



WHITE PAPER

TrueNAS® Overview



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1 Executive Summary

TrueNAS® is a unified storage array that is available in hybrid and all-flash configurations that deliver a comprehensive feature set and capacities up to 10.5PB at an unprecedented price point. TrueNAS all-flash storage arrays provide an ideal unified data store for the flash-centric data center. Every hybrid and the all-flash TrueNAS system uses TrueCache™ technology to provide blazing I/O performance while providing high levels of throughput and consistent sub-millisecond latencies.

Decades of experience in hardware design and Open Source project development positions iXsystems to deliver unparalleled innovative, highly reliable, and cost-effective enterprise storage solutions. TrueNAS also benefits from the extensive feedback and testing from the Open Source community that we have built around the Open Source FreeNAS project.

The TrueNAS family of enterprise storage appliances is engineered and built in the USA, ensuring seamless hardware and software quality control backed by an exhaustive system burn-in process. TrueNAS can be customized with any combination of enterprise hard disk drives (HDD) or solid-state drives (SSD), based on performance and capacity requirements.

TrueNAS is the only enterprise storage solution on the market that provides an Open Source driven stack with no artificial limits on performance or capacity. The powerful features of corruption prevention, variable block sizes, Intelligent Storage Optimization, snapshots, replication, vendor certification, and flash I/O acceleration result in exceptional value. Our highly transparent Open Source approach means that we have the most tested and competitively priced solution available. Deploying a TrueNAS enterprise storage array lets you reduce the storage cost for both physical and virtual deployments. With TrueNAS there are no compromises.

2 History of iXsystems

Located in the heart of Silicon Valley, iXsystems has been committed to serving technology needs with a focus on open source and enterprise hardware since our beginning in 2002. From our inception onward, we've been perfecting our craft of making quality storage solutions and custom-built servers backed by a passion for superior customer experience. See what our customers say about us at <https://www.ixsystems.com/reviews/>.

2.1 Open Source Background

If your company leverages open source technology, it's a distinct advantage to work with a company that speaks your language. Nearly everything we do at iXsystems involves and benefits open source technology. We incorporate open source solutions into our storage and server product lines and use them extensively ourselves. We are the main developers of TrueNAS® CORE, TrueNAS Enterprise, and TrueCommand® and contribute to FreeBSD, OpenZFS, Slackware Linux, and several other open source software repositories. We spread the open source message in print, radio, and video publications and through our participation in various industry events around the globe.



3 Overview of TrueNAS

Most enterprises buy their storage based on the specific capacity and performance needs of their existing applications. As a result, enterprises often end up with multiple classes of application-specific storage or “storage silos” including SAN, NAS, all-flash arrays, and many forms of direct attached storage (DAS). Managing and maintaining these dissimilar storage silos is costly and inefficient.

To make matters worse, enterprises are often forced to over-provision either capacity or performance to meet their current and future needs. For example, in order to meet a certain IOPS requirement, the traditional approach is to add high-RPM spindles to achieve the required IOPS. Customers soon find that they have added more capacity than is required in order to meet performance requirements which increases storage costs. This approach leads to waste and inefficiencies that drive up the cost of deploying storage with inconsistent performance and capacity gains.

TrueNAS is a hybrid storage array that addresses these issues by using TrueCache™ to combine RAM and cache storage to give the performance of flash at hard disk prices. This unified solution supports multiple protocols, allowing the consolidation of storage silos. This flexibility makes TrueNAS an incredibly effective solution for a wide variety of storage requirements.

3.1 Architecture

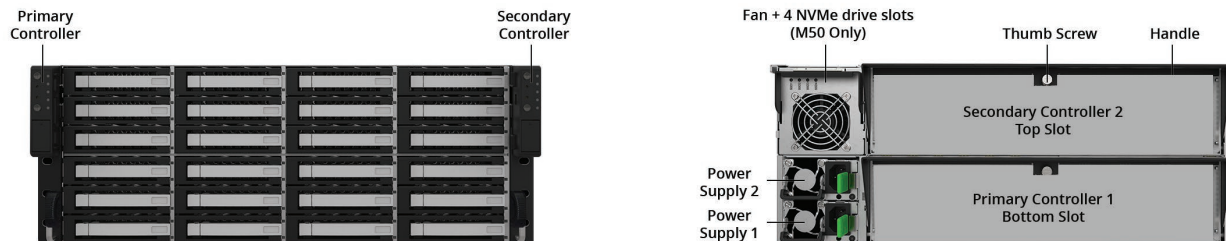
The TrueNAS X10, TrueNAS X20, TrueNAS M40, and TrueNAS M50 hybrid storage arrays use cache to accelerate the hard disk drives (HDDs) using RAM and flash-based technology, (including NVMe, NVDIMM, and SSDs), to dramatically improve I/O performance. This architecture provides the performance of flash with the capacity of hard disks, giving users the best of both worlds.

