FreeNAS Community Hardware Guide

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Proper hardware selection is essential to the operation of any server. This document contains Hardware Recommendations for FreeNAS, based on the community's experiences. It applies to both the FreeNAS 9.10 and FreeNAS Corral (Formerly FreeNAS 10) branches.

It is assumed that the user wants a reliable server that takes advantage of FreeNAS', and thus ZFS' strengths. These recommendations are based on a desire to reliably store data on the server. Accordingly, they are very different from recommendations for typical gaming builds, unlike some sources on the internet suggest.

Straying from these recommendations can have mixed results and should be done with caution. That said, the objective is not to list recommended hardware, but categories of hardware. Specific popular examples are listed, particularly where these are go-to choices. The community is very welcoming of users asking for help with their builds, as long as the suggested build has been researched – it's normal that questions will arise or that details will be overlooked and the community will gladly help. That said, the community is very conservative and will not easily endorse choices that compromise data integrity – in other words, "If you're going to do it, do it right".

The recommendations listed in this document are bound to change over time, as both software and hardware evolves. The updated version is available in the FreeNAS forums' Resources section, where changelogs can also be found.

Distribution of this document is discouraged, in order to avoid the proliferation of outdated versions. Please link to the Resource page instead of distributing this document.

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Chassis

The primary concern with the choice of chassis is hard drive cooling. Hard drive temperatures should be kept under 40 degrees Celsius, as life expectancy drops substantially with increased temperature beyond this point.

Other concerns include ease of access to the drives (particularly on larger servers) and noise characteristics.

Large Systems (10+ disks)

For large systems, the default solution is a Supermicro rackmount chassis. These are engineered for appropriate cooling, include server-grade power supplies and are known for their solid construction. As rackmount solutions, noise is a secondary concern, though newer models are more capable of suppressing noise output when possible.

As a more cost-effective solution, acquiring a used chassis is a popular method. This includes purchasing a decommissioned server with obsolete internals that can be discarded and replaced with the new system. Some accessories (especially hard drive backplanes) may need retrofitting, so research is advised before purchasing older models.

Even cheaper alternatives exist, such as the Norco RPC-4224. However, build quality is not on par with Supermicro, power supplies are generally not included and thermal design is mediocre at best. Overall, the cost reduction may not be great enough to justify these chassis over a used Supermicro. These are generally poor solutions, overall.

Medium Systems (6-10 disks)

Medium systems are frequently housed in desktop chassis. These are notably cheaper than rackmount chassis and may be plenty for most users.

A variation of this option involves acquiring a chassis with many (9-12) 5.25" drive bays, which can be populated with adapters for multiple 3.5" hard drives. Suitable chassis are becoming increasingly rare, so this option is somewhat restrictive and cost quickly escalates with the number of drives, as 5.25" to 3.5" adapters that provide proper cooling (and generally hot-swapping capabilities, as on rackmount systems) are not inexpensive.

Small Systems (2-6 Disks)

Even smaller systems are possible, though cooling becomes more complicated. Many popular miniITX chassis exist that take a few 3.5" drives.

NAS-oriented chassis often provide insufficient cooling, so care must be taken when using these.

Motherboard

The choice of motherboard is particularly crucial, as it limits the capabilities of the system and dictates what other hardware can be used.

Despite what common knowledge on general computer forums might suggest, server motherboards are not more expensive than similar consumer boards. In fact, many server boards can achieve lower price points than consumer boards while satisfying all users requirements. While it is trivial to find a motherboard that will be cheaper than any model recommended below, its suitability for a server will no doubt be dubious at best.

Cheap consumer motherboards rely on less-than-reliable components and significant cost-downs. For instance, most sub-100$/100€ motherboards use Realtek Gigabit Ethernet NICs – these are very poor controllers, with their 100BaseT predecessors being immortalized in the infamous rl(4) driver source.

On a more fundamental level, consumer motherboards do not support ECC RAM, which is considered fundamental for long-term data safety.

As an alternative to server motherboards, workstation-grade motherboards are a sort of middle ground between consumer/gamer motherboards and server motherboards. Their features are close to those of consumer motherboards, but they employ server-grade components (including Intel NICs) and chipsets (required for ECC support). These products are not optimized for servers, but will generally work within their expected parameters.

