization is, and understand in depth about QNAP NAS Virtualization Station and virtual machine performance tests. Through virtual machine functionality, matched hardware and actual performance results, the reader will obtain a clear picture of application scenarios and how to choose an appropriate QNAP NAS.

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Foreword

In a physical computer environment, every application must go through the operating system before it can provide services that include memory allocation, device drivers and other services. For incompatibility issues between applications and the operating system, if we use a NAS with a hypervisor, we can use virtualization technology to install a single application on a dedicated virtual machine, and configure its dedicated system environment and parameters to directly access the common file system.

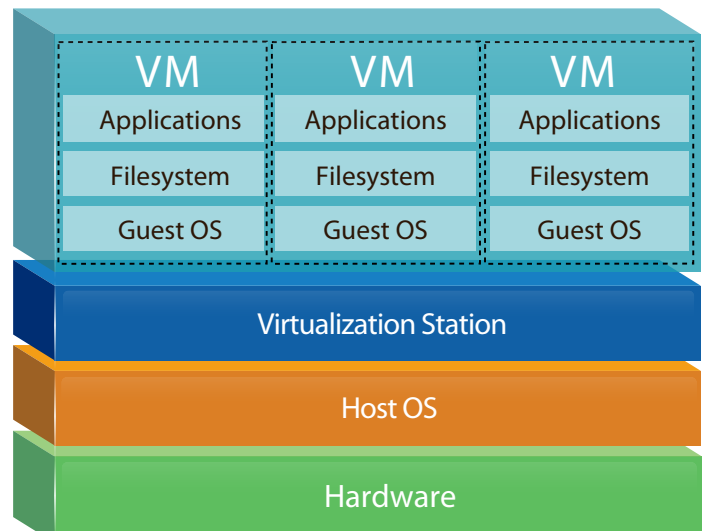
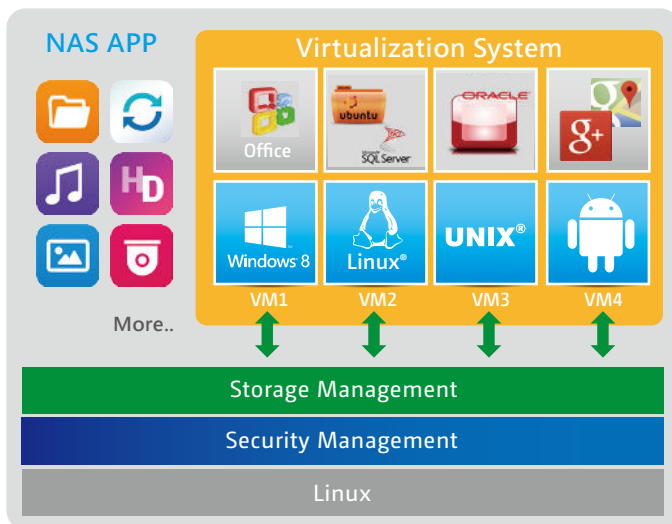
In the physical layer of IT infrastructure — server hardware, storage devices, network connection and power consumption — everything needs money. Virtualization can help achieve more in an economical way. In the past, different application systems required their own server hardware to conduct independent operations (for example, VMware® ESXi is responsible for computation, and coupled with storage units like NAS or storage servers), but now they can be integrated into a single QNAP NAS. With QNAP NAS virtualization technology coupled with its existing storage capabilities, we can efficiently make use of all the resources in a single device.

Using a QNAP NAS as a virtualization platform has the following benefits, giving you the choice to set up applications with different functions.

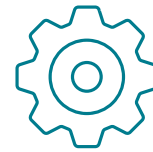
- Storage space expansion: QNAP NAS is easily expandable by using expansion enclosures or by using the unused storage capacity from another QNAP NAS via iSCSI VJBOD (QNAP Systems, Inc. 2017).
- Efficient resource usage: QNAP virtualization technology lets you pass-through the NAS hardware to hosted virtual machines, providing efficient use of the NAS hardware or connected USB devices.
- Availability: Advanced planning for peak-time workloads is one of the common reasons for maintaining capacity higher than normally needed. This means extra hardware, software and other resources are needed to cope with it. Using the retail industry for example, planning is needed for sudden increases in transaction traffic during shopping seasons. The better part of a year is spent on maintaining unused capacity, possibly all in the preparation for seasonal increases. Moving infrastructure and applications to virtual machines can let you add and allocate extra capacity in time of need without having to maintain it all-year round.
- Reliability: As virtualized systems are essentially software-based entities, they can be easily migrated to other physical devices with minimal downtime if a hardware fault occurs or if hardware is being upgraded.
- Flexibility: Virtualization makes applications more flexible and can be treated as an individual software component to be managed and maintained. Quickly set up a new server and reconfigure resources from predefined and preset image files in order to optimize performance and stability, and enhance resource efficiency and usage. For example, when coupled with QNAP QvPC Technology (QNAP – QvPC 2017), virtual machines can be directly operated by connecting a keyboard, mouse, and monitor to the NAS, greatly increasing the flexibility of use.

QNAP Virtualization Station

Virtualization technology allocates existing hardware resources like CPU, memory, and disk space to run several operating environments such as installing other operating systems (Guest OS) or replicating many of the same operating systems for running different applications and services. There are currently two major types of hypervisor in use: (1) Directly installed on the hardware (Bare metal) (2) Installed on the operating system (Hosted). Citrix XenServer®, VMware ESX/ESXi and Microsoft Hyper-V belong to type 1 and VMware Workstation and VirtualBox® belong to type 2. QNAP Virtualization Station is running on top of the QNAP QTS operating system and belongs to type 2. Virtualization Station makes use of the storage space provided by the NAS to install virtual machines. Through the highly-efficient NAS I/O, guest operating systems can use protocols like SAMBA and iSCSI to mount NAS storage space directly for their own uses.

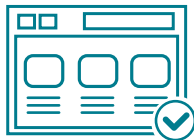


Introduction to virtual machine functions



The following will discuss hypervisors in three major parts:

1. Virtual machine management interface
2. Virtual machine functions and settings
3. Virtual machine operations

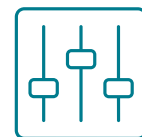


Virtual machine management interface

- Virtualization Station adopts the architecture of using a single NAS to run multiple virtual machines and allocating NAS hardware resources (CPU cores, memory, USB devices or display cards) to be used.
- Virtual machines can be imported/exported using formats such as *.vmx, *.ova and *.ovf.
- Multi-user environment. Virtual machines can be managed by the NAS administrator, but can be operated by different accounts with varying privileges. Operating permissions can be set up based on user needs like settings or desktop controls.
- Supports background operations. When scheduling tasks for virtual machines, you can get a real-time grasp of conditions and processes.
- Real-time resource monitoring, including virtual machines and the NAS itself.
- One-button installation of Free Windows VMs (QNAP - Download Free Official Windows Virtual Machines 2017) to quickly build a Windows operating environment.

Virtual machine functions and settings

- Create Windows, Linux, and UNIX virtual machines.
- Take snapshots of virtual machines for quickly reverting to a previous system state without needing to pause or shut down the virtual machine.
- Back up and restore virtual machines to remote NAS. If an error should occur, virtual machines can be restored from the remote NAS to minimize system downtime.
- Automatically start virtual machines. Virtual machines can be set to start when the NAS starts, allowing quick restoration of services if the NAS must be restarted.
- Supports virtio paravirtualization technology for enhancing the I/O performance of virtual drives and network interface cards.
- Supports multiple controllers and interfaces to improve compatibility of guest operating systems. For example, disk controllers, IDE and SATA; network interface cards, Intel Gigabit Ethernet, NE2000 and PCnet32.



Virtual machine operations

- Use an HTML5-based platform to operate virtual machines in your web browser. It also supports full screen webpage operation at 1080p.
- Manage virtual machines using a toolbar. Virtual machines can be operated, rebooted, and snapshots taken without needing to return to the Virtualization Station management page.
- Operate virtual machines directly with QvPC Technology. Simply connect a monitor, keyboard, and mouse to the NAS to use the virtual machine as if it is a real computer.

Advanced functions

Virtual machine configuration

Virtual machines can be set up with CPU cores according to the total number of logical processors on the NAS processor. For example, a NAS with the Intel® E5-2630 v3 can choose to configure up to 16 logical cores (physical cores: 8). Virtual machines can be configured with up to 1 TB RAM, a single virtual disk can be up to 16TB, and with up to 16 devices.

USB 2.0/3.0* passthrough and optical disc drive access

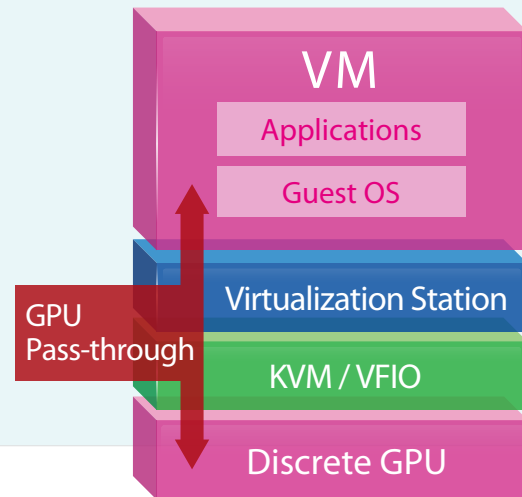
USB 2.0/3.0 devices (such as printers, barcode scanners, or storage devices) that are physically connected to the NAS can be passed through to virtual machines. In addition, optical disc drives (including the TVS-882BR, a NAS model with a built-in optical disc drive) can be allocated to virtual machines to enable disc-based applications and to write NAS data to optical discs.

* QNAP does not guarantee full compatibility for USB devices. Only Windows 8 (and later) support USB 3.0.