For customers implementing a flash-centric datacenter, TrueNAS is an all-flash solution that combines the performance of solid state drives with the simplicity and extensive feature set of TrueNAS Unified Storage.

Every TrueNAS storage array is a custom design with a modular, tool-less architecture enabling easy field servicing. The following components can be swapped out without tools:

- Power Supplies
- Storage Controller (head)
- Cache Devices
- Hard Disk Drives

The all-flash TrueNAS models include a secondary storage controller to ensure high availability and 100% non-disruptive updates. A secondary storage controller is also available for TrueNAS hybrid arrays.



The front of a TrueNAS M-Series enclosure features 24 storage bays while the TrueNAS X10 has 12 storage bays. Both have lights for power, network activity, disk activity, and failure/rebuild status, plus a global fault notification light. The rear of the enclosure includes slots for two field-replaceable storage controller logic boards and two power supplies. Additionally, every TrueNAS includes:

- 1 or 2 storage controllers with a flash-based boot device
- SAS based 3.5" or 2.5" multipath, hot pluggable, hot-swappable HDDs and SSDs
- Intel® Xeon® multi-core CPUs
- Enclosure monitoring alert notification via lights, SNMP, or the administrative GUI
- Hardware-accelerated disk encryption
- A flashing discovery light which can be triggered in the GUI or by pressing a button on the array
- 3-year return-to-depot parts replacement



- 30-day deployment assistance
- Server and power management/monitoring via the IPMI out-of-band interface on each controller
- Veeam and VMware vendor certification
- Optional 8/5 or 24/7 Help Desk phone and email software support
- Optional 4-hour on-site hardware support response
- Optional on-site advanced parts shipment
- Optional next business day storage controller replacement

Each TrueNAS storage array supports multiple hot-plug SAS drives and multiple external expansion shelves.

3.2 High Availability Design

There's no point buying storage you can't rely on. Gartner's Magic Quadrant for Data Warehouses found that the lack of high availability and disaster recovery (HA/DR) is the leading cause of data loss. They state that when choosing a storage provider, select one that addresses business continuity and understands your industry.

For this reason, TrueNAS provides redundancy throughout the array by including redundant fans, power supplies, and boot devices. Additionally, it can be configured with fully-redundant, field-replaceable storage controllers with redundant paths to each external storage expansion shelf. This means that TrueNAS can be updated to newer software, upgraded to higher models, and serviced in the field with no downtime.

3.2.1 Redundant Storage Controllers

TrueNAS can be configured with two redundant storage controllers. Each storage controller uses Intel® Xeon® multi-core CPUs. One storage controller is in active mode and the other in standby mode (booted) so that in the event of a failover, the user does not have to wait for the other storage controller to boot up before they can access their shares. There is no unique data stored in the controller and in the event of a failover, the I/O request will be serviced by the other storage controller.

Every drive used in a TrueNAS storage array is multipathed. In the event of a storage controller failover, the SAS controller in the other controller will complete the I/O to the same drive.

3.2.2 Expansion Slots

Each TrueNAS storage controller supports multiple network adapters or SAS external host bus adapters. The expansion slots are not hot pluggable. If you have two storage controllers, the standby storage controller must be powered down to add a network or storage network adapter, but services will not be interrupted.

3.2.3 Storage Network Adapters

Each storage controller in a TrueNAS system has two 10 GbE network ports. Additionally, depending on the TrueNAS model, each controller can be upgraded with an additional three dual-port or 1/10/25/40/50/100 GbE or 16 Gb Fibre Channel storage network adapter cards.

