



What is Network-Attached Storage (NAS)? A Complete Guide

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[What is network-attached storage \(NAS\)?
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NAS is used to provide centralized storage for data that distributed teams, such as remote workers, need to access, and can act as a private cloud to give multiple users access to data on multiple hard drives. It is also used in larger enterprises as a backup target using NAS arrays, and for small virtualization environments for VMs.

Learn about the various types of network-attached storage, how it is used, why it's important, the various products available and the future of NAS, in this comprehensive guide.

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What is network-attached storage (NAS)? A complete guide

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WHAT IS NETWORK-ATTACHED STORAGE (NAS)?

Network-attached storage (NAS) is dedicated file storage that enables multiple users and heterogeneous client devices to retrieve data from centralized disk capacity. Users on a local area network (LAN) access the shared storage via a standard Ethernet connection.

NAS devices typically don't have a keyboard or display and are configured and managed with a browser-based utility. Each NAS resides on the LAN as an independent network node, defined by its own unique IP address.

[NAS stands out for its ease of access, high capacity and low cost.](#) The devices consolidate storage in one place and support a cloud tier and tasks, such as archiving and backup.

Network-attached storage and storage area networks ([SANs](#)) are the two main types of networked storage. NAS handles unstructured data, such as audio, video, websites, text files

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and Microsoft Office documents. SANs are designed primarily for [block storage](#) inside databases, also known as *structured data*, as well as block storage for enterprise applications.

WHAT IS NETWORK-ATTACHED STORAGE USED FOR?

The purpose of network-attached storage is to enable users to collaborate and share data more effectively. It is useful to distributed teams that need remote access or work in different time zones. NAS connects to a wireless router, making it easy for distributed workers to access files from any desktop or mobile device with a network connection. Organizations commonly deploy a NAS environment as a [storage filer](#) or the foundation for a personal or private cloud.

Some NAS products are designed for use in large enterprises. Others are for home offices or small businesses. Devices usually contain at least two drive bays, although single-bay systems are available for noncritical data. Enterprise NAS gear is designed with more high-end data features to aid storage management and usually comes with at least four drive bays.

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Prior to NAS, enterprises had to configure and manage hundreds or even thousands of file servers. To expand storage capacity, NAS appliances are outfitted with more or larger disks; this is known as *scale-up NAS*. Appliances are also clustered together for [scale-out storage](#).

In addition, most NAS vendors partner with cloud storage providers to give customers the flexibility of redundant backup.

Although collaboration is a virtue of network-attached storage, it can also be problematic. Network-attached storage relies on hard disk drives (HDDs) to serve data. I/O contention can occur when too many users overwhelm the system with requests at the same time. Newer systems use faster solid-state drives (SSDs) or [flash storage](#), either as a tier alongside HDDs or in all-flash configurations.

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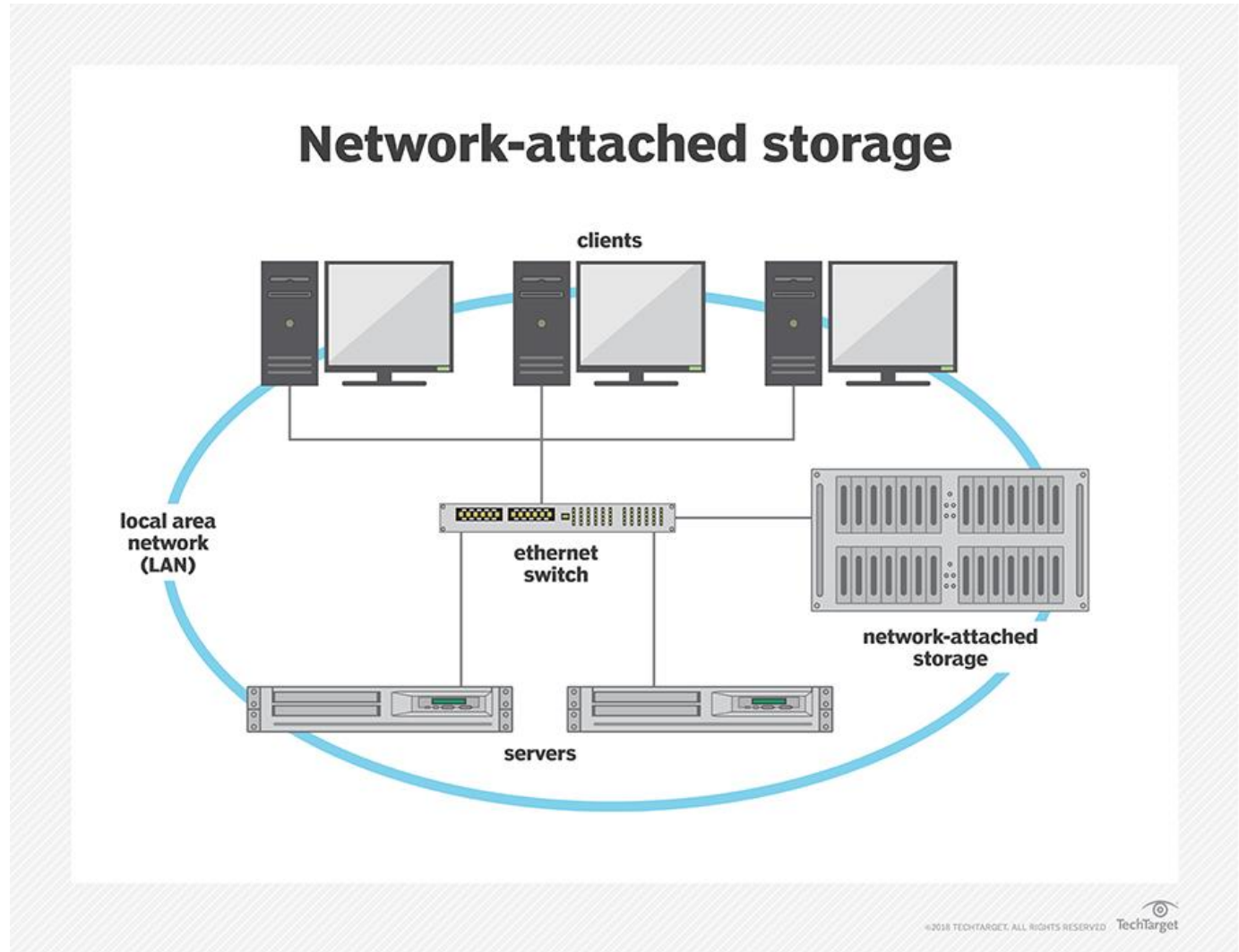
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NAS USE CASES AND EXAMPLES

The type of HDD selected for a NAS device will depend on the applications to be used. Sharing Microsoft Excel spreadsheets or Word documents with co-workers is a routine task, as is performing periodic data backup. Conversely, using NAS to handle large volumes of streaming media files requires larger capacity disks, more memory and more powerful network processing.

At home, people use a NAS system to store and serve multimedia files and to automate backups. Home users rely on network-attached storage to do the following:

- manage smart TV storage;
- manage security systems and security updates;
- manage consumer-based IoT components;
- create a media streaming service;
- manage torrent files;
- host a personal cloud server; and
- create, test and develop a personal website.

In the enterprise, NAS is used in the following ways:

- as a backup target, using a NAS array, for archiving and disaster recovery;
- for testing and developing web-based and server-side web applications;
- for hosting messaging applications;

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- for hosting server-based, open source applications, such as customer relationship management, human resource management and enterprise resource planning applications; and
- for serving email, multimedia files, databases and print jobs.

Take this example of how enterprises use the technology: When a company imports many images every day, it cannot stream this data to the cloud because of latency. Instead, it uses an enterprise-class NAS to store the images and cloud caching to maintain connections to the images stored on premises.

Higher-end NAS products have enough disks to support redundant arrays of independent disks, or [RAID](#), which is a storage configuration that turns multiple hard disks into one logical unit to boost performance, high availability and redundancy.