PCIe card pass through

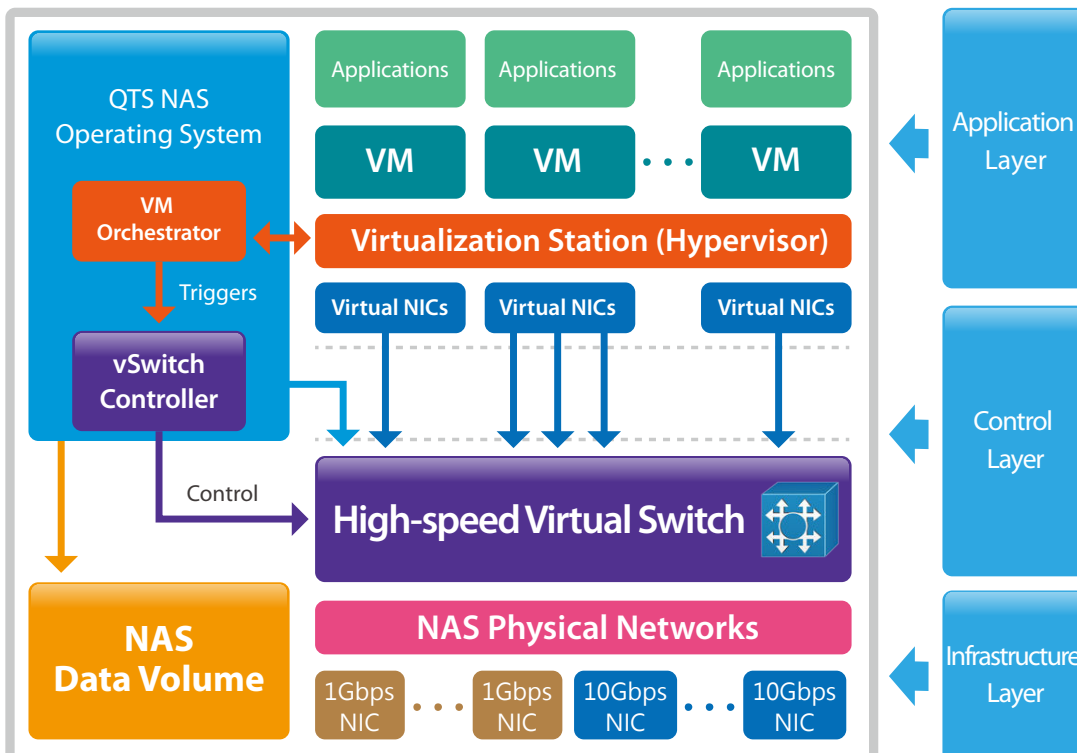
PCI Express (PCIe) cards, including graphics cards and USB 3.1 Gen 2 expansion cards, can be passed through to virtual machines to expand the functionality of virtualization tasks. Graphics cards¹ can empower virtual machines with greater graphical and processing performance and USB 3.1 Gen 2 expansion cards² have 10 Gb/s transfer speed to provide higher efficiency and diversified application scenarios.

¹ Refer to www.qnap.com for compatible NAS models and graphics cards.
² Optional purchase. Sold separately.



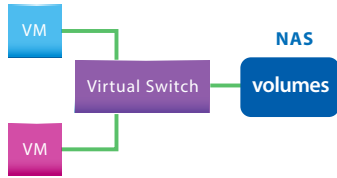
Network setup (Host, Bridged, External-only, Isolated)

Using the concept of software-defined networking, multiple network modes are supported through creation of virtual switches to go with support for NAT and DHCP services and provide a plural and flexible network to make you plan virtual network topologies with ease.



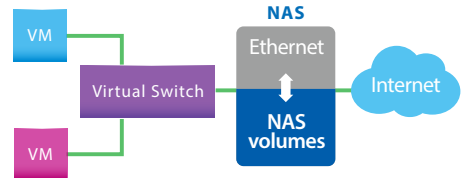
Host

No external physical network interface required. Provides an internal high-speed transmission environment between the virtual machine and the NAS.



Bridged

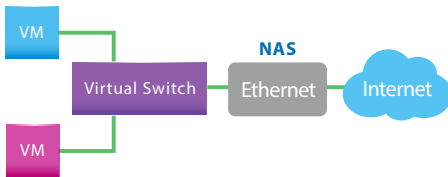
Connects to the physical network interface (including port-trunking*) through a virtual switch, in addition to the high-speed transmission environment between the virtual machine and the NAS. It can also go through the physical network interface to communicate with external networks.



* Supported port-trunking modes: Active Backup, IEEE 802.3ad, Balance-tlb.

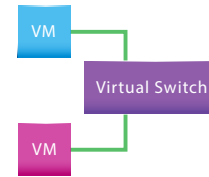
External-only

After a physical network interface is configured to a virtual switch, this physical interface will provide dedicated network bandwidth for virtual machines. This network mode may require manual configuration of virtual IP addresses, or IP addresses can be assigned using an external DHCP server.



Isolated

Use a virtual switch to connect to multiple virtual machines and manually set up the IP address of the virtual machine to create an isolated network without the need to communicate with the outside world.



Disaster recovery: backup and restoration

Provides task-oriented local/remote backup of virtual machines and real-time knowledge of task progress and scheduling. Tasks can be manually started and paused. Virtualization Station also supports online backup. To make efficient use of the storage space, you can also set scheduled intervals and the upper limit of the number of backups. Backup virtual machines can be started to reduce downtime during restoration.

The screenshot shows the 'Virtualization Station 3' interface. The main window is titled 'Back Up & Restore VM' and contains a 'Task Overview' table. Below the table is a diagram showing three server icons with blue arrows indicating data flow between them.

Task Name	VM	Destination	Schedule	Status	Action
Backup_1	Win10	.Public\Win10_backup	-	Standby	[Icons]
Backup_2	Linux_14.10	.Public\linux_14.10_backup	-	Standby	[Icons]
Backup_3	Win2012	.Public\Win2012_backup	-	Standby	[Icons]

In-depth usage scenarios and performance assessment

This chapter is divided into four parts to discuss using Virtualization Station to integrate storage, computation, and virtualization into one entity

Converting a physical machine to a virtual machine

Microsoft has discontinued support for old operating systems such as Windows XP and Windows Server 2003. If you choose to maintain old "legacy" computers with these systems, it can be laborious for IT staff to find replacement hardware and compatible drivers.

To assist IT staff and to consolidate IT infrastructure, these legacy computers can easily be converted into virtual machines and run on Virtualization Station to retain their functionality without worrying about potential hardware issues.

VMware® vCenter Converter can be used to easily convert physical systems to virtual machines. The resulting file (*.vmx) can then be imported into Virtualization Station for a seamless transition from a physical to a virtual machine.

Assessment of virtual machine performance

After NAS hardware resources have been virtualized on the hypervisor, the actual hardware performance may be affected because of the physical to virtual conversion. This chapter will use common benchmarking software to test processor, memory, disk and network I/O performance as well as the number of virtual machines that can be run concurrently. Coupled with the scores from related applications, performance figures of multiple models of QNAP NAS can be compared.

Tested QNAP NAS models	
TDS-16489U-SB3	Processor : Intel® Xeon® E5-2630 v3 8-core 2.4 GHz Memory : 256GB
TS-1277-1700-64G	Processor : AMD Ryzen™ 1700 8-cores 3GHz, Memory : 64GB
TS-1685-D1531-128GR-550W	Processor : Intel® Xeon® D-1531 6-cores 2.2 GHz, Memory : 128 GB
TVS-1282-i7-64G-450W	Processor : Intel® Core™ i7-6700 quad-core 3.4 GHz, Memory : 64GB
TVS-873-64G	Processor : AMD R-Series RX-421BD quad-core 2.1 GHz, Memory : 64GB
TS-653B-8G	Processor : Intel® Celeron® J3455 quad-core 1.5GHz, Memory : 8GB

Disk configuration: 8x WD Blue 500GB SSD in RAID 0

Virtual machine settings:

- Operating system: Windows 10, 64-bit version
- Processor logical cores: 4 and configurable maximum value
- Memory¹: 16 GB
- Disk: 250 GB (interface: virtio, cache mode: writeback)
- Network: Virtio
- Display card: Standard VGA
- PCIe graphics card²: AMD Radeon™ RX-460
- Application installation: Microsoft Office 2016, Autodesk 3ds Max 2015

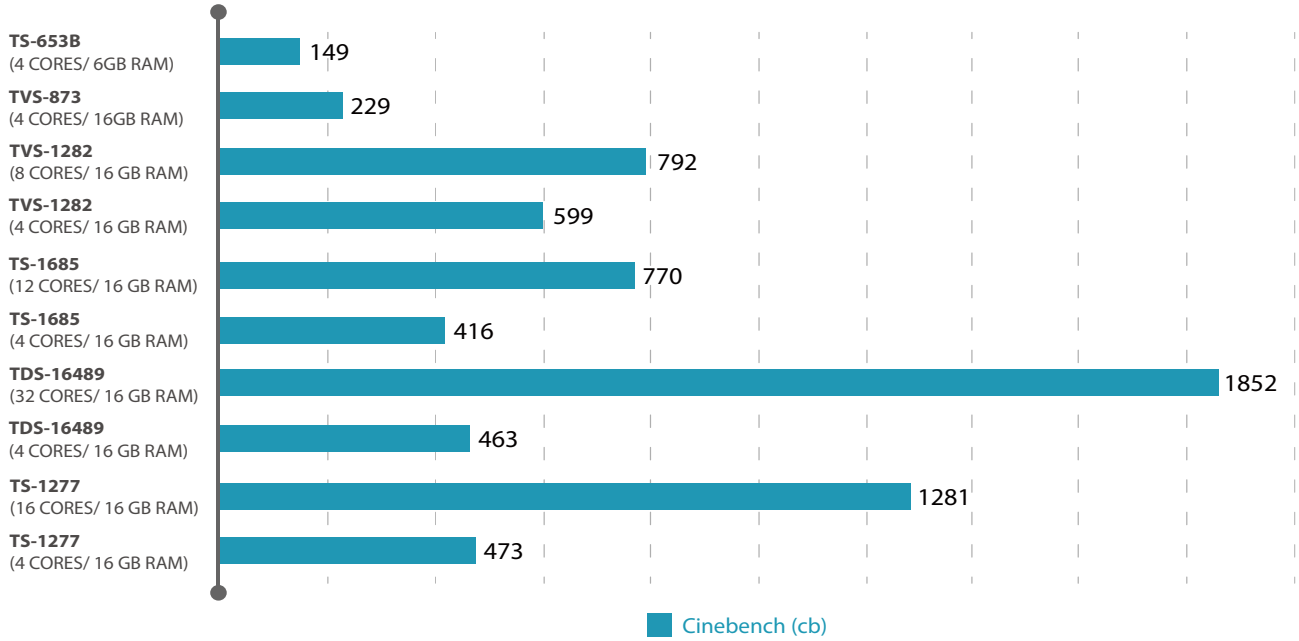
¹ The TS-653B has 6 GB memory.