3.2.4 SAS External Host BUS Adapter

TrueNAS has 12 Gb/sec SAS interfaces supporting 12 or 24 dual-ported hot pluggable drives in the TrueNAS chassis. The TrueNAS SAS controller has one port that connects to disks in one expansion shelf. TrueNAS has twelve SAS ports, providing more bandwidth to the disks for enhanced performance. In the event that there is a failure of a SAS host bus adapter, TrueNAS will fail over to the secondary controller.

3.2.5 Boot Devices

A TrueNAS storage controller boots from an on-board flash device, ensuring that the boot process does not wait for spinning media. Everytime an update is applied, the previous software and configuration is preserved, allowing the TrueNAS administrator to boot from an earlier software configuration if necessary.

3.2.6 USB Ports

The X-Series only has one usable USB port and the M-Series four usable USB ports. A USB port can be used for monitoring and management of an uninterruptible power supply.

3.2.7 Management Port

Each storage controller in a TrueNAS array has a 1GigE out-of-band remote management (IPMI) port.

3.2.8 Cooling and Power

Each TrueNAS array and expansion shelf has redundant fans and redundant 115V-220V auto-sensing, balanced, high-efficiency power supplies. For data centers that have two independent power paths, there is no single point of failure that will interrupt the operation of the storage protocols.

3.2.9 Drives



TrueNAS line supports hot-pluggable 3.5" and 2.5" drives in every drive slot. Each drive tray has red, amber, or blue status lights that are externally visible.

TrueNAS X10 array without its front bezel.



TrueNAS M50 without its front bezel.



Each expansion shelf uses 2.5" and 3.5" hot pluggable 12 Gb/sec SAS HDDs and SSDs, where the ES12 supports up to 12 devices, the ES24 up to 24, and the ES60 up to 60.

TrueNAS supports the following 2.5" and 3.5" drives:

Size	RPM	Details	Supported in X10	Supported in X20	Supported in M40	Supported in M50
2 TB, 3 TB, 4 TB, 6 TB, 8 TB, 10 TB, 12 TB	7.2K	3.5" NL-SAS	Yes	Yes	Yes	Yes
400 GB, 500 GB, 800 GB, 1 TB, 1.6 TB, 1.92 TB, 3.84 TB, 7.68 TB	SSD	2.5" SAS MLC	Yes	Yes	Yes	Yes

3.2.10 Read Cache

TrueNAS has one or more optional high-performance flash-based devices (SSD or NVMe) that are used for the read cache. The maximum read cache varies from 400 GB to 4 TB.

3.2.11 Write Cache

TrueNAS includes a flash-based, high-performance write cache that is optional for the TrueNAS X10 and TrueNAS X20, and NVDIMM-based for the TrueNAS M40 and TrueNAS M50.

3.2.12 Side Rails

TrueNAS includes tool-less side rails that support any 4-post rack that uses rails with square or round holes and supports racks from 28" to 36" deep. A fully populated TrueNAS array can weigh over 100 lbs and requires two people to lift and insert it into a rack.



Front

Rear



3.3 Features

Unlike many other storage vendors, iXsystems does not impose arbitrary fees for access to storage features. Snapshots, clones, thin provisioning, Intelligent Storage Optimization, encryption, and all protocols are integral parts of TrueNAS.

3.3.1 Unified

TrueNAS provides NAS, SAN, and object storage. TrueNAS offers the flexibility of SMB, AFP, NFSv3, NFSv4, and WebDAV for file storage, iSCSI for block storage, and S3-compatible APIs for object storage. TrueNAS, except for the X10, also supports Fibre Channel for block storage. Every common operating system, hypervisor, and application is supported.

3.3.2 Hybrid Storage

TrueNAS is flash-turbocharged, giving applications the speed of flash with spinning disk capacity and economics. It uses ZFS caching to leverage DRAM and flash technology to dynamically and automatically cache reads and writes. The performance of these cache layers are orders of magnitude faster than HDDs while their power requirements are far lower. Caching increases performance, conserves power, and provides flash performance without compromising capacity and scalability, maximizing your investment.

For write acceleration, TrueNAS caches writes in low-latency, high-throughput enterprise-grade flash so writes do not wait for spinning media. Data is then asynchronously written to disk, reducing write latency. For read acceleration, most-recent and most-often-read data is cached in DRAM and flash devices so that reads don't have to wait for spinning media. TrueNAS offloads as much of the storage I/O from spinning disk as possible, keeping I/O performance high and read latency low.