NAS COMPONENTS AND HOW THEY WORK

[A NAS device is fundamentally a dedicated storage server](#) -- a specialized computer designed and intended to support storage through network access. Regardless of the size and scale of the network-attached storage, every NAS device is typically composed of four major components:

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- **CPU.** The heart of every NAS is a computer that includes the central processing unit (CPU) and memory. The CPU is responsible for running the NAS OS, reading and writing data against storage, handling user access and even integrating with cloud storage if so designed. Where typical computers or servers use a general-purpose CPU, a dedicated device such as NAS might use a specialized CPU designed for high performance and low power consumption in NAS use cases.
- **Network interface.** Small NAS devices designed for desktop or single-user use might allow for direct computer connections, such as USB or limited wireless (Wi-Fi) connectivity. But any business NAS intended for data sharing and file serving will demand a physical network connection, such as a cabled Ethernet interface, giving the NAS a unique IP address. This is often considered part of the NAS hardware suite, along with the CPU.
- **Storage.** Every NAS must provide physical storage, which is typically in the form of disk drives. The drives might include traditional magnetic HDDs, SSDs or other non-volatile memory devices, often supporting a mix of different storage devices. The NAS might support

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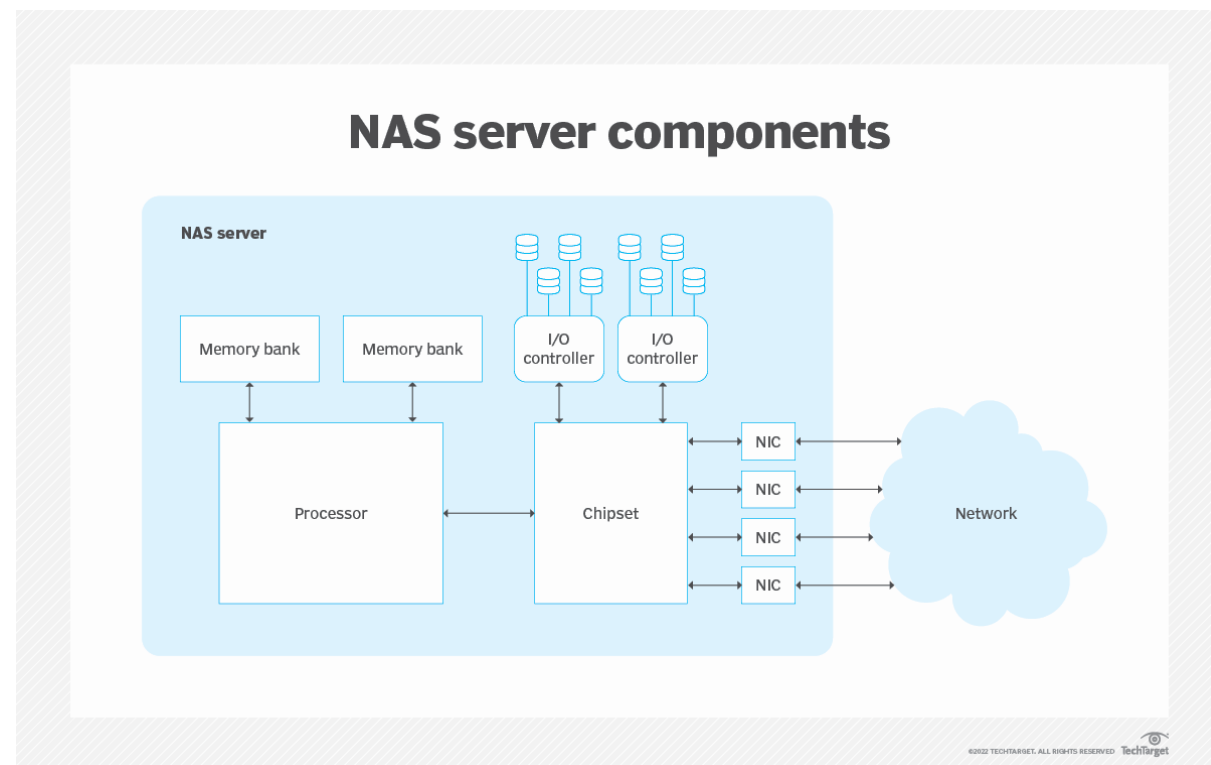
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logical storage organization for redundancy and performance, such as mirroring and other RAID implementations -- but it's the CPU, not the disks, that handle such logical organization.

- **OS.** Just as with a conventional computer, the OS organizes and manages the NAS hardware and makes storage available to clients, including users and other applications. Simple NAS devices might not highlight a specific OS, but more sophisticated NAS systems might employ a discrete OS such as Netgear ReadyNAS, QNAP QTS, Zyxel FW or TrueNAS Core, among others.



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TOP CONSIDERATIONS FOR CHOOSING NAS

Although the storage goals of NAS might seem straightforward, selecting a NAS device can be deceptively complex. Price considerations aside, enterprise NAS users should consider an array of factors in product selection, including the following:

- **Capacity.** How much storage can the NAS provide? There are two major issues: the number of disks and the logical organization of those disks. As one simple example, if the NAS can hold two 4 TB disks, the capacity of the NAS can be 8 TB. But if those disks are configured as RAID 1 -- mirroring -- those two disks simply copy each other; so, the total usable capacity would only be 4 TB, but the storage would be redundant.
- **Form factor.** Where will the NAS be installed? The two principal form factors are rackmount and tower (standalone). An enterprise NAS can use a 2U or 4U rackmount form factor for installation into an existing data center rack. A tower or self-contained NAS can be a good choice for deployment in smaller department data closets or even on desktops.
- **Performance.** How many users will the NAS support? It takes a finite amount of network and internal computing power to handle a storage request from the network and then translate that request into actual read/write storage tasks within the NAS. A busy NAS will demand higher levels of performance and internal caching to provide greater storage I/O and efficiently support more simultaneous users. Otherwise, users will need to wait longer (lag) for the NAS to service their storage request.
- **Connectivity.** How will the NAS connect to users and applications? Most NAS equipment includes one or more traditional Ethernet ports for cabled network connectivity. High-capacity network connectivity is essential for busy NAS devices in enterprise data centers.

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NAS designed for smaller, less-demanding environments can get by with Wi-Fi connectivity, while small NAS devices for end-users might supply a USB port for direct PC connectivity.

- **Reliability.** How can the NAS handle problems? Reliability has three major layers: the reliability of the NAS itself, the reliability of the disks installed within the NAS and the reliability of the data stored on the disks. At the NAS level, the equipment itself should be designed to provide long, continuous service at the peak expected performance level. Disk reliability depends on the disks installed in the NAS; high-quality SAS disks can offer excellent error-correction and enormous mean time between failure figures, but all disk choices should include a replacement plan. Finally, the NAS handles RAID, replication and other means of maintaining data integrity within the device, but those features must be enabled and configured.
- **Security.** [How is data protected on the NAS?](#) Look for NAS equipment that [provides native data encryption](#) and strong network access controls to ensure that only authorized users and applications can access storage.
- **Usability and features.** How easily can the NAS be set up and deployed? Look for NAS equipment that is easy to deploy and configure, and consider the features and functionality included with the NAS OS/software, such as data snapshots, data backups, data replication, automatic data tiering and RAID.

WHY IS CHOOSING THE RIGHT NAS IMPORTANT?

Any network-attached storage deployment is an investment of capital and time, and the storage offered by NAS will be a valuable resource for users -- whether at home, within a small business or across an enterprise. Consequently, a NAS investment demands careful

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evaluation of each consideration above before making a purchase decision. Choosing the wrong network-attached storage can result in undesirable outcomes, such as the following:

- **Inadequate storage capacity.** Although a NAS setup can typically receive additional storage devices to increase its capacity, it's important for business users to predict utilization and capacity requirements across the NAS lifecycle to ensure the necessary capacity will be available. Too much capacity results in wasted capital, while too little capacity without expansion will require additional NAS purchases.
- **Inadequate performance.** NAS must serve multiple client systems, including users and other applications, across a network. The NAS must be able to handle network traffic and support the internal I/O needed to read/write data to storage in response to network demands. Inadequate performance might result in unacceptable application lag and reduced user experience.
- **Inadequate resilience.** Simple NAS is little more than storing data on a remote disk, but businesses that rely on data availability -- and must guard against data loss due to factors like disk failure -- must select and implement resilience features, such as RAID. A NAS deployment that lacks these features, or where those features aren't implemented, might put the business at risk in terms of both revenue and compliance.
- **Inadequate security.** Every business requires data security, so NAS subsystems must include adequate access control as well as additional security capabilities, such as native data encryption, to meet business and compliance needs. NAS that lacks or fails to implement these features might expose the business to additional risk.

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NAS PRODUCT CATEGORIES

NAS devices are grouped in three categories based on the number of drives, drive support, drive capacity and scalability.

High end or enterprise

The high end of the market is driven by organizations that need to store and share vast quantities of file data, including virtual machine (VM) images. Enterprise NAS devices can scale to provide petabytes of storage, serve thousands of client systems and provide rapid access and clustering capabilities. The clustering concept addresses drawbacks associated with traditional NAS.