² The TS-653B and TVS-873 does not support PCIe graphics cards.

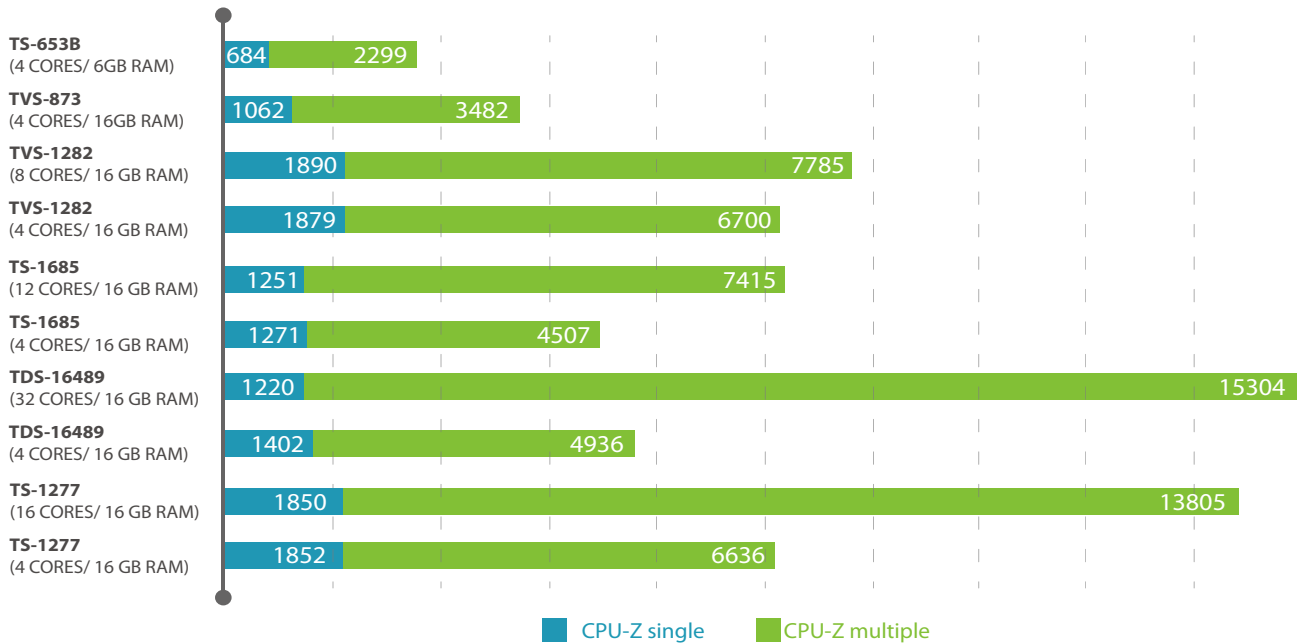
Processors

Benchmarking tools: Cinebench R15, CPU-Z, wPrime 32M/ 1024M and x.265 FHD Benchmark