3.3.3 Self-Healing File System

Continual availability of business-critical data is required by all enterprises. With traditional storage, single bit errors in stored data occur more often than you'd expect and often without notice. The industry calls this silent data corruption or bit rot. Traditional volume managers won't notice when bit rot occurs but TrueNAS will proactively detect and repair data corruption. During a read, if the data is corrupted, TrueNAS will read from redundant storage and automatically repair the bad data. If the data is infrequently read, the corrupted data will be fixed when TrueNAS performs an automatic integrity check. Under no circumstances will TrueNAS return bad data as though it were good.

During a write, changed data is written to a completely new location on disk which preserves the original data until the write is verified as successful. This strategy prevents data loss due to incomplete writes and allows for advanced features such as snapshots and rollbacks.

3.3.4 Directory Services Integration

Directory services are an essential part of today's network-centric computing infrastructure. Directory-enabled applications now power almost all the mission critical processes of an enterprise including resource planning, value chain management, security and firewalls, and resource provisioning. Directory services also provide the foundation for deployment of e-business and extranet applications.

TrueNAS integrates with industry-standard Microsoft Active Directory, LDAP, and NIS directory services. It also supports Kerberos realms and keytabs. This allows for administration of a user database by system administrators while users get the advantage of a single sign-on to many corporate services.

3.3.5 Intelligent Storage Optimization

TrueNAS uses multiple techniques and technologies to reduce the volume of data actually stored to disk. This storage optimization happens while the data is in transit and reduces the size of I/Os that reach storage media, which in turn increases performance while conserving space for additional data. This keeps data growth under control and further improves the TCO of TrueNAS hybrid and all-flash array

COMPRESSION

The TrueNAS Adaptive Compression (TAC) algorithm achieves an impressive compression ratio without impacting disk performance. Compression not only saves space, it also improves performance. This is because the time it takes for the CPU to compress and decompress the data is quicker than the time it takes to read and write uncompressed data to disk. In addition to fast compression, TAC also decompresses data quickly. TAC has virtually no impact to disk access and will only compress data that will yield a savings. Several less-performant compression algorithms that conserve even more space are also available for high-density archival storage.

DEDUPLICATION

Deduplication is the process of eliminating duplicate copies of data in order to save space. When TrueNAS deduplication is enabled, data is scanned and analyzed for potential duplicates before being stored.

Compression can reduce the physical or RAW capacity up to two and a half times, while using compression and deduplication can reduce it up to ten times. To mitigate the reduced capacity of flash drives as compared to NL-SAS drives, the all-flash model leverages Intelligent Storage Optimization to the greatest extent possible. Unlike the hybrid TrueNAS arrays, TrueFlash is designed to utilize compression and deduplication before placing the data on flash storage. By using Intelligent Storage Optimization, TrueFlash will have a comparable density to an NL-SAS array of the same size, but with vastly higher and more consistent performance at a lower \$/GB. TrueFlash is very well suited for use as backing storage for critical, high-performance virtualization infrastructure and databases with high transaction loads.

3.3.6 Thin and Thick Provisioning

TrueNAS offers highly-granular quota and capacity reservation tools. For storage deployments with unknown long-term capacity requirements, TrueNAS allows for thin provisioning of storage. This makes later scaling seamless for end users. Conversely, when long-term capacity requirements or restrictions are well-established, TrueNAS allows for storage reservations and limitations with the same level of granularity.

3.3.7 Snapshots, Clones, and Replication

TrueNAS offers a simple-to-use automated file version retention and restoration system that provides unlimited and instant snapshots without intervention by administrators. With a user-defined snapshot schedule, data is automatically protected locally against unintentional alteration and can be replicated remotely to another TrueNAS storage array for redundancy and disaster recovery.

TrueNAS does not require a dedicated portion of space for snapshot or clone data - the entire pool can be used as space for snapshots and clones. Operations occur instantaneously, and the initial snapshot or clone uses no space. It is only when data changes that space is used for the original and changed data. This makes snapshots and clones incredibly space-efficient. When you combine VM provisioning with storage optimization, TrueNAS ensures that VMs occupy minimal space, increasing IOPS and reducing latency.