For example, one device allocated to an organization's primary storage space creates a potential single point of failure. Spreading mission-critical applications and file data across multiple boxes and adhering to scheduled backups decreases the risk. Redundancy is typically accomplished through some form of duplication -- copying data onto more than one storage device or storage subsystem.

[Clustered NAS](#) systems also reduce NAS sprawl. A distributed file system runs concurrently on multiple NAS devices. This approach provides access to all files in the cluster, regardless of the physical node on which it resides.

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Midmarket

The NAS midmarket accommodates businesses with hundreds of client systems that require several hundred terabytes of data. These devices cannot be clustered, however, which can lead to file system silos if multiple NAS devices are required.

Low end or desktop

The NAS low end is aimed at home users and small businesses that require local shared storage for just a few client systems up to several terabytes. This market is shifting toward a [cloud NAS](#) service model, with products such as Buurst's SoftNAS Cloud NAS and software-defined storage (SDS) from legacy storage vendors.

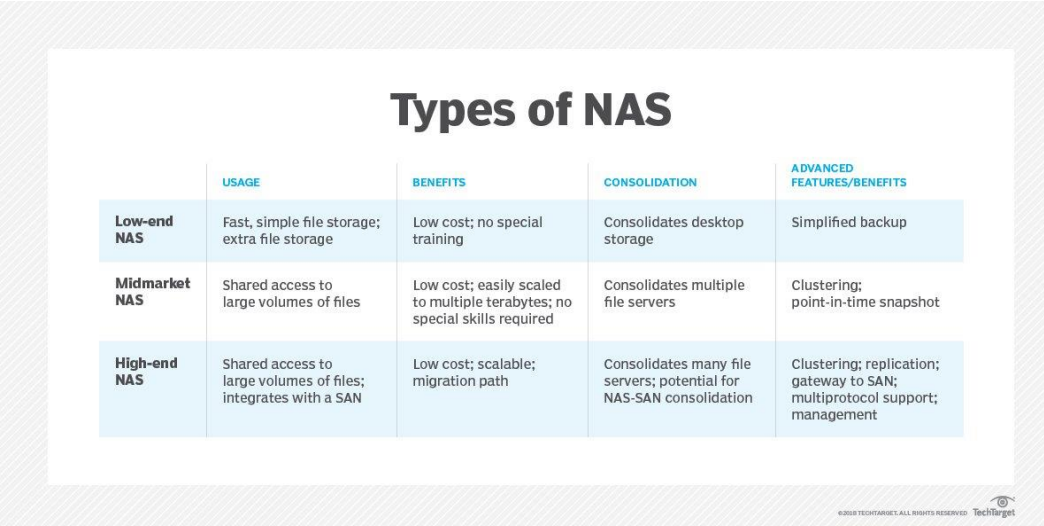
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The image shows a table titled "Types of NAS" with five columns: USAGE, BENEFITS, CONSOLIDATION, and ADVANCED FEATURES/BENEFITS. The rows represent Low-end NAS, Midmarket NAS, and High-end NAS. The table is set against a light blue background with a white border.

	USAGE	BENEFITS	CONSOLIDATION	ADVANCED FEATURES/BENEFITS
Low-end NAS	Fast, simple file storage; extra file storage	Low cost; no special training	Consolidates desktop storage	Simplified backup
Midmarket NAS	Shared access to large volumes of files	Low cost; easily scaled to multiple terabytes; no special skills required	Consolidates multiple file servers	Clustering; point-in-time snapshot
High-end NAS	Shared access to large volumes of files; integrates with a SAN	Low cost; scalable; migration path	Consolidates many file servers; potential for NAS-SAN consolidation	Clustering; replication; gateway to SAN; multiprotocol support; management

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NAS DEPLOYMENTS FOR BUSINESS

The chart below describes five different [ways NAS can be deployed](#) and lists the pros and cons for each approach. Each deployment can easily be managed by a single network manager.

The different deployment approaches include these options:

- **NAS gateways.** These are best for large, enterprise-class users who have a SAN.
- **Integrated NAS.** This approach works well for users of all sizes without a SAN.

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- **Clustered file systems.** Large compute cluster users who need high-performance access to file data find these clustered file systems optimal for their needs.
- **Parallel file systems.** These also work well for large compute cluster users requiring high-performance file data access, or any organization needing parallel access to file data.
- **NAS aggregators.** These are ideal for multibox and multivendor environments.

NAS approaches: Pros and cons			
APPROACH	PROS	CONS	BEST FITS
NAS gateways	<ul style="list-style-type: none">■ Available SAN storage can be used■ Easy, single-vendor migration tools■ Upgrade back end or front end separately	<ul style="list-style-type: none">■ Capacity and performance are limited to what is available behind a gateway	<ul style="list-style-type: none">■ Large, enterprise-class users that have a SAN■ Single-vendor consolidation
Integrated NAS	<ul style="list-style-type: none">■ No SAN requirements; simpler configuration■ Easy, single-vendor migration tools	<ul style="list-style-type: none">■ Compared to gateways, the file system, performance and capacity may be limited■ All-or-nothing performance upgrades	<ul style="list-style-type: none">■ Small-sized to enterprise-class users without a SAN■ Single-vendor consolidation
Clustered file systems	<ul style="list-style-type: none">■ Able to scale out■ Performance of servers can be dialed to whatever is required	<ul style="list-style-type: none">■ Some vendors have limited or no CIFS support	<ul style="list-style-type: none">■ Large compute cluster users requiring high-performance access to file data
Parallel file systems	<ul style="list-style-type: none">■ Able to scale out■ Parallel file system improves throughput and performance	<ul style="list-style-type: none">■ Some vendors don't support CIFS or have limited NFS support■ Parallel file access only available on limited clients and requires special client software	<ul style="list-style-type: none">■ Large compute cluster users requiring high-performance access to file data■ Anybody needing parallel access to file data
NAS aggregators	<ul style="list-style-type: none">■ Heterogeneous box consolidation■ Single namespace over multiple NAS boxes	<ul style="list-style-type: none">■ Added overhead■ Additional hardware to install, configure and maintain	<ul style="list-style-type: none">■ Multibox/multivendor environment■ Single namespace configurability/usability

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NAS FILE-SHARING PROTOCOLS

The baseline functionality of network-attached storage devices has broadened to support virtualization. High-end NAS products might also support data deduplication, flash storage, multiprotocol access and data replication.

Some NAS devices run a standard operating system, such as Microsoft Windows, while others run a vendor's proprietary OS. IP is the most common data transport protocol, but some midmarket NAS products might support additional protocols, such as the following:

- Network File System
- Internetwork Packet Exchange
- NetBIOS Extended User Interface
- Server Message Block (SMB)
- Common Internet File System ([CIFS](#))

Additionally, high-end NAS devices might support Gigabit Ethernet for even faster data transfer across the network.

Some larger enterprises are switching to [object storage](#) for capacity reasons. However, NAS devices are expected to continue to be useful for small and medium-sized businesses.

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SCALE-UP AND SCALE-OUT NAS VS. OBJECT STORAGE

Scale up and scale out are two versions of NAS. [Object storage is an alternative to NAS](#) for handling unstructured data.

Scale-up NAS

In a network-attached storage deployment, the NAS head is the hardware that performs the control functions. It provides access to back-end storage through an internet connection. This configuration is known as *scale-up architecture*. A two-controller system expands capacity with the addition of drive shelves, depending on the scalability of the controllers.

Scale-out NAS

With scale-out systems, the storage administrator installs larger heads and more hard disks to boost storage capacity. Scaling out [provides the flexibility](#) to adapt to an organization's business needs. Enterprise scale-out systems can store billions of files without the performance tradeoff of doing metadata searches.

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Object storage

Some industry experts speculate that object storage will overtake scale-out NAS. However, it's possible the two technologies will continue to function side by side. Both scale-out and object storage methodologies deal with scale, but in different ways.

NAS files are centrally managed via the Portable Operating System Interface (POSIX). It provides data security and ensures multiple applications can share a scale-out device without fear that one application will overwrite a file being accessed by other users.

Object storage is a new method for easily scalable storage in web-scale environments. It is useful for unstructured data that is not easily compressible, particularly large video files.

Object storage does not use POSIX or any file system. Instead, all the objects are presented in a flat address space. Bits of metadata are added to describe each object, enabling quick identification within a flat address namespace.

NAS VS. DAS

Direct-attached storage ([DAS](#)) refers to a dedicated server or storage device that is not connected to a network. A computer's internal HDD is the simplest example of DAS. To access DAS files, the user or computer must have access to the physical storage.

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DAS has better performance than NAS, especially for compute-intensive software programs. This is due to dedicated disk access while avoiding the latency of network traffic. In its barest form, DAS might be nothing more than the drives that go in a server.