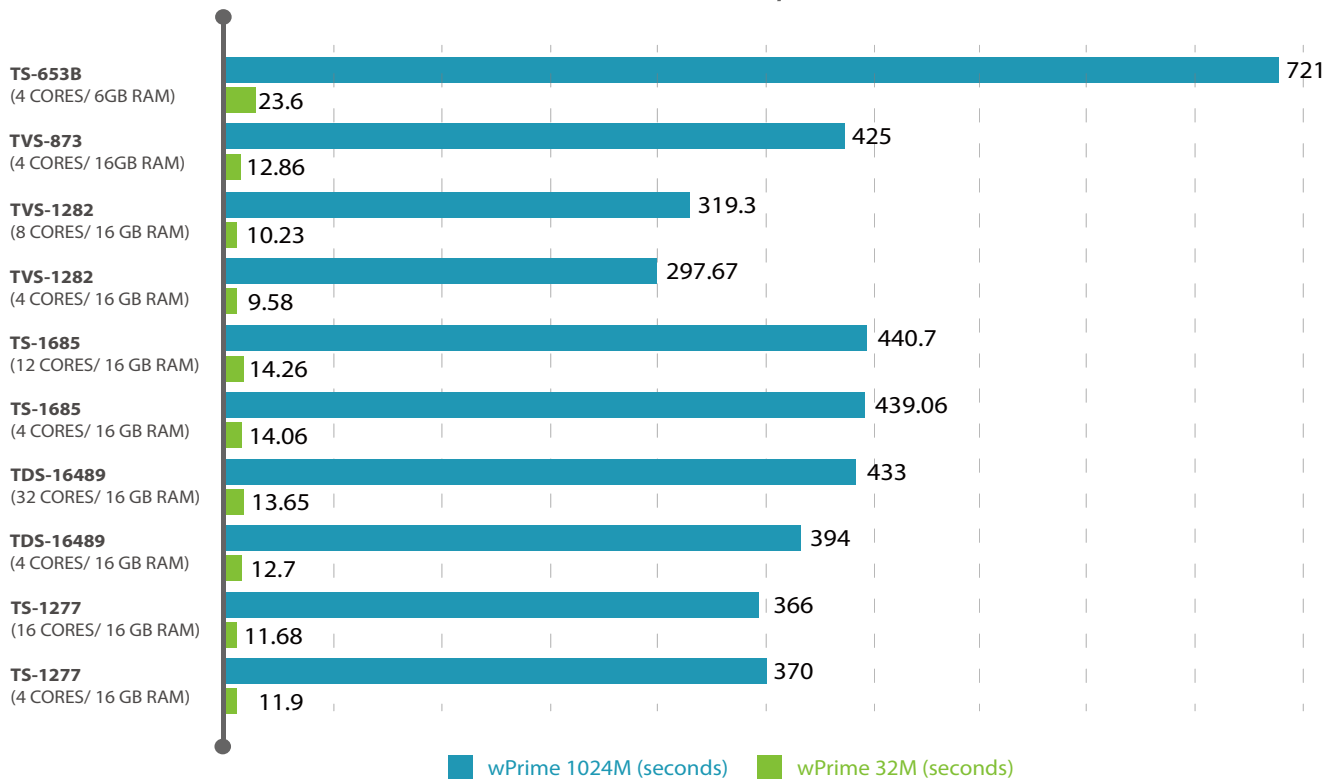
Cinebench R15



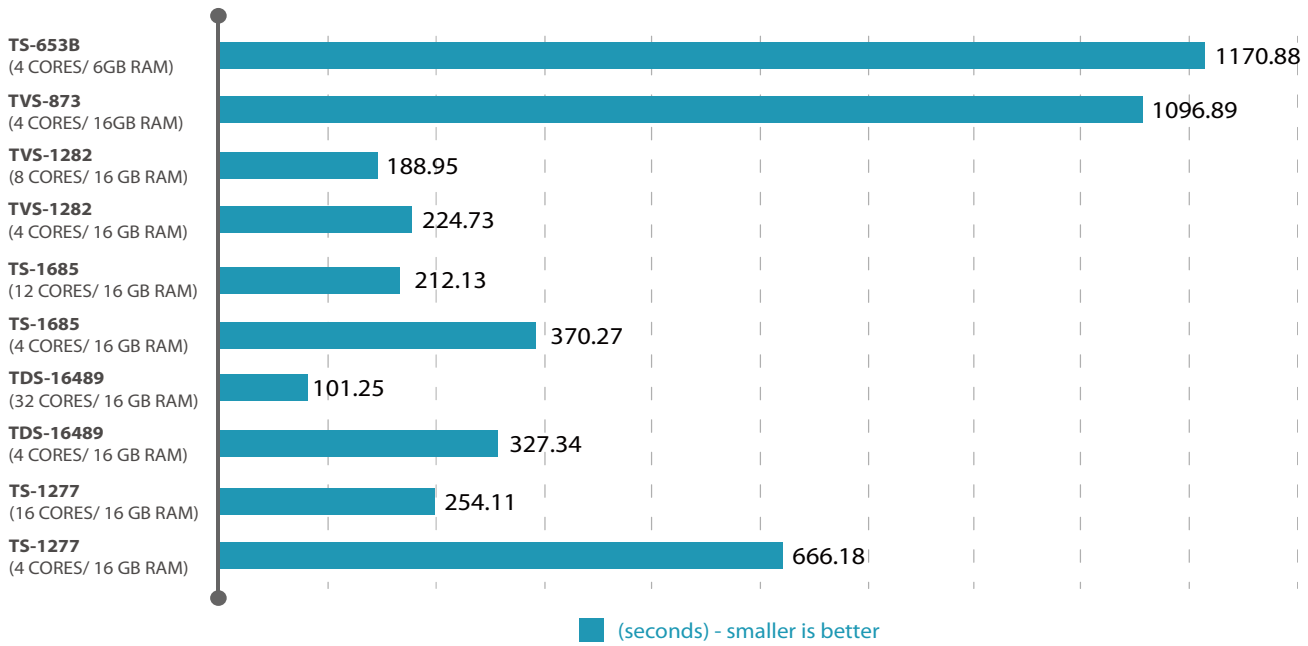
CPU-Z



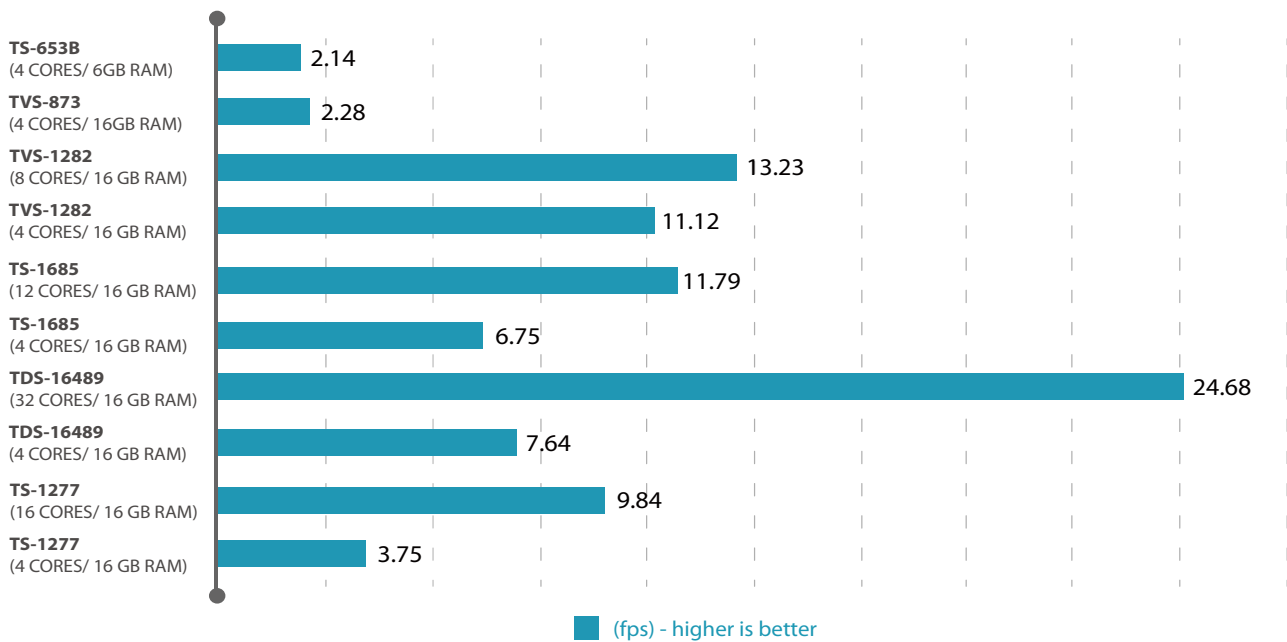
wPrime 32M/1024M



x.265 FHD Benchmark – decode 2500 frames (1/2)



x.265 FHD Benchmark – decode 2500 frames (2/2)

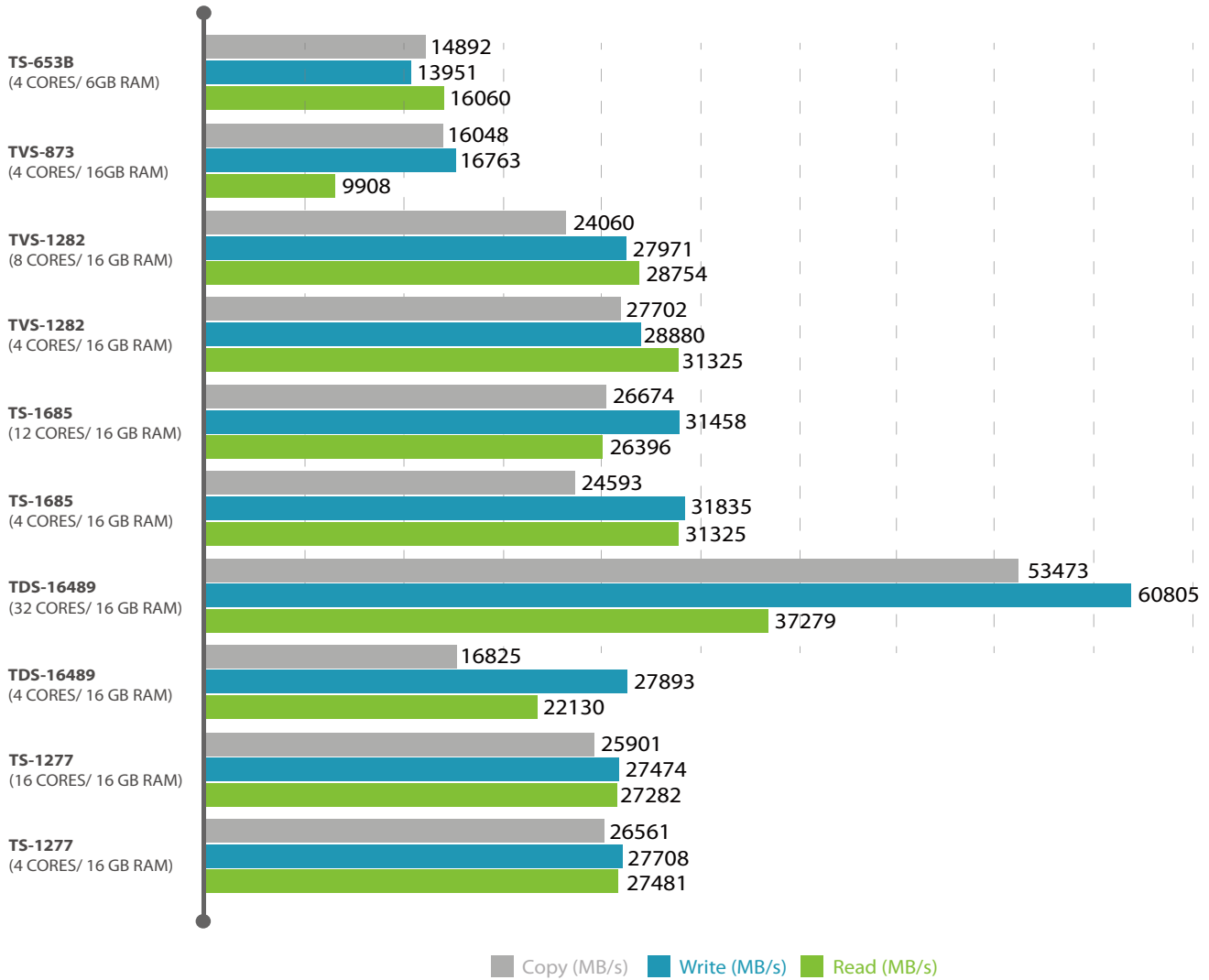


From Cinebench R15 and CPU-Z tests, we can see when the logical cores are fixed at 4, the higher the clock rate it is, the higher the obtained score it is. But if viewed from the total number of logical cores, the overall performance will depend on the number of logical cores. Besides, observation of the test results of multi-threading from wPrime 32M (performance)/1024M (stability) shows that even if the number of logical cores allocated to virtual machines might be different, the performance can remain constant.

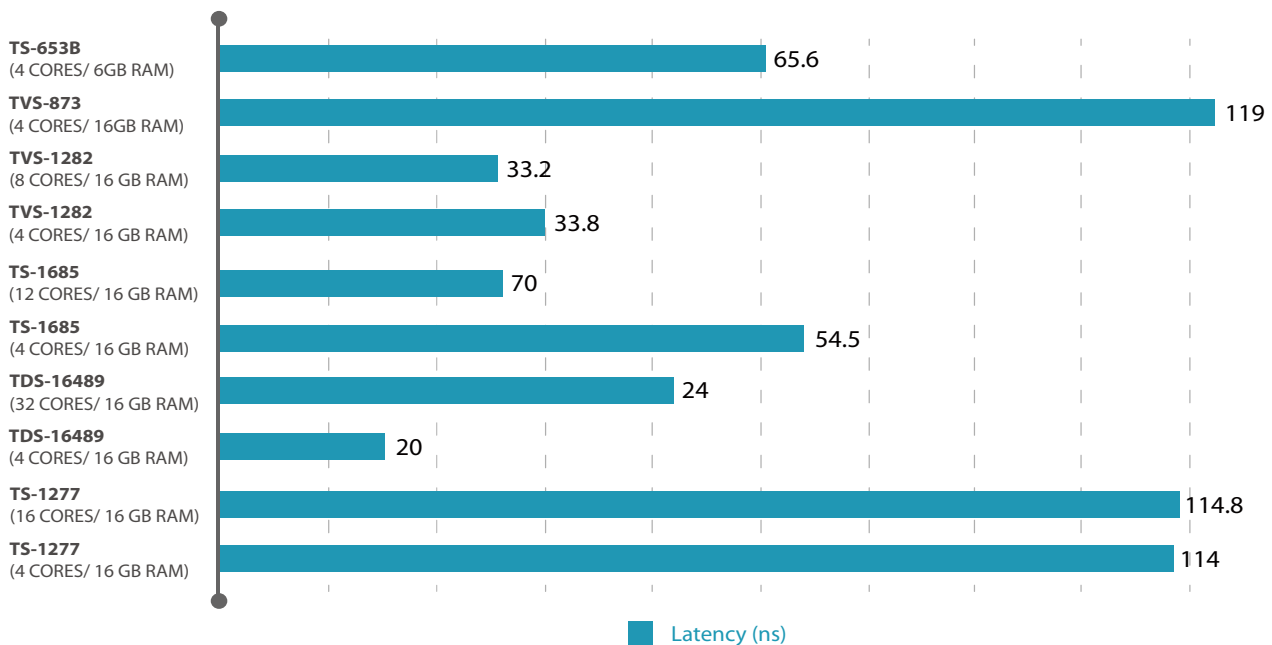
Processors

Benchmarking tools: AIDA64 Extreme

AIDA-64 (1/2)



AIDA-64 (2/2)