A snapshot can be replicated inside a data center or between two remote data centers. Snapshot replication enables disaster recovery for physical and virtualized data centers and ensures application redundancy with a highly-available data storage environment. Replication is asynchronous, avoiding impacts on application performance due to waiting for a round-trip transfer and receipt acknowledgement from the remote site. Replication sends only changed data which is encrypted before transmission. This reduces WAN overhead, avoids connection saturation, and lowers network risks and costs.

3.3.8 Data Encryption

TrueNAS is your key to data security. Many regulated industries and applications require encryption on in-place and in-flight data. To meet these needs, TrueNAS supports a variety of disk-level and network encryption modes. TrueNAS remote replication is encrypted and the TrueNAS Web User Interface can be configured to work over HTTPS. TrueNAS firmware updates are signed with a certificate issued by a public Certificate Authority. When you can't leave security to chance, TrueNAS has you covered.

3.3.9 Storage for Backup, Virtualization, and Applications

TrueNAS has been certified to support Citrix XenServer, Veeam Backup and Recovery and VMware vSphere. Vendor testing ensures that backup images and VMs stored on TrueNAS work with these products. This rigorous testing and certification allow customers to use TrueNAS with confidence. TrueNAS also supports bhyve, Xen, KVM, and VirtualBox hypervisors as well as various backup solutions.



3.3.10 Open Source Development Model

iXsystems is passionate about building Open Source driven enterprise storage and server hardware and software solutions. Virtually everything we do is Open Source. Open Source is in our DNA because we value it and understand its competitive advantage. We have more FreeBSD code committers than almost any company and also contribute to SAMBA and Linux projects.

Our experience shows that more eyeballs on the code results in a more secure and stable project. Open Source provides a faster development model since many people are involved in both testing and development. Thousands of people test our nightly and beta builds, report bugs, and request features, helping us close bugs and making a bigger impact than would otherwise be possible.

3.3.11 Lifecycle Management/Automatic Updates

TrueNAS will check an update server each day and can be configured to manually or automatically download available updates. Updates can then be installed at any time, and in models with redundant storage controllers, updates can be installed non-disruptively.

3.3.12 TrueNAS Automation via the REST API

TrueNAS provides a REST API which can be used as an alternate mechanism for remotely automating a TrueNAS array. The REST API is ideal for customers that want to integrate TrueNAS with business applications or add TrueNAS to their existing storage portal. The REST API uses an easy-to-read HTTP library of functions, known as resources, which are available beneath a specified base URL. Each resource is manipulated using the HTTP methods defined in RFC 2616, such as GET, PUT, POST, or DELETE.

3.3.13 Managing TrueNAS with a Web UI

Great storage isn't useful if it is hard to use. Every aspect of a TrueNAS solution can be managed from a Web User Interface. A setup wizard further simplifies configuration at installation time or later in the setup process. For example, volume creation and permissions configuration for individual shares can be done without missing a critical step or encountering a silent failure.

Many services have advanced configuration options available in the advanced menus. Ultimately, TrueNAS makes deployment easier than other storage array vendors and provides advanced options and features. Most importantly, TrueNAS doesn't get between you and the solution you need.

3.3.14 Fleet Management for TrueNAS Systems



TrueCommand helps many organizations utilize multiple TrueNAS systems for various tasks and sites. It provides a team-oriented approach to managing these systems on a 24x7 basis. Consolidated monitoring, alerts, and reporting improves productivity and generally improves response and fix times for issues. Predictive analytics lets you know if capacity is running out. Configuration audits and Role Based Access Control (RBAC) ensure the security of the system and reduce the complexity of resolving issues

4 Conclusion

This paper described how TrueNAS is an enterprise storage array designed for easy field-support, scalable capacity and performance, and high availability. It showed how TrueNAS supports multiple file, block, and object storage applications and reduces the risk of storage silo proliferation. It included many technical specifications for TrueNAS, including how the usable capacity scales to 10.5 PB while its Intelligent Storage Optimization provides over two and a half to five times more effective capacity.

Unlike other storage vendors, you can use the enterprise features of TrueNAS without having to pay per feature - *it's all included*. It is a unified storage array that includes snapshots, storage optimization, multiple protocols, and replication for less than most competitors' basic model price. There's no question that TrueNAS is hands down the best value in storage. Don't take our word for it, see why DCIG, a leading analyst site, ranked TrueNAS "Excellent" with "Best in Class" hardware.