With DAS, the storage on each device must be separately managed, adding a layer of complexity. Unlike NAS, DAS does not lend itself well to shared storage by multiple users.

Storage platform architecture comparison	
SAN	Highly scalable, high-performance network connecting hosts with a shared pool of block-level storage over SCSI-based protocols.
DAS	Attached to and managed by a single host. Storage consists of disks in a host and/or external disk enclosures that are directly connected to the storage controllers in the host.
NAS	Shared-storage option that stores and shares files via standard file system protocols—mainly the Network File System and Server Message Block protocols—over IP networks.

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NAS VS. SAN

What are the [differences between SAN and NAS](#)? A SAN organizes storage resources on an independent, high-performance network. Network-attached storage handles I/O requests for individual files, whereas a SAN manages I/O requests for contiguous blocks of data.

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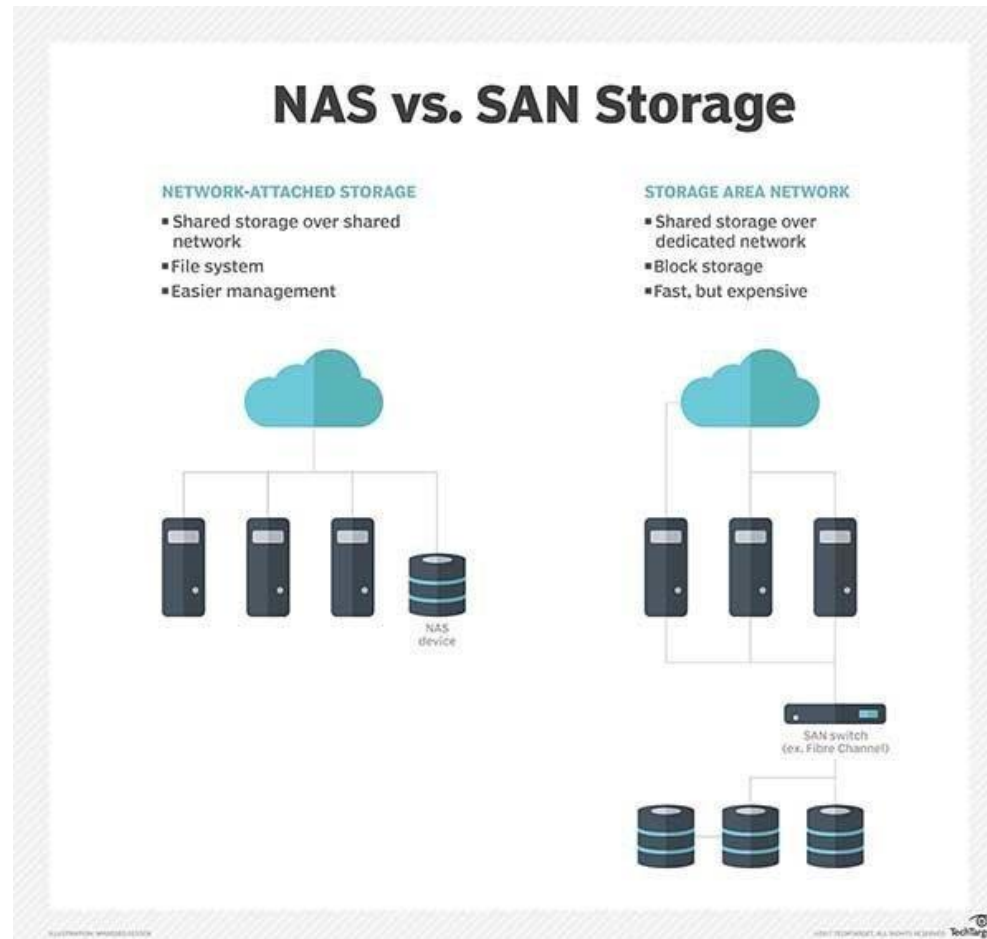
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NAS traffic moves across TCP/IP, such as Ethernet. SAN, on the other hand, routes network traffic over the Fibre Channel ([FC](#)) protocol designed specifically for storage networks. SANs can also use the Ethernet-based [iSCSI](#) protocol instead of FC.

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Although NAS can be a single device, SAN provides full block-level access to a server's disk volumes. Put another way, a client OS will view NAS as a file system, while a SAN appears to the disk as the client OS.

SAN/NAS CONVERGENCE

Until recently, technological barriers have kept the file and block storage worlds separate. Each has had its own management domain and its own strengths and weaknesses. The prevailing view of storage managers was that block storage is "first class" and file storage is "economy class." Giving rise to this notion was a prevalence of business-critical databases housed on SANs.

With the emergence of unified storage, vendors sought to improve large-scale file storage with SAN/NAS convergence. This consolidates block- and file-based data on one storage array. Convergence supports SAN block I/O and NAS file I/O in the same set of switches.

But the promise of SAN/NAS convergence goes far beyond a simple matter of storage approach. Designers have long recognized that SAN and NAS are complementary rather than competing storage technologies, and combining SAN and NAS into a single storage system can benefit users in a range of way, including the following:

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- eliminating islands -- and complexity -- of separate SAN or NAS storage;
- improved storage scalability and a common management platform for both SAN and NAS;
- improved file-level access and virtualization for SAN;
- supporting optimizations for mixed file and block data; and
- mitigating the costs of separate SAN/NAS storage and management.

The concept of hyper-convergence first appeared in 2014, pioneered by market leaders Nutanix and SimpliVity Corp., now part of Hewlett Packard Enterprise (HPE). Hyper-converged infrastructure (HCI) bundles the computing, network, SDS and virtualization resources on a single appliance.

HCI systems pool tiers of different storage media and present it to a hypervisor as a NAS mount point. They do this even though the underlying shared resource is block-based storage. However, a drawback of HCI is that only the most basic file services are provided. That means a data center might still need to implement a separate network with attached file storage.

Converged infrastructure (CI) packages servers, networking, storage and virtualization resources on hardware that the vendor has already integrated and validated. Unlike HCI, which consolidates devices in one chassis, CI employs separate devices. This gives customers greater flexibility in building their storage architecture. Organizations looking to simplify storage management might opt for CI or HCI systems to replace a NAS or SAN environment.

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Today's convergence and HCI offerings not only combine SAN and NAS storage, but also consolidate computing (servers) and networking gear into the same gear suite -- optimizing entire data center deployment and build-out opportunities.

NAS AND FILE STORAGE VENDORS

Despite the growth in flash storage, network-attached storage systems still primarily rely on spinning media. The list of vendors is extensive, with most offering more than one configuration to help customers balance capacity and performance.

NAS systems come either fully populated with disks or as a diskless chassis where customers add HDDs from their preferred vendor. Drive vendors Seagate Technology, Western Digital and others work with NAS providers to develop and qualify media.

[Vendors of NAS appliances](#) or scalable file storage include the following:

- **Accusys Storage Ltd.** Accusys supplies scalable shared flash with Peripheral Component Interconnect Express-based ExaSAN. Accusys Gamma and T-Share devices are Thunderbolt 3-designed devices with built-in RAID.
- **Arcserve Inc.** The data and ransomware protection provider acquired StorageCraft's NAS technology for enterprise environments.

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- **Asustor.** A subsidiary of Taiwanese computer electronics giant Asus, Asustor offers NAS models for personal and business use.
- **Buffalo Americas Inc.** Offerings include the TeraStation desktop and rackmount NAS appliances. Buffalo's LinkStation NAS devices are targeted at small business and individuals.
- **Buurst Inc.** The vendor's SoftNAS Cloud NAS software-only product enables customers to scale data migration to Amazon Web Services, Microsoft Azure and VMware vSphere.
- **Cloudian.** HyperFile by Cloudian is a scale-out NAS system for scalable enterprise file services on premises.
- **Ctera Networks.** The software company's Edge X Series offers a cloud storage gateway and NAS appliance.
- **Ciphertex Data Security.** Ciphertex SecureNAS CX is a line of secure storage appliances.
- **DataDirect Networks.** DDN specializes in storage systems for high-performance computing, including the ExaScaler arrays engineered for high parallelization.
- **DataOn Storage.** The vendor certified its scale-out file server to enable tunable, shared clustered storage to Windows Server 2019.
- **Dell EMC.** PowerScale -- replacing EMC Isilon -- is a scale-out NAS that provides the flexibility of a software-defined architecture with accelerated hardware.
- **Drobo.** 5N NAS is the vendor's low-end complement to the Drobo B810i and B1200i iSCSI midrange arrays.
- **Excelero Inc.** Excelero jumped in the market in 2017 with NVMesh Server SAN software, which sits between block drives and logical file systems. It writes data directly to non-volatile memory express devices using its patented Remote Direct Drive Access.
- **Fujitsu.** Celvin NAS servers are suited for backup, cloud, file sharing and SAN integration cases.
- **Hitachi Vantara.** The Hitachi NAS Platform combines Hitachi's Virtual Storage Platform arrays and Storage Virtualization Operating System and is geared to large VMware environments.