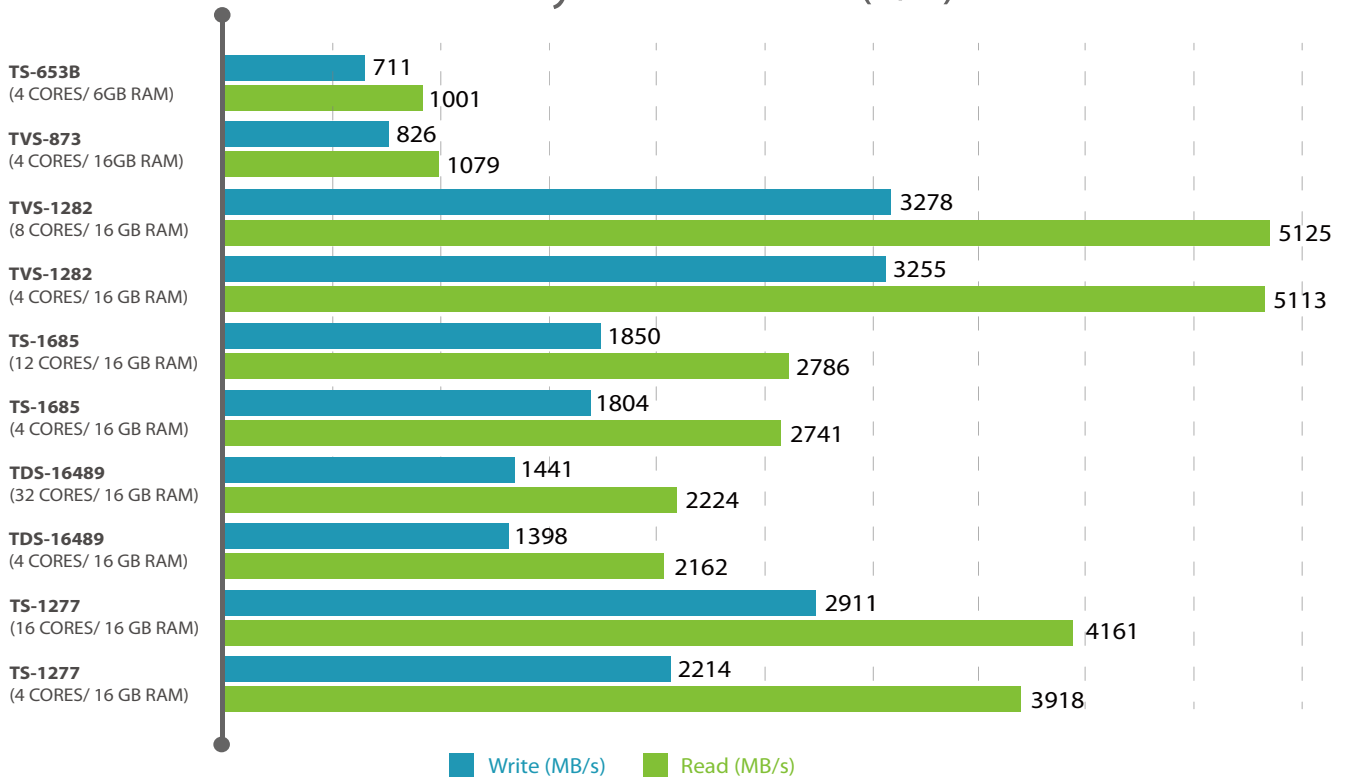


Disk I/O

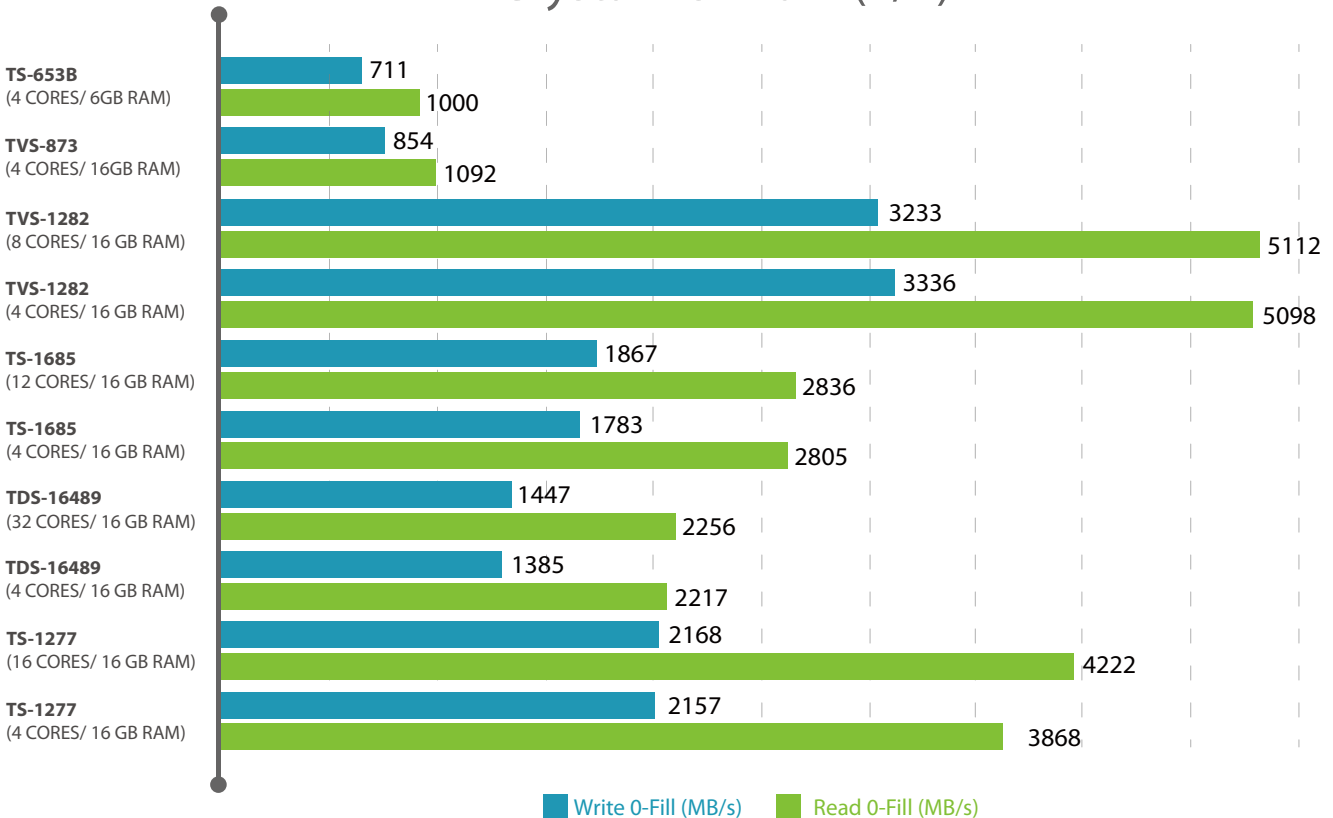
Benchmarking tool: CrystalDiskMark (1024K sequential)

Direct tests of I/O access speeds of virtual disks.

CrystalDiskMark (1/2)



CrystalDiskMark (2/2)



We clearly see that it is not related to the number of logical cores and memory allocated to the virtual machine and is related to the clock rate of the NAS processor. Therefore when choosing a NAS model, if computation is a higher priority and the number of virtual machines running at the same time is not in the picture, you can choose a model with a higher clock rate.