Server-specific features

Server motherboards generally employ a Baseboard Management Controller (BMC). The BMC is, in essence, a separate embedded computer with deep hooks in the host system.

BMCs in server boards, at the very least, are responsible for display adapter duties (basic graphics suitable enough for server consoles, text or graphical) and system management tasks such as fan control.

Most server motherboards include more advanced BMCs that add Intelligent Platform Management Interface (IPMI) support. IPMI extends BMC functionality to allow for remote access to the system, enabling nearly all tasks related to the server to be done remotely. Additionally, logging and sensors management is available through IPMI. IPMI on most boards can use either a dedicated network interface or share one of the host system's Intel i210 NICs.

Most users of IPMI agree that it is nearly indispensable for any sort of server application and it is strongly recommended to all users, though not a data safety requirement. Some manufacturers have the nasty habit of only enabling IPMI with the purchase of a separate dongle, but all boards recommended here include IPMI out of the box (though Supermicro requires an activation code for remote flashing of the BIOS – this issue can be sidestepped by manually using the IPMI remote console to flash the BIOS as one would locally on the machine).

Additional considerations

It is generally a good idea to consider future expansion of the system when choosing a motherboard. For instance, if a motherboard takes up to 32GB of RAM and the system is estimated to require all 32GB from the start, it might make more sense to choose a different motherboard that will have the option of expanding RAM in the future. Similarly, acquiring a board that only takes 8GB of RAM, the absolute minimum for FreeNAS, is not a good idea.

Mechanical hard drives barely exceed SATA 1.5Gb/s speeds on a good day, meaning that SATA 3Gb/s is more than adequate for most uses. Naturally, SSDs may benefit from SATA 6Gb/s interfaces, particularly when using 10GbE networking.

Multiprocessor motherboards are generally not required. The added cost is significant and Intel Xeon E5 single CPU solutions are quite capable. More than compute requirements, RAM capacity may be the factor that leads to the use of a dual (or, theoretically, quad) processor motherboard.

Recommended brands

The FreeNAS community has had good experiences with both Supermicro and ASRock Rack. Supermicro has long produced the community's workhorse boards and is an established server hardware vendor. ASRock Rack is a relatively new player in the server market, but their products have been well received in the community and some have targeted interesting niches. The latter has had some more dubious models, as detailed in the

ASRock Rack C2750D4I/C2550D4I mass die-off section.

Recommended models

This section covers some of the more popular and interesting motherboards available from the recommended manufacturers. Other models exist and are likely to work well, particularly variants (such as Supermicro's -LN4F versions, which add an additional two NICs).

miniITX systems

MiniITX boards always involve some compromise, so their use should be carefully considered, especially taking into account that compact chassis tend to have additional disadvantages that make larger form factors more appealing.

Supermicro Avoton miniITX

These boards are broadly comparable to the ASRock Rack boards, but more reliable. Pricing and availability make these boards less popular than ASRock Rack's offerings and Avoton is getting long in the tooth.

Xeon-D

A very wide variety of Xeon-D boards is available from both Supermicro and ASRock Rack. Most boards are available with a choice of CPU, allowing for different core counts. These tend to be very expensive, but extremely competent for the size and power envelope. Most make use of Xeon-D's integrated 10GbE controller, exposing two such ports – most boards employ 10GBaseT, but SFP+ boards are also available.

ASRock Rack E3C224D4I-14S

This is a very interesting board, because it is essentially a voodoo-shrunk X10SL7-F in an extended miniITX format. Unlike other boards in this size category, it uses socketed Haswell/Broadwell LGA 1150 processors. It includes an LSI/Avago SAS2308 SAS2 controller, for a total support for 14 drives directly attached. Its only major limitation is the 32GB RAM limit imposed by the platform. This board is often combined with a Lian-Li PC-Q26 chassis for a very compact server that still has a lot of compute horsepower and can take ten 3.5" HDDs.

ASRock Rack C226 miniITX

These motherboards shrink a standard Haswell/Broadwell LGA 1150 motherboard into a miniITX format. Most notably, they sacrifice two DIMM slots, and are as such limited to 16GB of RAM.