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- **HPE.** 3PAR StoreServ from HPE is a flash storage NAS system.
- **Huawei.** Scalable File Service (SFS) is a NAS service on Huawei Cloud with scalable high-performance file storage.
- **IBM.** Spectrum NAS combines IBM Spectrum SDS with storage hardware. Spectrum NAS runs on x86 servers. IBM Spectrum Scale handles file storage for high-performance computing. Spectrum Scale is SDS based on IBM's General Parallel File System.
- **Infinidat.** The vendor's petabyte-scale InfiniBox unified NAS and SAN array predominantly with disk. It uses a B-tree architecture that caches data and metadata on SSDs, enabling reads directly on the nodes.
- **IXSystems Inc.** IXSystems designs consumer-oriented TrueNAS for enterprises.
- **Microsoft Azure.** Microsoft's FXT Edge Filer, with a file system designed for object storage, offers cloud-integrated hybrid storage that works with an organization's NAS and Azure Blob Storage.
- **NetApp Inc.** With its Fabric-Attached Storage and All Flash FAS, NetApp helped pioneer the use of an extensible file system.
- **Netgear.** ReadyNAS by Netgear is available in desktop and rackmount models as storage for hybrid and private clouds.
- **Nexenta Systems Inc.** NexentaStor is SDS that also supports FC and NAS. The software runs on bare metal, VMware hosts or inside VMs on hyper-converged hardware.
- **Nexsan.** Unity, the vendor's durability-focused arrays, handles SAN and NAS protocols -- enabling hybrid media to support mixed workloads, especially in rugged physical locations.
- **Oracle.** The Sun Storage 7000 Unified Storage Systems are enterprise-class storage systems for efficiency, scalability and ease-of-use with integrated tools.
- **Panasas.** The ActiveStor parallel hybrid scale-out system runs the Panasas PanFS file system.
- **Pure Storage.** The vendor positions its all-flash FlashBlade as a highly scalable platform for big data analytics.

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- **Quanta Cloud Technology.** QCT offers MESOS CB220 NAS appliances.
- **QNAP Systems Inc.** QNAP has an extensive NAS portfolio that spans small and midsize businesses, as well as midrange and high-end enterprises. It also has products for home users.
- **Quantum Corp.** The company launched its Xcellis scale-out NAS to compete with Dell EMC Isilon and NetApp FAS. Xcellis uses the Quantum StorNext scalable file system.
- **Qumulo Inc.** Qumulo Core file storage was developed by several of the creators of the Dell EMC Isilon technology. The Core OS runs on Qumulo C-series and P-series branded arrays, as well as commodity servers.
- **Rackspace Technology.** Enterprise services include dedicated NAS based on the NetApp OnTap OS for managed block- and file-level storage.
- **Seagate.** The BlackArmor NAS 220 enterprise arrays scale from 1 TB to 6 TB, with smaller BlackArmor models topping out at 2 TB. Seagate Personal Cloud NAS targets the consumer market with capacity up to 5 TB.
- **Spectra Logic Corp.** The storage company introduced BlackPearl NAS ranging from 48 TB to 420 TB of optional hybrid flash in a 4U rack.
- **Synology Inc.** Offerings include NAS devices for business and personal uses, such as DiskStation NAS as well as the company's FS, XS, J, Plus and Value Series devices.
- **TerraMaster.** The vendor offers a series of business-capable multidrive systems, including the F5-422 and T6-423.
- **Thecus Technology Corp.** Thecus markets a range of NAS appliances.
- **Verbatim Corp.** A subsidiary of Mitsubishi Chemical Corp., Verbatim offers PowerBay NAS, which supports four hot-swappable HDD cartridges that can be configured for various RAID levels.
- **WekaIO.** The vendor's VM-deployed NAS software gets installed on flash-enabled x86 servers, using its parallel file system to scale to trillions of files.

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- **Western Digital Corp.** My Cloud NAS comes in various models with branded HelioSeal helium HDDs. Portable, rugged NAS also is available through Western Digital's G-Technology subsidiary.
- **Zadara Storage.** Cloud NAS provides scalable file storage as a service with the software-defined Zadara Virtual Private Storage Array.

CLOUD-BASED FILE STORAGE

In addition to NAS devices, some data centers augment or [replace physical NAS with cloud-based file storage](#). Amazon Elastic File System is the scalable storage in Amazon Elastic Compute Cloud. Similarly, Microsoft's Azure Files service furnishes managed file shares based on SMB and CIFS that local and cloud-based deployments can use.

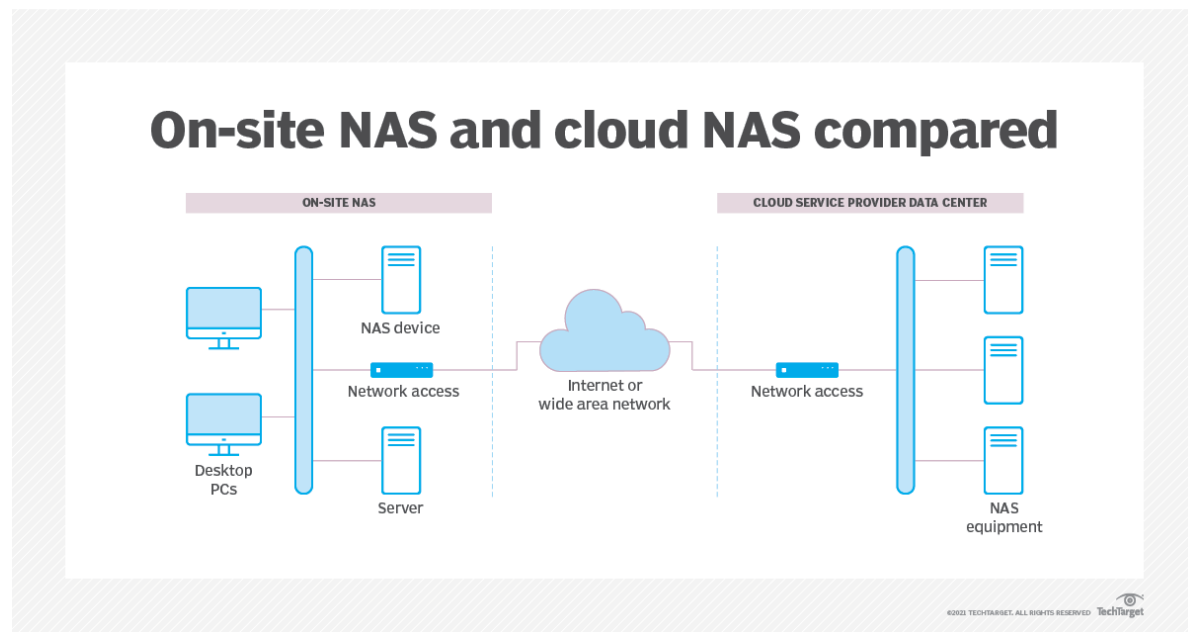
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Ideally, cloud-based file storage enables a user or business to store and access data from cloud storage with the same ease and convenience as a local NAS device in the data center or desktop. Cloud file storage has many varied use cases, including web serving, content management, data analytics, data backups and archiving, streaming content and software development. Simultaneously, the cloud provider must support key storage attributes including high availability, good performance, high security, comprehensive management and modest cost. The following are some common cloud file storage options:

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- Barracuda Cloud Backup
- Dropbox
- Google Drive
- IDrive
- Microsoft OneDrive

Not as common now, [NAS gateways](#) formerly enabled files to access externally attached storage, either connecting to a high-performance area network over FC or simply a bunch of disks in attached servers. NAS gateways are still in use but less frequently; customers are more likely to use a cloud storage gateway, object storage or scale-out NAS.

A cloud gateway sits at the edge of a company's data center network, shuttling applications between local storage and the public cloud. Nasuni Corp. created the cloud-native UniFS file system software, bundled on Dell PowerEdge servers or available as a virtual storage appliance.

Nasuni rival Panzura provides a similar service with its Panzura CloudFS file system and Freedom Filer cache appliances.