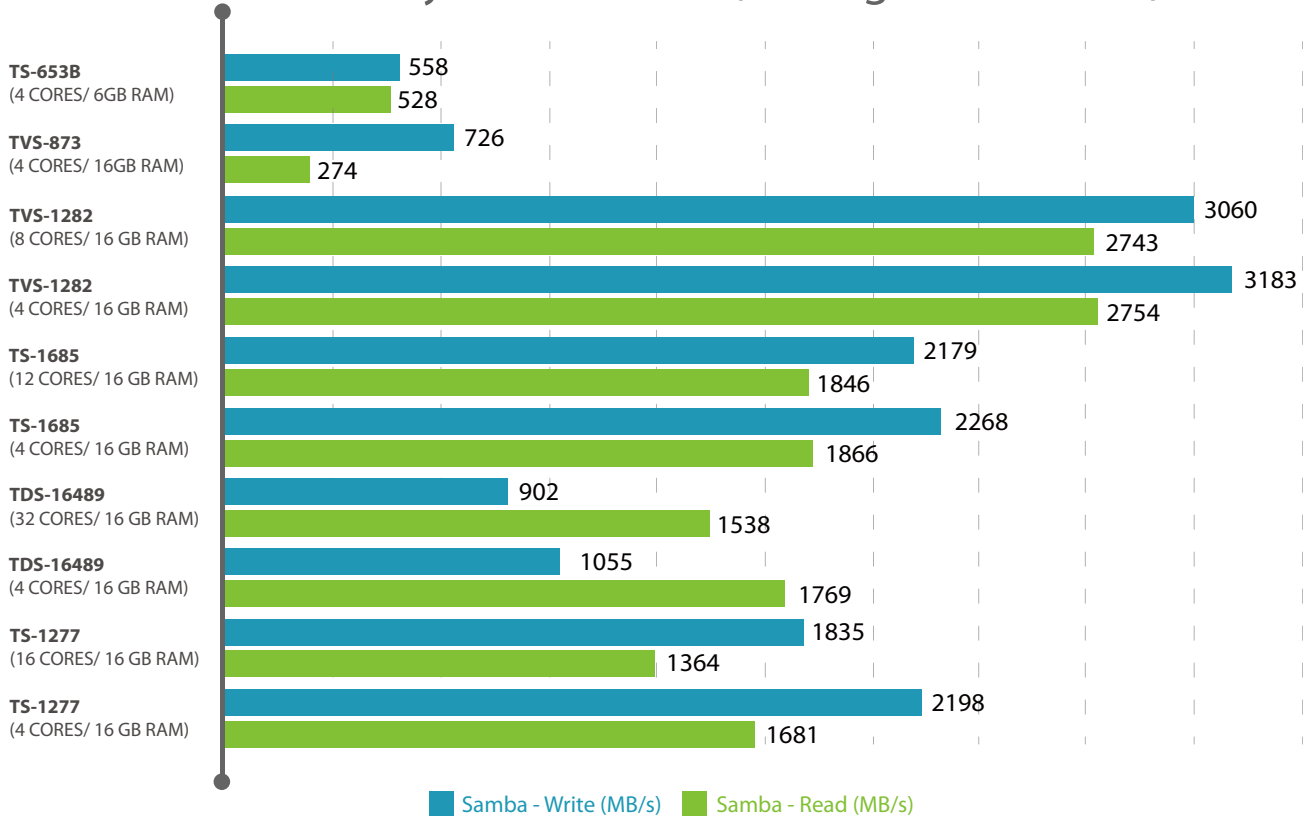
Network I/O

Benchmarking tool: CrystalDiskMark/ Iperf

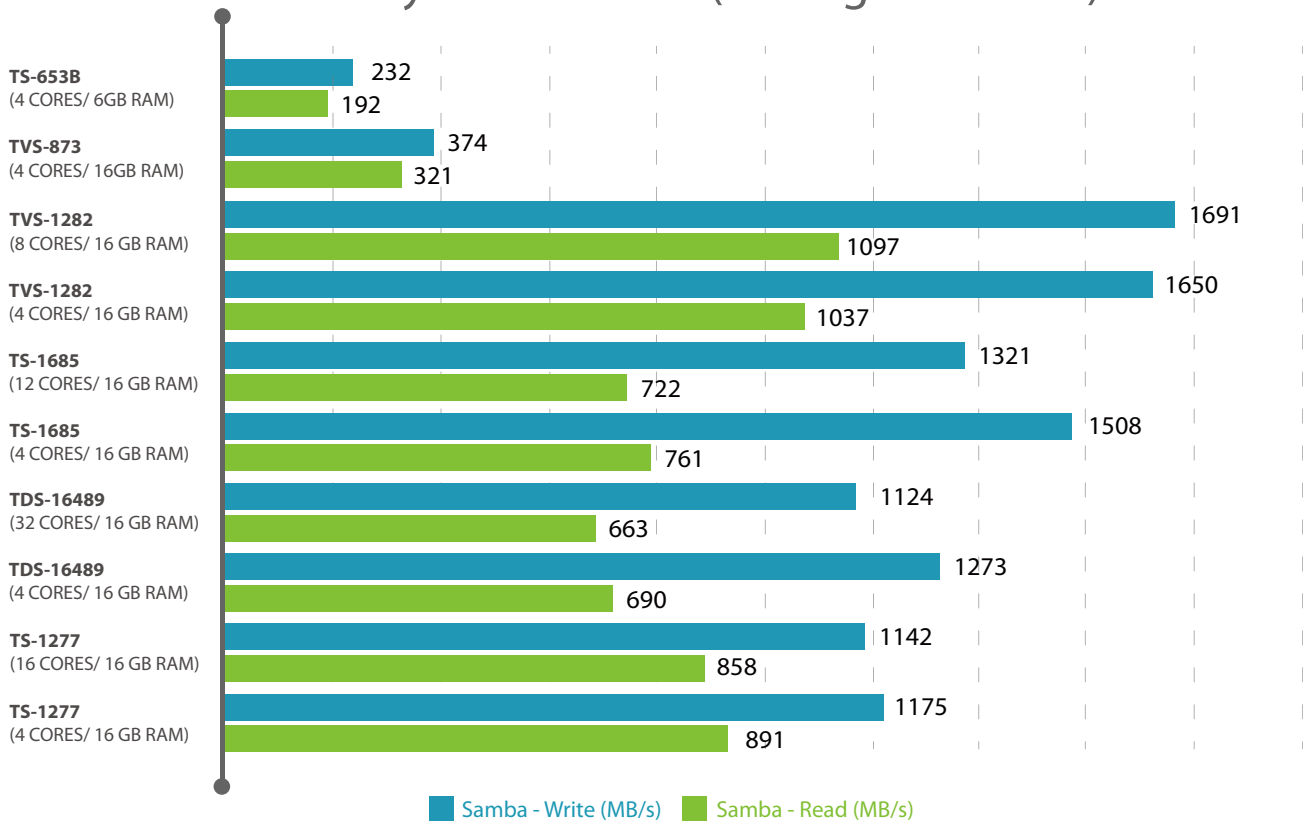
CrystalDiskMark: Used to test two different communication protocols (Samba, iSCSI) for tests of read/write efficiency.

Iperf: Divided into three different scenarios to test network speed. 1) NAS > VM 2) VM > NAS 3) VM > V

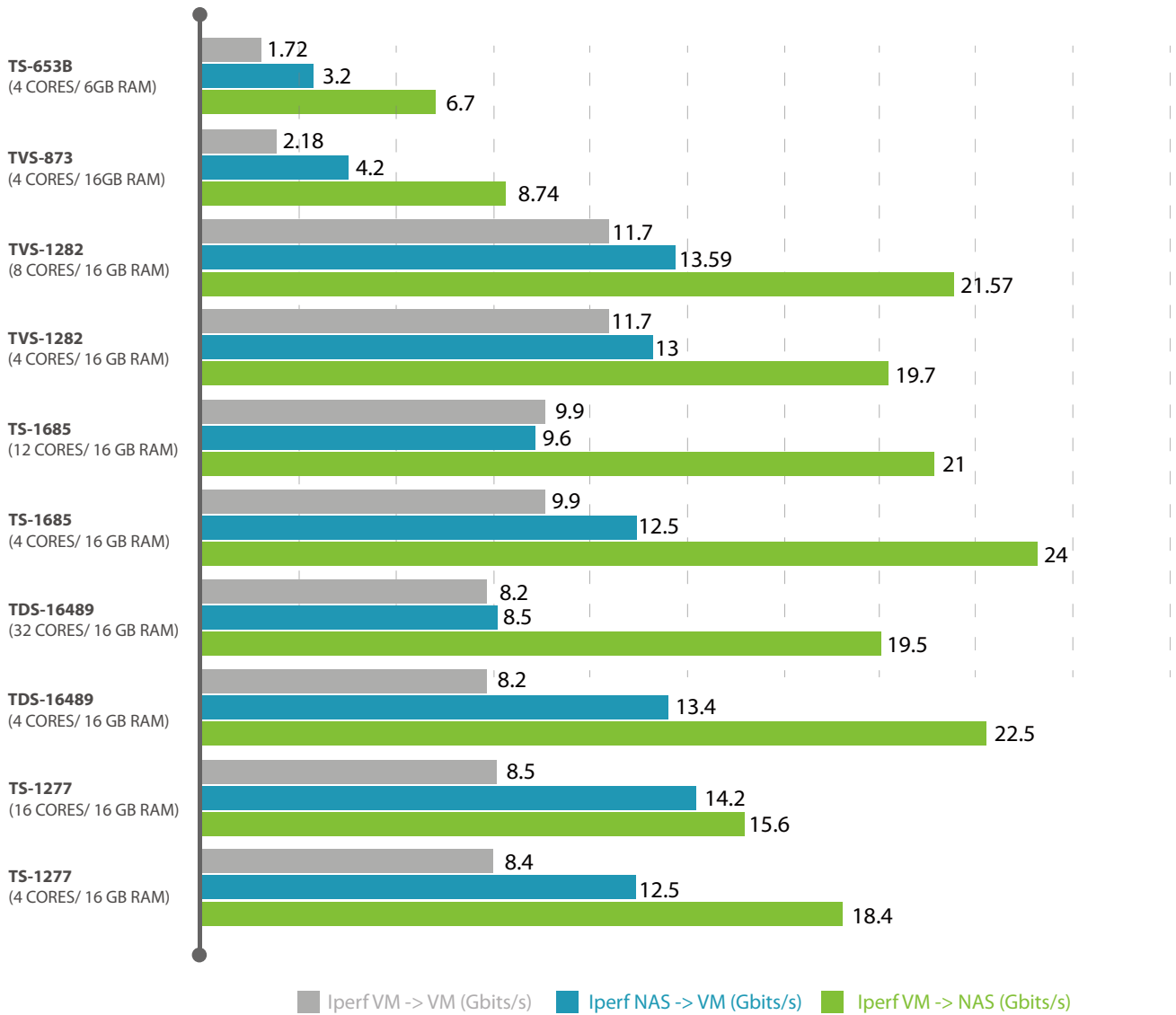
CrystalDiskMark (throughout Samba)



CrystalDiskMark (throughout iSCSI)



Iperf

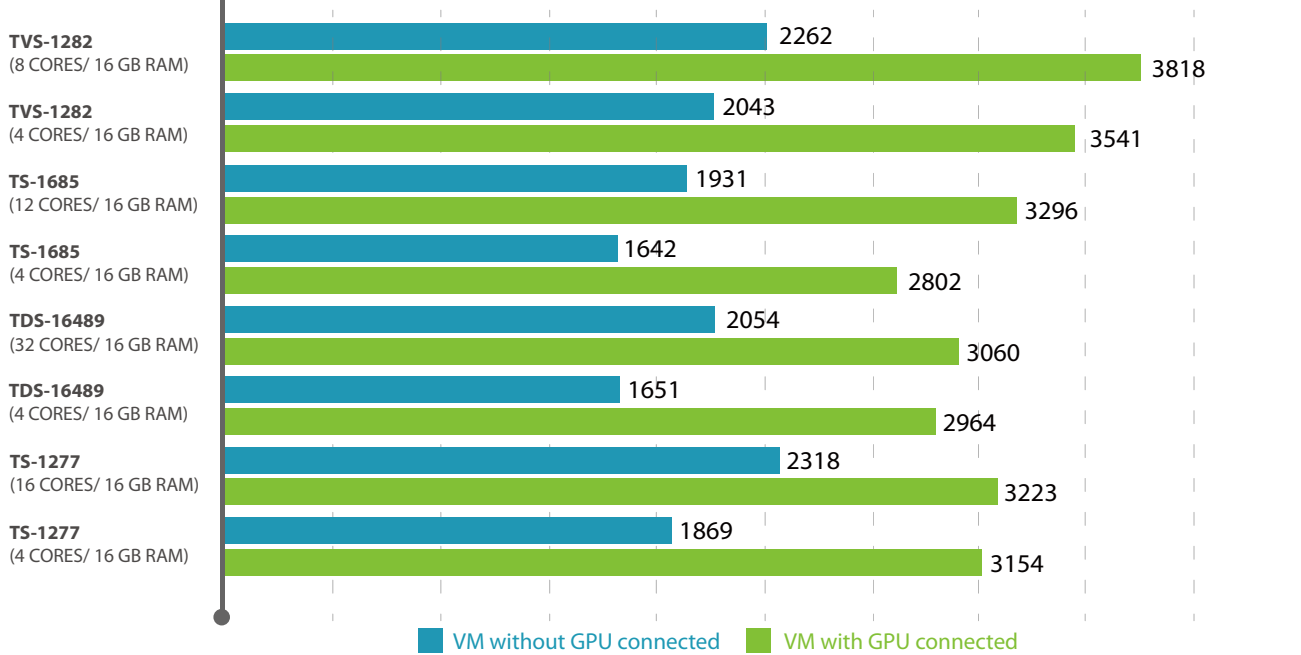


From the test results we can find that VM > NAS has the fastest speed; between VM > VM, it is simultaneous I/O access on the same NAS storage space, therefore the access speed is slower.