ASRock Rack C236 miniITX

Much like their LGA 1150 counterparts, these boards make some compromises to fit into a miniITX format. However, the newer Skylake platform allows for up to 32GB of RAM from the two DIMM slots. The C236 version also lacks the C236 PCH's additional two SATA ports, only providing six, like older models.

microATX

MicroATX motherboards are the most popular size for FreeNAS servers, mostly because entry-level server motherboards based on LGA 115x platforms tend to use this form factor.

Supermicro X10SLL-F

This model is the go-to entry-level option. It provides an adequate set of features at a reasonable price and uses the C222 PCH.

Supermicro X10SLM+-F

This board is a popular mid-range LGA 1150 board, with a few added features compared to the X10SLL-F, most notably additional connectivity (courtesy of the C224 PCH) and matched Intel i210 NICs.

Supermicro X10SL7-F

The X10SL7-F is an extremely popular model, as it includes an LSI/Avago SAS2308 SAS2 controller onboard, for less than the price of an LSI/Avago SAS2008 or SAS2308-based HBA. It supports a total of 14 drives directly attached. As a cost tradeoff, it uses the cheaper C222 PCH, but most users find this downgrade acceptable given the excellent value provided by the board.

X11SSL-F

This model is broadly equivalent to the X10SLL-F, but with the newer Skylake platform. The C232 PCH employed limits the board's feature set compared to other models, but it does allow for up to 64GB of RAM.

X11SSM-F

For the Skylake generation, the X11SSM-F is much more interesting than the X11SSL-F due to the use of the C236 PCH, which provides eight SATA ports instead of six. It is the most popular Skylake choice at the moment.

X11SSL-cF

The Skylake equivalent of the X10SL7-F, the X11SSL-cF takes the X11SSL-F's feature set and adds an LSI/Avago SAS 3008 SAS3 controller, for a total of 14 direct-attach drives. With its 64GB RAM limit, it is a natural choice for those servers that would be limited by the X10SL7-F's 32GB RAM limit.

ASRock Rack equivalents

ASRock Rack has several C22x and C23x boards that are broadly equivalent to some Supermicro model, often targeting slightly different features. These are generally expected to work, but are less popular.

ATX

Larger motherboards are frequently needed due to memory requirements that cannot be met in a microATX form factor, either due to platform limitations (LGA 115x boards) or cost (Xeon-D). Compute is rarely the driving force behind the move to Xeon E5 platforms, which are the main product available in the ATX form factor. Xeon E3 platforms are rarely used with such large boards, as fully-featured boards can easily fit on a microATX board.

Supermicro X10SRL-F

The basic Xeon-E5 motherboard, the Supermicro X10SRL-F supports obscene amounts of RAM (up to 1TB), provides 10 onboard SATA 6Gb/s ports, dual Intel i210 NICs and a number of other common features. Seven different PCIe slots allow for much flexibility in tapping the 40 PCIe 3.0 lanes provided by the CPU.

Supermicro X10SRi-F

The X10SRi-F is essentially the same as the X10SRL-F, but with a single dual-port Intel i350 NIC, which supports higher end networking features, mostly related to virtualization. It also has a single electrical 16x PCI-e 3.0 slot.

X10SRH-F

Much like the X10SL7-F and similar boards, the X10SRH-F includes an LSI/Broadcom/Avago SAS 3008 SAS3 controller. Otherwise, the feature set is similar to the X10SRi-F.

X10SRH-LN4F

The -LN4F version swaps out the dual-port i350 GbE controller for the quad-port version.

Dual-Socket Boards

Most FreeNAS servers would not benefit from a second CPU. They can make sense if the platform cost is lower for a given total amount of RAM, as extremely-high capacity DIMMs often command significant premiums.

CPU

The major restriction on CPU choice for a FreeNAS server is support for ECC RAM. Intel Core i5 and Core i7, as well as consumer Atom, do not support ECC functionality.

Most workloads can be handled by LGA115x – the main reason for Xeon E5 CPUs being support for larger amounts of RAM and, to a lesser extent, additional PCIe connectivity. Haswell/Broadwell and older Xeon E3 are limited to 32GB of RAM and Skylake CPUs are limited to 64GB of RAM.