Learn more about [five key benefits of cloud storage](#): scalability, flexibility, multi-tenancy, simpler data migration and lower-cost disaster recovery.

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WHAT'S THE FUTURE OF NETWORK-ATTACHED STORAGE?

Two central themes for future NAS development include diversification and automation.

Diversification. Although the concepts of SAN/NAS convergence offer a compelling glimpse into one possible storage future, businesses can be leery of one-size-fits-all platforms. NAS use cases are diversifying, and the needs of each specific use case must be carefully evaluated. Some NAS offerings are well suited for backups and archives but might not possess the performance, scale and reliability attributes needed for hosting virtualized environments, data analytics, AI/ML computing and demanding databases. As the variety of NAS products grows, it's important for IT and business leaders to select the NAS platform that best meets the needs of the task at hand.

Automation. The diversification of NAS and file storage also carries enormous management challenges to data integrity and data quality. Data has to be on the right platform -- or in the proper pool -- such as NVMe-based NAS for top performance, disk-based NAS for capacity or cloud NAS for convenience. This need is driving the use of automation to put the right data in the right NAS locations and ensure that all of the data is complete, intact and secure -- while reducing the need for human intervention.

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Still, NAS is expected to coexist with SAN and object storage subsystems well into the future to meet a wide array of technical and business needs.



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cloud NAS (cloud network attached storage)

PAUL KIRVAN, INDEPENDENT IT CONSULTANT/AUDITOR

WHAT IS CLOUD NAS?

Cloud NAS ([network attached storage](#)) is remote storage that is accessed over the internet as if it is local. The storage is usually hosted by a third-party service provider, who charges the customer a fee based on capacity and bandwidth. Many enterprises use a similar [chargeback](#) method for their off-site storage.

Cloud NAS is often used for backup and archiving. A key benefit of this approach is that data stored in the cloud can be accessed whenever needed and from any place. The main drawback, however, is that the [data transfer rate](#) is limited by speed of the network connection the data is accessed over.

Think of cloud NAS as the same as on-site NAS except the storage devices are located inside a cloud vendor's data centers. The cloud vendor's storage resources are essentially NAS configured to meet customer storage needs.

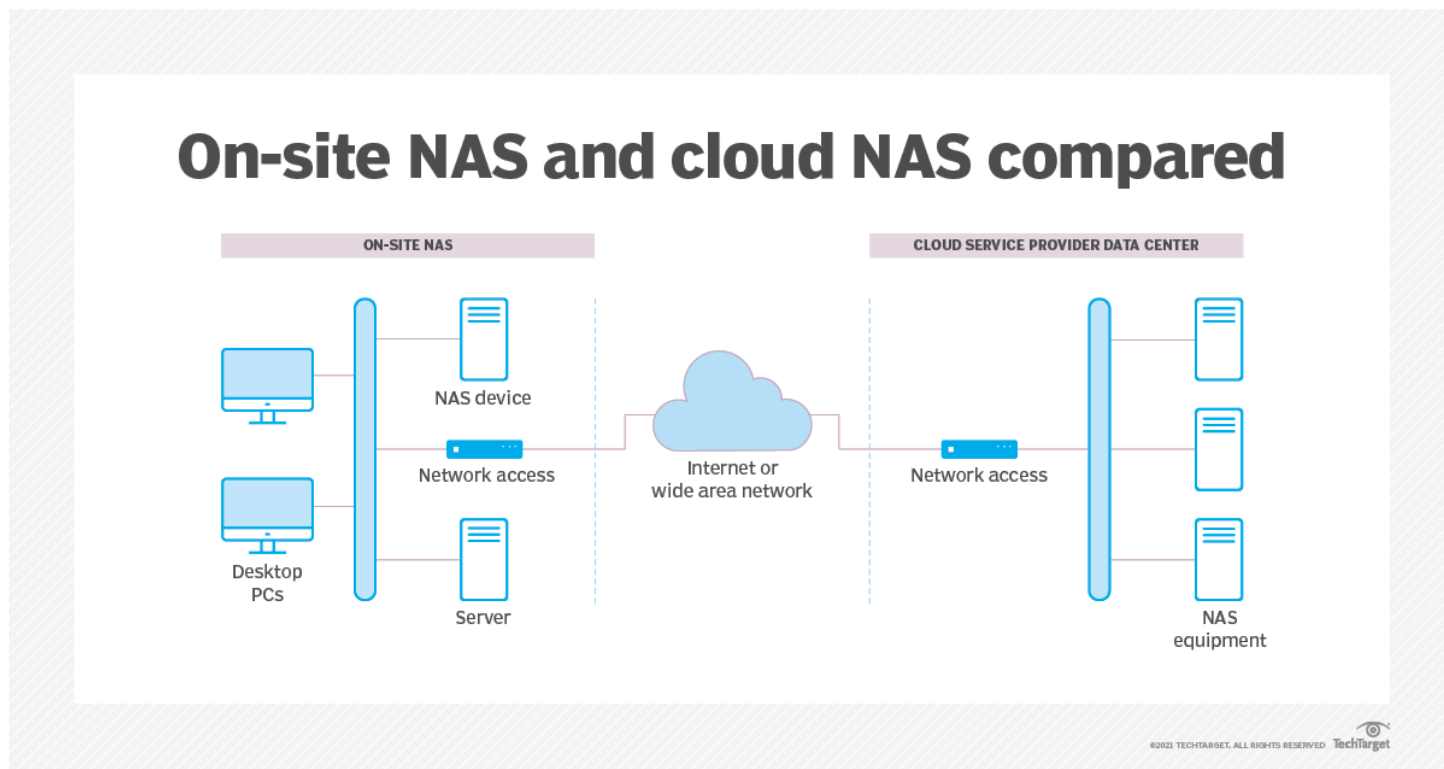
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WHAT IS A NAS SYSTEM?

NAS systems are typically deployed as a standalone storage device with one or more external hard drives to provide more storage than a standard desktop system or laptop. It has its own operating system (OS) and [file system](#) and supports a variety of applications, the same as a desktop system.

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A NAS system does not connect directly to a computer; instead, it connects to a wired or wireless network used by one or more computers. It can provide dedicated storage for one device or shared storage across many devices. It can be used in place of additions to a primary storage system. A NAS system can be located in a data center rack or a work area.

[Disaster recovery](#) (DR) setups can also include NAS systems. If greater storage is required, multiple NAS devices can be scaled out, sharing the same file system and supporting the creation of larger volumes of shared storage.

Because a NAS device typically has its own OS, it is important to check for compatibility with planned applications for the NAS. Examples of specialized applications that may be supported in NAS include the following:

- business applications, such as [customer relationship management](#) and [enterprise resource planning](#);
- productivity tools, such as email, documents, file services and spreadsheets;
- support for cloud computing;
- data protection;
- file-share and collaboration;
- [integration of public and private clouds](#);
- support for websites; and
- software application development.

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WHICH IS BETTER: ON-SITE NAS VS. CLOUD NAS

Before the emergence of cloud technology, NAS devices were installed in a data center or in work areas. The systems were compact and fit well there.

The advent of [cloud storage made it easy to replicate NAS resources](#) in a cloud-based environment. The capabilities are the same, except in the cloud, users do not have direct access to the NAS equipment.

The [advantages of cloud NAS](#) over on-site NAS include the following:

- access to data from anywhere;
- no additional floor space needed;
- cost effective because customer is charged only for services used;
- scalability for special circumstances, such as a merger or acquisition;
- reduced overhead; and
- useful for DR.

[Key considerations when comparing the two approaches](#) include the following:

- The network connection used to get data from the user to the cloud NAS may slow throughput, compared to on-site storage solutions.
- [Pricing considerations](#) must be factored into the discussion. Storage vendors typically include storage capacity and network requirements as part of their pricing models.

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Which configuration is better will depend on the application needing the additional storage. It is important to consider business requirements, costs and risks when deciding on the storage location.

WHAT APPLICATIONS IS NAS USEFUL FOR?

When [moving applications to the cloud](#), it is important to select a cloud NAS arrangement that supports a specific application. Depending on the on-premises application, migration to a cloud environment can require application development and can be costly. If the NAS supports protocols associated with legacy applications, such as [Network File System](#) and [Active Directory](#), migration can be easier.

Cloud NAS is the best choice for some applications with specialized requirements that need a lot of storage capacity for computer-intensive systems. Artificial intelligence and machine learning applications fit in this category.

The cloud approach may also be best for [applications with long-term storage needs](#), such as for legal or compliance issues. Cloud NAS also works well for daily storage requirements, making files and databases accessible and providing storage capacity that scales as needed.