Applications

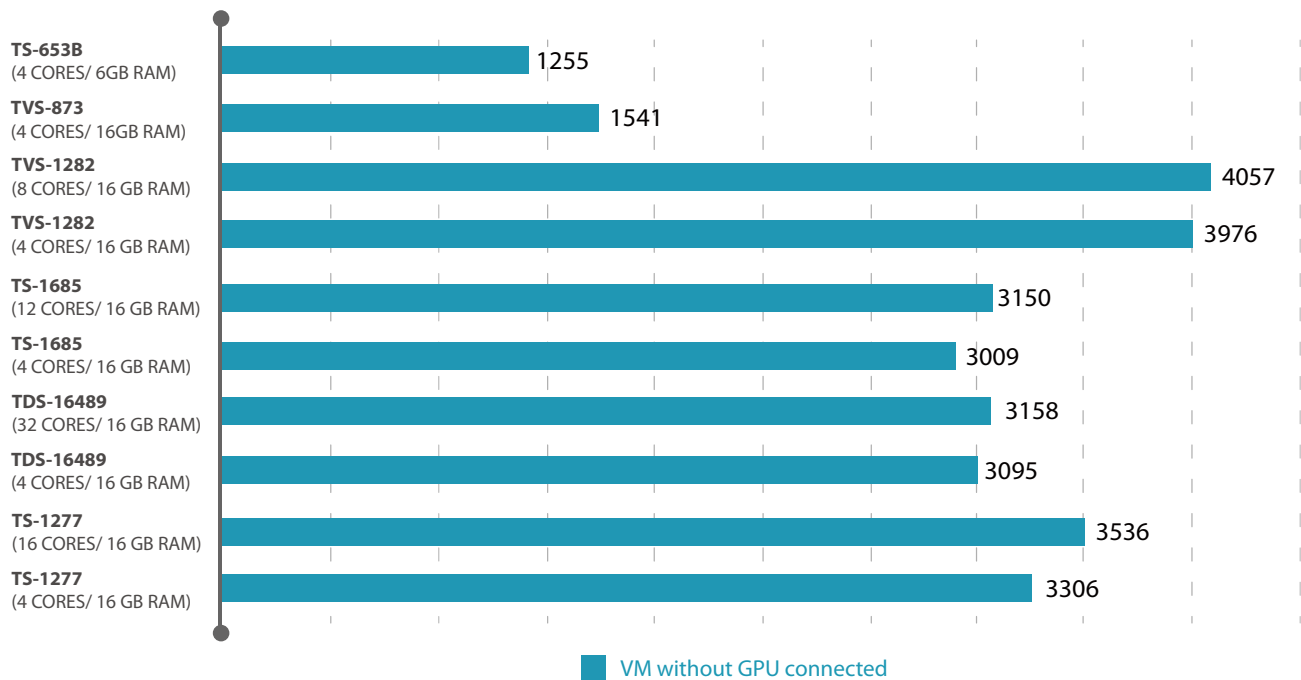
Benchmarking tool: PCMark 8 Home conventional 3.0 score/ PCMark 8 Application: Microsoft Office

PCMark 8 Home conventional 3.0 score - w/ GPU v.s. w/o GPU connected



Applications (Microsoft Office score)

PCMark 8 Applications - w/o GPU connected



Benchmarking tool: SPECapc 3ds Max

The figures are obtained when an AMD Radeon RX-460 is passed through. Performance may vary based on the graphics card used. Furthermore SPECapc 3ds Max will also calculate the video processing efficiency of the NAS processor. Therefore whether the processor supports video processing or not will also affect the performance figures. For example, CPU Composite Score.

SPECapc 3ds Max 2015

Core/ RAM, GPU connected	TS-1277 16 cores (max.) / 16GB ram	TDS-16489U 32 cores (max.) / 16GB ram	TS-1685 12 cores (max.) / 16GB ram	TVS-1282 8 cores (max.) / 16GB ram
CPU Composite Score	2.94	2.92	2.79	3.48
GPU Composite Score	1.11	1.14	1.82	2.01
Large Model Composite Score	1.56	1.56	2.12	2.75
Large Model CPU	1.13	0.93	1.12	1.62
Large Model GPU	2.16	2.6	4.01	4.67
Interactive Graphics	1.13	1.76	2.21	2.35
Advanced Visual Styles	2.3	2.18	2.71	2.71
Modeling	0.66	0.81	1.1	1.22
CPU Computing	2.17	2.08	2.22	2.56
CPU Rendering	4.26	4.5	3.86	4.88
GPU Rendering	1.08	1.3	1.63	2.08

Support for number of virtual machines running concurrently

Knowledge Worker in Login VSI is used as the standard of testing. This is a simulation of common office applications including Microsoft Office and Adobe Reader. Through configuring the same number of logical cores and memory we tested the number of virtual machines that can be run and operated on the NAS concurrently.

Login VSI (Login VSI 2016) specifies various indicators based on the response times of applications and file opening and closing as well as the usage curves of related computation resources to provide the number of virtual machines that can be supported.

Benchmarking tool: Login VSI

NAS Settings	
Hard disk	8* Seagate ST4000VN000-2AH166 (SATA)
Configuration	RAID 6

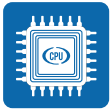
Virtual Machine Settings	
Guest OS	Windows 10 64-bit
Number of logical cores	2
Memory	2 GB
Disk	250 GB Virtio interface/Writeback cache mode
Network	Virtio interface
Login VSI worker	Knowledge Worker (benchmark mode)

Model	TDS-16489U-SB3	TS-1277-1700-64G	TS-1685-D1531-128GR-550W	TVS-1282-i7-64G-450W	TVS-873-64G	TS-653B-8G
Number of VMs running concurrently	20	16	18	18	4	3

When 8 disks are configured in RAID 6, we see that NAS models with more cores can support a larger number of virtual machines running concurrently from the results. Besides, during the actual testing process we found that using different hard disks or RAID configurations (such as using SSDs or other disk configurations) to enhance write performance can effectively increase the number of running virtual machines.

In addition, when write performance is no longer a bottleneck, the major factor of the number of running virtual machines will be the processor performance of the NAS and the configurable memory capacity. Therefore for a virtual machine demanding a large amount of computation, the primary condition is to choose a NAS model with more cores and support for higher memory capacity. For example: the TDS-16489U or TS-1277.

How to configure virtual machine resources information system



Logical core numbers

Intel® HT (Hyper-Threading) Technology makes a single physical core support two logical processing units concurrently - for example a processor with 4 physical cores would have 8 logical cores. The number of logical cores configured for a virtual machine depends on the number of local cores on the processor. With Hyper-Threading, configuring additional virtual cores for a virtual machine does not necessarily mean it will provide a better user experience, as it depends on if the application being used has been optimized for multiple cores. Besides, CPU usage can also be observed from the guest operating system. If a virtual machine is consistently under full load (about 80-90% usage) you should consider allocating more logical cores to it.

Furthermore, the number of virtual machines running concurrently has to be considered as well. When the number is more with more allocated number of cores, it may cause two logical cores to run on the same physical core, leading to no use of Intel® HT technology and causing performance issues to occur.



Memory

When a virtual machine is started on the Virtualization Station, the virtual machine will monopolize the configured memory. It is recommended that you configure corresponding memory capacity according to the requirements of the operating system. For example: 64-bit Windows 10 recommends at least 2GB memory (Microsoft 2016).



Disks

Storage interface: IDE, SCSI, SATA, Virtio
The choice of supporting IDE, SCSI, and SATA interfaces can save the hassle from installing additional drivers for the disk drive to be recognized when the operating system is being installed. Legacy operating systems (such as Windows XP and 7) only support the IDE disk interface.

Virtio can be treated as an abstract concept of the hardware and provides a universal application programming interface (API) and through that interface you can get higher disk access rates. Most Linux operating systems already support virtio (QNAP Systems, Inc 2017), but on Windows operating systems a storage device driver must be installed before you can switch to the virtio interface to avoid the system from being unable to detect the boot drive.



Disk – cache settings

Disk cache settings will directly affect the access performance of a virtual machine reading and writing data.

• Writeback

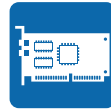
Uses the NAS and disk caching to read and write at the same time, and can provide better access performance. But if a virtual machine is closed unexpectedly and the data in the disk cache cannot be written to the hard disk in time, there may be a risk of data inconsistency.

• Writethrough

Use NAS caching to read, but does not go through disk caching to write directly onto the drive when writing is in process. Its write performance is worse than writeback, but does not risk data inconsistency.

• None

Only uses disk caching to support writes. Its read performance is worse than writeback and writethrough, but it has the best write speeds.



Network interface cards

Network interface: Intel Gigabit Ethernet, NE2000, PCnet32, Realtek Fast Ethernet and Virtio Gigabit Ethernet.

The purpose of providing multiple interfaces is to provide better compatibility. Once a guest OS template is chosen for creating a virtual machine, the system will automatically configure a bootable network interface. In the same manner, the network interface card can also choose the virtio interface that when coupled with the physical 10 Gbps network card on the NAS, it can provide higher-speed data access performance.



Display

Emulated GPU: VGA, VMVGA, Cirrus and QXL

Different emulated GPUs can correspond to part of the legacy Linux and Windows XP systems to provide higher compatibility. Even with its convenient HTML5 remote desktop controls, it does not compare to the complete performance of an actual graphics card. QNAP models with HDMI output can display virtual machines on a monitor using an emulated QXL display to enhance the smoothness. GPU pass-through can be used on compatible NAS for complete graphics card applications.

How to choose NAS

External devices (USB and graphics cards)

QNAP NAS supports passing through USB devices to virtual machines. USB 3.0 (also called USB 3.1 Gen1) is supported on Windows 8 (and later). If additional USB ports are needed for virtual machine operations, then a NAS with the ability to install PCIe USB cards should be considered.

Graphics cards can be installed in specified NAS models with adequate power supplies. Before purchasing a graphics card for use in their NAS, users should take into consideration the compatibility of the graphics card, the physical size of the graphics card, the physical space available inside their NAS, and the NAS power supply (QNAP recommends using a NAS with at least a 450w power supply for graphics cards applications).