Light usage

For servers expected to do little more than provide file sharing, a low-end CPU from the Pentium line often suffices.

Intel Pentium G3220

A very popular choice for LGA1150 systems, though currently EOL. Two cores, no turbo boost and no hyperthreading.

Intel Pentium G4400

A popular choice for LGA1151 systems. Two cores, no turbo boost and no hyperthreading. A significant upgrade over earlier generations is the support for AES-NI, which used to only be available from Core i3 and upwards.

Intel Pentium G4600

A slight upgrade over the G4400 for LGA1151 systems. Comparable price with slightly higher clocks.

Intel C2550 (Avoton)

Only available embedded in boards, the C2550 uses four Atom cores and is capable of respectable performance in realistic workloads. Though it supports up to 64GB of RAM, the required 16GB DDR3 UDIMMs are prohibitively priced – to the point of making a Xeon E5 system, which can use cheaper 16GB (or larger) RDIMMs, notably cheaper.

Medium usage

Some users may have more significant requirements that necessitate a faster CPU. Heavy users of Jails/Plugins/VMs tend to fall into this category, as do users who require regular transcoding. Some specific features not available on lower-end CPUs may also necessitate an upgrade to this category.

Intel Core i3-4330

A midrange LGA 1150 Core i3 model, capable of handling most small server workloads with ease. Two cores with hyper-threading but no turbo boost.

Intel Core i3-6300

A midrange LGA 1151 Core i3 model, capable of handling most small server workloads with ease. Two cores with hyper-threading but no turbo boost.

Heavy usage

Generally speaking, the typical heavy workload involves multiple concurrent, high-quality transcodes.

Intel Xeon E3-1220 v3

An LGA 1150 CPU equivalent to a Core i5 CPU. Four cores with no hyperthreading, but with turbo boost. Does not have an iGPU.

Intel Xeon E3-1220 v5

An LGA 1151 CPU equivalent to a Core i5 CPU. Four cores with no hyperthreading, but with turbo boost. Does not have an iGPU.

Intel Xeon E3-1220 v6

A small upgrade over the E3-1220 v5, with higher clocks and the same feature set.

Intel Xeon E3-1231 v3

A higher-end LGA 1150 Xeon E3 model, equivalent to a Core i7 CPU. Four cores with hyperthreading and turbo boost. Does not have an iGPU.

Intel Xeon E3-1230 v5

A higher-end LGA 1151 Xeon E3 model, equivalent to a Core i7 CPU. Four cores with hyperthreading and turbo boost. Does not have an iGPU.

Intel Xeon E3-1240 v5

Essentially a Xeon E3 1230 v5 with slightly higher clocks.

Intel Xeon E3-1230 v6

Essentially a cheaper Xeon E3-1240 v5.

Intel Xeon E3-1240 v6

A small upgrade over the E3-1240 v5, with higher clocks and the same feature set.

Intel C2750 (Avoton)

Only available embedded in boards, the C2750 uses eight Atom cores and is capable of surprisingly good performance in realistic workloads, being able to handle several simultaneous transcodes and respectable speeds over 10GbE networks. Though it supports up to 64GB of RAM, the required 16GB DDR3 UDIMMs are prohibitively priced – to the point of making a Xeon E5 system, which can use cheaper 16GB (or larger) RDIMMs, notably cheaper.

Xeon E5-1650 v3/v4

The Xeon E5-1650 is a popular six-core model. The v3 and v4 models use the LGA2011-3 socket. Lower core-count versions such as the E5-1620 exist. Xeon E5-16xx CPUs support single-socket systems only and do not support LRDIMMs.

Xeon E5-2xxx and E5-4xxx

An immense number of models exists to suit nearly all tastes. E5-2xxx CPUs support up to two sockets and E5-4xxx CPUs support up to four sockets. LRDIMM support is included.

Xeon-D

Based on the Broadwell microarchitecture, the Xeon-D line of CPUs has been very successful in the datacenter market due to its energy efficiency. There are many different models, all of them only available embedded in motherboards. Many core counts are available, though their low TDP limits peak performance.