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Cloud NAS is also an option for DR. It is available quickly and can have critical systems already in place and ready if primary storage becomes unavailable.

Learn more about [cloud backup and how it compares to on-site NAS systems](#).

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direct-attached storage (DAS)

ROBERT SHELDON, CONTRIBUTOR

WHAT IS DIRECT-ATTACHED STORAGE (DAS)?

Direct-attached storage (DAS) is a type of [storage](#) that is attached directly to a computer without going through a [network](#). The storage might be connected internally or externally. Only the host computer can access the data directly. Other devices must go through the host computer to work with the data.

Most servers, desktops and laptops contain an internal hard disk drive ([HDD](#)) or solid-state drive ([SSD](#)). Each of these devices is a form of direct-attached storage. Some computers also use external DAS devices. In some cases, an enterprise server might connect directly to drives that are shared by other [servers](#).

A direct-attached storage device is not networked. There are no connections through [Ethernet](#) or Fibre Channel ([FC](#)) [switches](#), as is the case for network-attached storage ([NAS](#)) or a storage area network ([SAN](#)).

An external DAS device connects directly to a computer through an interface such as Small Computer System Interface ([SCSI](#)), Serial Advanced Technology Attachment ([SATA](#)), Serial-

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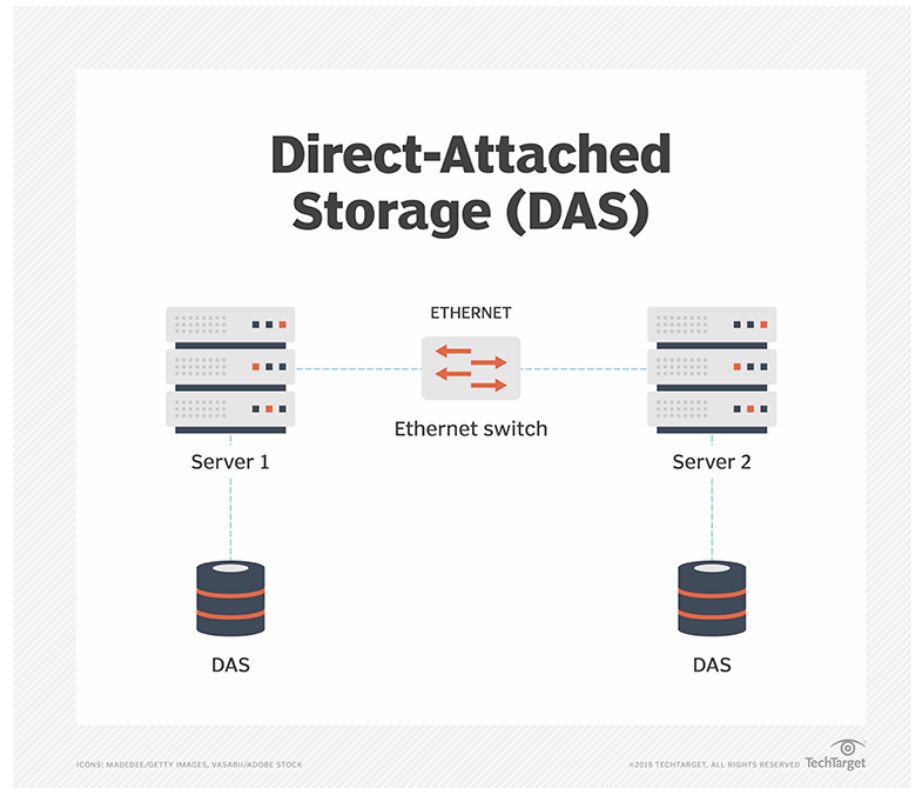
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Attached SCSI ([SAS](#)), FC or Internet SCSI ([iSCSI](#)). The device attaches to a card plugged into an internal bus on the computer.

Other types of storage, such as optical devices and tape, are technically DAS as they are directly attached to a system, either internally or externally. However, references to DAS are usually related to storage devices such as HDDs or SSDs.



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DIRECT-ATTACHED STORAGE PROS AND CONS

DAS can provide users with better performance than networked storage because the server does not have to traverse a network to read and write data, which is why many organizations turn to DAS for applications that require high performance. DAS is also less complex than network-based storage systems, making it easier to implement and maintain, and it is cheaper.

DAS is not without challenges, however. It has limited [scalability](#) and lacks the type of centralized management and [backup](#) capabilities available to other storage platforms. In addition, it can't be easily shared and doesn't facilitate failover should the server crash. Because of these challenges, conventional forms of DAS might not be suited for many enterprise [workloads](#).

However, advancements in [virtualization](#) technologies have breathed new life into DAS, a trend that's been especially apparent in the many hyperconverged infrastructure ([HCI](#)) systems now on the market. An HCI system is made up of multiple server and DAS storage nodes, with the storage consolidated into logical resource pools, providing a more flexible storage solution than conventional DAS.

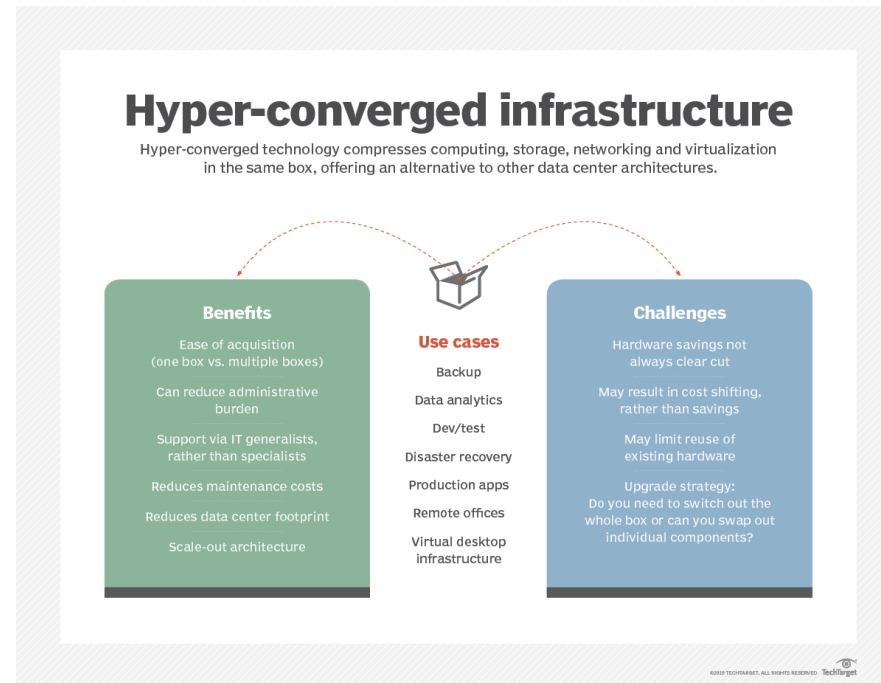
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WHAT ARE THE DIFFERENCES BETWEEN SAN, NAS AND DAS?

NAS and SAN are networked storage systems that [pool storage](#) capacity and share it with application servers over a high-speed network.

In contrast, DAS attaches directly to the servers, which means connectivity and expandability are both constrained by the number of expansion slots in the server. The size of the DAS

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enclosure also restricts storage capacity, and DAS is typically limited to a small number of ports or host connections, making it more difficult to share storage resources.

In addition, DAS often lacks many of the more advanced [storage management](#) features common to NAS and SAN systems, such as [remote replication](#) and [snapshots](#). Although virtualization, HCI and other innovations are reinvigorating DAS, they also come with their own limitations.

Storage platform architecture comparison	
SAN	Highly scalable, high-performance network connecting hosts with a shared pool of block-level storage over SCSI-based protocols.
DAS	Attached to and managed by a single host. Storage consists of disks in a host and/or external disk enclosures that are directly connected to the storage controllers in the host.
NAS	Shared-storage option that stores and shares files via standard file system protocols—mainly the Network File System and Server Message Block protocols—over IP networks.

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On the plus side, DAS is less expensive than SAN or NAS and is easier to deploy when directly plugged into a server. Administrators need only connect a new drive to a server to increase [storage capacity](#) by as much as several [terabytes](#). This has made DAS a practical storage choice for many small- and medium-sized businesses ([SMBs](#)), where storage costs and administrative overhead are considerations.

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Even when organizations use NAS or SANs, most physical servers continue to boot from DAS storage. The speed of SSDs, in particular, makes booting locally more efficient than networked storage. Thanks to local SSDs, a physical server can often boot in only a few seconds.

This speed can be especially useful when a physical server hosts [virtual machines](#) that need to start up quickly in the event of a crash or after scheduled downtime for service or maintenance.