Requirements for running multiple virtual machines (number of processor cores, memory capacity support)

When Virtualization Station is allocating virtual processor cores to virtual machines, it is using the logical cores on the NAS as the units. Therefore if there is a need for multiple virtual machines to be run on a single NAS, you need to consider planning the number of logical cores and NAS memory capacity in advance. Currently the QNAP TDS-16489U supports up to 32 logical cores and supports up to 1 TB memory for you to enjoy the fullest computation power and system resources in an environment demanding a large number of virtual machines. For common desktop NAS models, you can choose the TVS-x73 series, TS-x77 series, TVS-x82 series and TES-x85 models. These models also have more logical cores and expandable memory, enough for the need of ordinary small to medium businesses (QNAP Systems, Inc. 2017).

Virtual machine computation efficiency (processor clock rate)

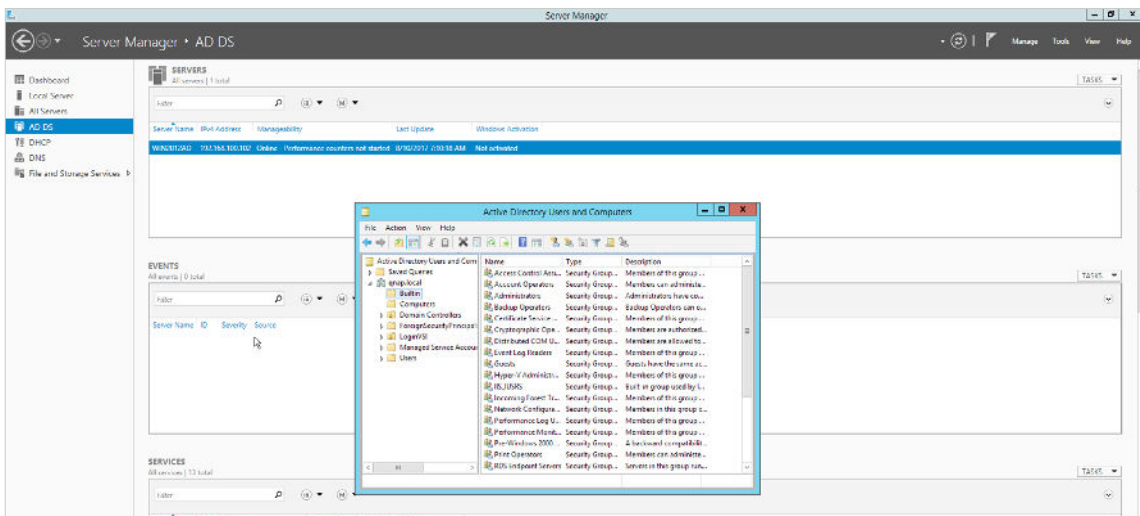
Depending on different computation needs and different implementations of applications, some applications can make full use of the advantage of multi-threading to process in parallel. In a situation like this, normally there is no need for a higher processor clock rate, but instead it depends on multiple cores to get an advantage. But for applications designed to run on a single thread, a processor with a higher clock rate will be more important than the number of cores. Currently some of the 4-core QNAP NAS models like the TVS-x82 and TVS-x80 series models with Intel® i3 and E3 have clock rates above 3.0GHz for your use, suitable for running single-threaded applications.

Application cases

The private compute engine with combined storage provided by Virtualization Station is comparable to public cloud services (like Amazon® Web Services, Google Cloud Platform and Microsoft Azure®). IT administrators can use virtual machines to deploy servers or application services that can be used to run online service systems. Virtual machines are also ideal for testing purposes or as temporary solutions when existing services are being maintained.

Windows Server, databases and other client applications

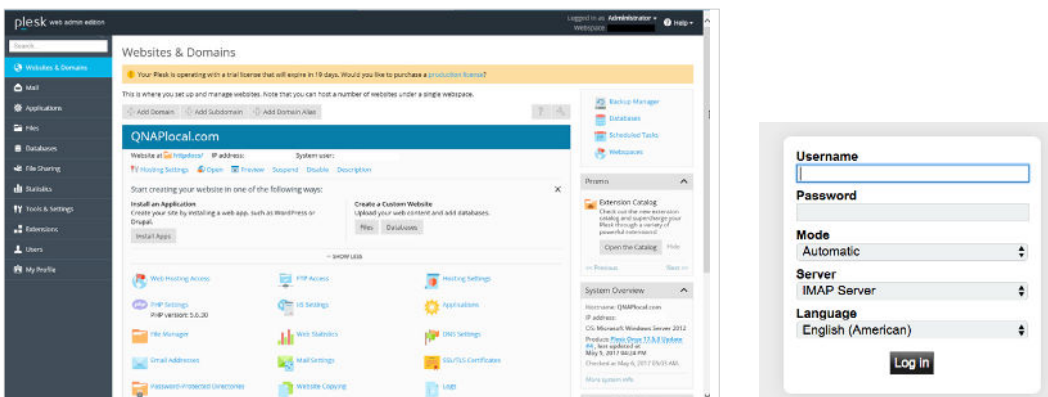
Supports installing Windows Server 2016. Common server services in a data center (including Windows Active Directory, DHCP, and Internet Information Services) can all be run 24/7 through the NAS to ensure service usability. For database storage requirements at the block level, you can use the NAS to create a LUN and then mount it for use. Furthermore, client software on Windows can also be installed on a virtual machine for long-time operation or frequent file access. For example, SuperGIS® DataConvertor data conversion software, Digital Photo Professional for picture conversion of RAW files that not only need long conversion time, but also can access NAS space directly.



In addition to employing virtual machines to provide application services, no matter the generated files are at file level or block level, the purpose of maintaining data security and disaster recovery can be achieved through the NAS apps Hybrid Backup Sync (QNAP Systems, Inc. 2017) or Snapshot Replica (QNAP Systems, Inc. 2017).

Information systems

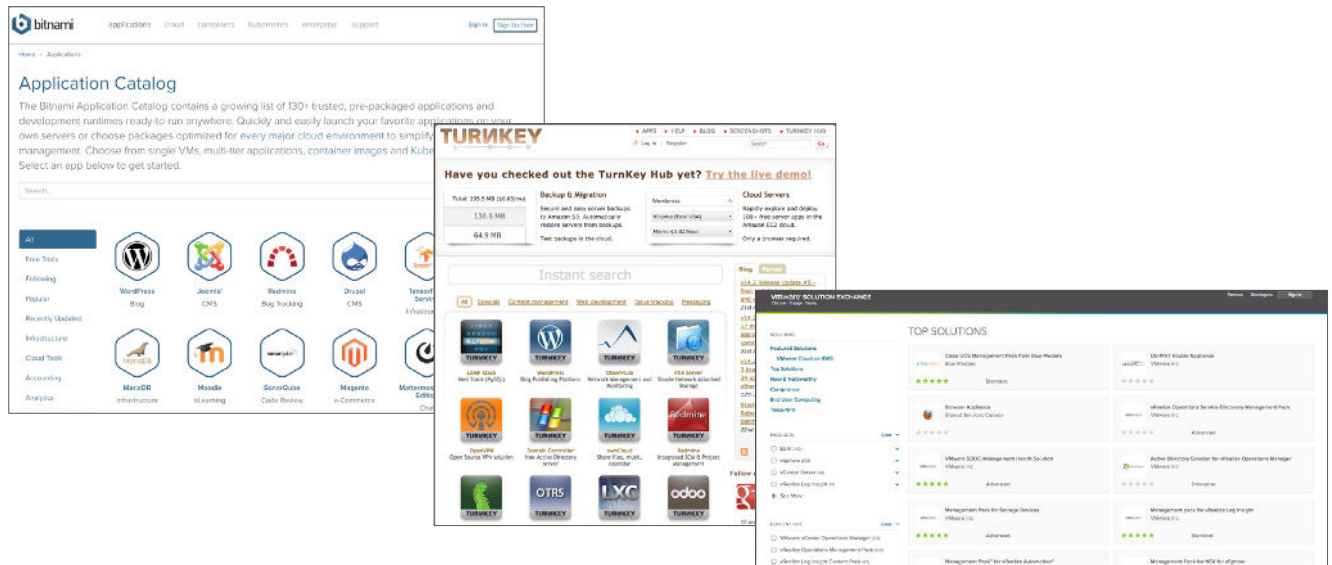
The NAS can directly run business systems including email servers and web management suites. Using a virtual switch to access internal storage space can reduce data transmission between compute and storage nodes. In addition, virtual machines can run website management platforms like Plesk to quickly install many applications like WordPress, Drupal, database servers, or common email servers like Postfix and Horde IMP.



Deployment of software development environments

Use virtual machines to deploy open source applications for development uses like GitLab and GitHub to let developers upload source code of the project under their care easily through a browser. Furthermore you can also do it through adding or cloning virtual machines to quickly create a sandbox testing environment. The process can also coupled with snapshots to conduct risk tests so if a problem occurs, the testing environment can be instantly restored.

Cloud service providers (like Bitnami, Turnkey and VMware®) can package application services and their running operating systems directly (Virtual Appliance) for users to download or to be run directly through private cloud IaaS (Infrastructure as a Service) or PaaS (Platform as a Service) platforms. In terms of deployment, apart from adding virtual machines and installing operating systems, you can do it through import to directly import and use an already packaged virtual machine.



Conclusion

Virtualization provides high availability and fast deployment. Coupled with the high-speed I/O performance and fundamental storage service provided by the NAS, users are empowered with more choice and flexibility alongside a simple installation process and no additional software licensing fees.

Over the years, QNAP R&D has been dedicated to fine-tuning virtual machine performance and functions on the software side as well as analyzing the user experience. The virtualization performance figures not only comply with virtualization industry standards, but QNAP was the first vendor to introduce its own virtualization platform. QNAP also possesses a history of designing and developing dependable hardware solutions. As for the user interface design, QNAP has prioritized creating a usable and familiar interface that lowers the learning curve of users. Inexperienced users and enterprise users alike can enjoy the convenience brought by virtual machines.

For plural virtual machine applications like information systems and software development, QNAP also introduces Virtualization Station inside the enterprise for use on running the company's internal process system and MIS management system like IBM® Lotus Notes®, Redmine and GitLab to use the dual role of developer and user to make sure we can definitely provide the best user experience.

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