SECURITY ISSUES WITH DIRECT-ATTACHED STORAGE

As with all storage systems that host an organization's critical applications and data, security is a prime consideration when [planning storage](#). To protect data stored on direct-attached storage, users should do the following:

- **Perform an in-depth security assessment** of your DAS environment to discover weaknesses. You might discover vulnerabilities such as lax user permissions, missing patches or misconfigured systems.
- **Run an audit of user permissions.** In addition, scan the DAS devices for [unstructured information](#) accessible to everyone on the network. Once that's done, lock down permissions. Also consider segmenting your network to better protect critical DAS systems.

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- **Make patching a priority.** Not keeping up with operating system and application [software patches](#) can leave your DAS vulnerable to malfeasance. An intruder who gains access to the DAS host can access all data on that system, and organizations may not even know the system has been breached.
- **Conduct [business continuity](#) and [fault tolerance](#) testing** by checking the resiliency of the DAS system. Focus on realistic system scenarios, such as storage hardware failures or the data center being damaged or destroyed.



FUTURE DAS OUTLOOK AND TRENDS

Three important technologies have come together to enable DAS to deliver exceptional performance: flash-based SSDs, non-volatile memory express ([NVMe](#)) and Peripheral Component Interconnect Express ([PCIe](#)).

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Over the years, [flash storage](#) has gotten faster, denser and cheaper, but the traditional storage interfaces -- particularly SATA and SAS -- could not take full advantage of flash's capabilities. This led to the development of NVMe, a logical device interface for direct-attached PCIe storage devices.

NVMe has been architected for higher-performance SSDs. It accelerates performance by exploiting PCIe parallelism through an optimized command set. PCIe is now in its fourth generation, with [PCIe 5.0 just around the corner](#).

Flash SSDs are not the only devices to benefit from the NVMe/PCIe combo. [Storage class memory](#) devices such as [Intel's Optane SSDs](#) are based on the [3D XPoint](#) technology codeveloped by Intel and Micron Technology. The Optane SSDs offer higher throughput, lower latency, greater density and improved endurance over [NAND flash](#) technology. They're also more expensive.



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clustered network-attached storage (NAS) system

ROBERT SHELDON, CONTRIBUTOR

WHAT IS A CLUSTERED NETWORK-ATTACHED STORAGE (NAS) SYSTEM?

A clustered network-attached storage ([NAS](#)) system is a [scale-out storage](#) platform made up of multiple NAS [nodes](#) networked together into a single cluster. The platform pools the storage resources within the cluster and presents them as a unified [file system](#). To achieve this, the platform uses a distributed file system that runs concurrently on every NAS node in the cluster. The file system enables each node to access all files from any of the clustered nodes, regardless of the physical location of the file.

The number and location of the nodes are transparent to the users and applications accessing files. Today's clustered NAS systems can be scaled out to include numerous nodes and provide petabytes (PB) of raw capacity. For example, the latest [NetApp](#) Fabric-Attached Storage storage arrays -- FAS8700/FAS9000 series -- can support up to 24 nodes in a [cluster](#) and up to 176 PB of raw capacity, in either a 4U or 8U controller chassis form factor.

Clustered NAS systems typically provide transparent replication and [fault tolerance](#). If one or more nodes fail, the system continues to function without data loss. In addition, data and

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[metadata](#) can be striped across both the storage nodes and the underpinning block storage subsystems -- direct-attached storage ([DAS](#)) or storage area network ([SAN](#)).

There is no fixed configuration for NAS clusters, with each vendor taking a different approach to how the controllers and storage devices are deployed. However, they all rely on a distributed file system to present the data on an operating system (OS) to manage the volumes and protect the data. The file system and OS work hand in hand to deliver unified file services. In some cases, the file and operating systems are combined into a single software layer, such as Dell EMC's OneFS OS.

Although clustering appears similar to [file virtualization](#), the key difference is that, with a few exceptions, the system nodes must be from the same vendor and part of the same product line from that vendor. For example, an organization can create a cluster made up of Dell's PowerStore T appliances or PowerStore X appliances, but a single cluster cannot contain both types of Dell appliances. However, administrators can typically configure a cluster's nodes with different types of storage devices or with different capacities, unless two nodes are set up in a [failover](#) configuration.

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WHAT ARE THE MAIN BENEFITS OF CLUSTERED NAS STORAGE?

Traditional NAS systems have served organizations well over the years, but the rapid growth of data -- especially [unstructured data](#) -- has forced decision-makers to look for more effective ways to provide storage that can meet the demands of rapidly evolving [workloads](#).

Clustered NAS provides a scale-out storage solution that can deliver the performance and capacity needed to support many of these workloads, including those that require a high degree of concurrency. A clustered NAS system uses [load balancing](#) to spread the data across storage nodes and present those nodes as a single repository that contains all the data, helping to simplify user access and application delivery.

A clustered NAS system also offers more flexibility than traditional NAS. If an organization needs more compute or storage resources, administrators can add nodes to the cluster or beef up the individual nodes, often with the ability to scale compute (performance) and storage (capacity) resources independently. They can also remove components from the cluster as workload requirements change. Most contemporary scale-out NAS systems include built-in mechanisms that make it quick and easy to modify the cluster infrastructure and configuration.

A cluster's nodes can also be set up in a failover configuration that protects against data loss and extended downtime in the event of component failure. For example, a six-node cluster

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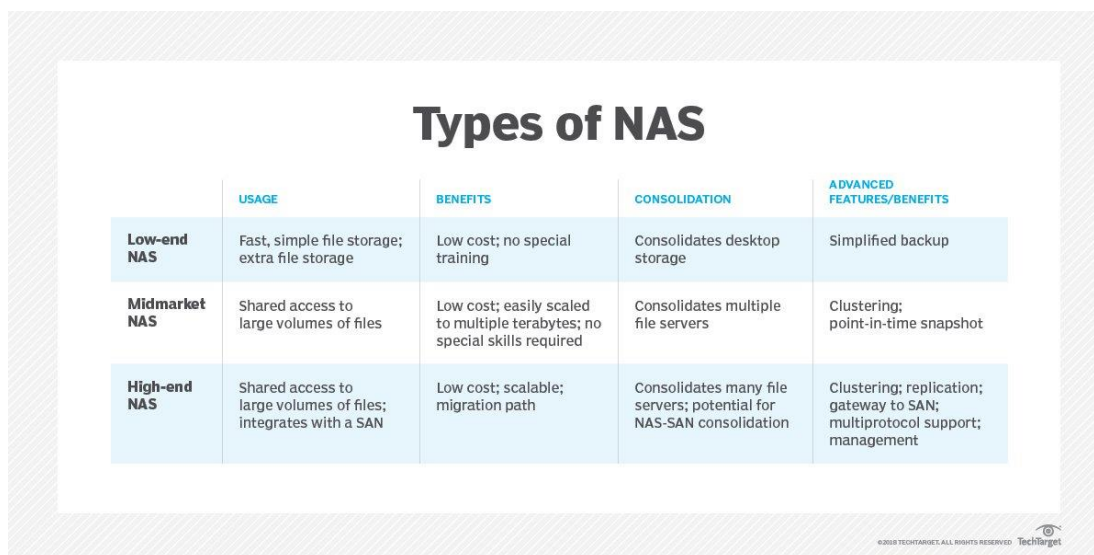
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might be organized into three sets, with each set including two nodes deployed in an active/passive configuration. If a node fails, it automatically fails over to the passive node within that set.



The image shows a table titled "Types of NAS" with four columns: USAGE, BENEFITS, CONSOLIDATION, and ADVANCED FEATURES/BENEFITS. The rows represent Low-end NAS, Midmarket NAS, and High-end NAS. The table is set against a light blue background with a white border.

	USAGE	BENEFITS	CONSOLIDATION	ADVANCED FEATURES/BENEFITS
Low-end NAS	Fast, simple file storage; extra file storage	Low cost; no special training	Consolidates desktop storage	Simplified backup
Midmarket NAS	Shared access to large volumes of files	Low cost; easily scaled to multiple terabytes; no special skills required	Consolidates multiple file servers	Clustering; point-in-time snapshot
High-end NAS	Shared access to large volumes of files; integrates with a SAN	Low cost; scalable; migration path	Consolidates many file servers; potential for NAS-SAN consolidation	Clustering; replication; gateway to SAN; multiprotocol support; management

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See how to master clustered storage with *Storage Spaces and Scale-Out File Server*, a [data storage capacity growth survival guide](#), the [top five reasons to choose NAS vs. DAS](#) and how to [beat the software bottleneck by improving storage performance](#).