Xeon-D boards are available from both Supermicro and ASRock Rack, with a large selection of board features and CPUs.

Some Xeon-D variants may be optimized for different use cases, such as networking, and may have a slightly less optimal feature set than standard Xeon-D parts.

It should be noted that Xeon-D supports RDIMMs and thus up to 128GB of RAM, unlike Xeon E3 which is limited to 32GB or 64GB, depending on the platform.

Notes on low-TDP CPUs

The Thermal Design Power (TDP) figure for CPUs is not a realistic measure of power consumption, but of peak consumption. Realistic workloads are bursty, not a continuous stream of strenuous calculations, which means that faster processors can finish more quickly and thus more quickly enter a lower power state.

Low-TDP CPUs, designated by a T for Core i3 and L for Xeon E3, use the exact same physical processor as their regular counterparts – the only difference being an artificially low limit on TDP. In practice, this means that the low-TDP version will be limited to slower clocks in order to remain within its tighter thermal envelope. The realistic expectation is that the integral of power over time will be similar for both cases, but some benchmarks have shown a significant power consumption advantage for regular-TDP processors.

Finally, it should be noted that idle power will be exactly the same, minus variations between units. It is theoretically possible to bin the units that exhibit better low-power behavior for low-TDP usage, but there's little evidence that suggests such binning takes place.

In conclusion, low-TDP CPUs only make sense in scenarios where either a heat dissipation or power distribution constraint exists. A properly-designed server should suffer from neither of these.

Notes on Kaby Lake processors

Unlike Skylake, Kaby Lake i3s do not support ECC, for the most part. However, the differences between these two families are essentially none, which makes Skylake i3s a continued viable option.

Kaby Lake Celerons and Pentiums continue to support ECC.

Bhyve support

The bhyve virtualization platform, available in both FreeNAS 9.10 and FreeNAS Corral, requires hardware support in the form of VT-x with Extended Page Tables (EPT) plus support for Unrestricted Guests. All recommended CPUs support these features.

RAM

ZFS and, by extension, FreeNAS require a lot of RAM. A rule of thumb for RAM sizing is 1GB per 1TB of storage. This rule is left deliberately vague as it is only a rule of thumb.

The minimum requirement for FreeNAS is 8GB of RAM and lower quantities are not supported. 16GB is probably the sweet spot for most home users, but more RAM is generally an easy way of improving server performance. For heavy jails/VM/plugin usage, 32GB might be a better starting point.

Higher-density DIMMs are highly recommended (except where their cost is significantly higher, such as when higher densities are enabled by using LR-DIMMs instead of RDIMMs), to facilitate future upgrade paths, thanks to the empty DIMM slots.

ECC

The FreeNAS community has embraced ECC RAM, as it closes a significant gap that would otherwise have no error correction. This lack of error correction would be a bit counterproductive, since ZFS goes to great lengths to guarantee data integrity. If data integrity is not a priority, many other filesystems exist, with lower resource requirements than ZFS.

Basically, the community's approach is "If you're going to do it, do it right".

RAM selection

For best results, models should be chosen from the motherboard manufacturer's Qualified Vendor List. As a less desirable alternative, RAM manufacturers have validation lists of their own and may guarantee compatibility with certain systems.

It is hard to go wrong with RAM from any of the big DRAM producers: Micron (and their Crucial brand), Samsung and Hynix – in no particular order.

Unbuffered vs. Registered vs. Load-Reduced

The RAM chosen should match the type required by the platform.

LGA115x platforms support only UDIMMs, Xeon E5-16xx and Xeon-D additionally support RDIMMs, and Xeon E5-2xxx and Xeon E5-4xxx support all three.

Registered DIMMs alleviate load on the memory bus by using registers to drive the address lines of the DRAM chips. LR-DIMMs extend this to the data lines as well. These techniques allow for greater capacities, at the expense of some added latency.

Supermicro LGA1150 X10 RAM recommendations

Over time, more specific knowledge was built up for Supermicro LGA1150 X10 motherboards and their behavior with certain types of RAM. A guide to this topic can be found here.

Power Supply

The PSU is an often overlooked component in any computer, despite its importance.

The most important considerations are the choice of a quality model from a reputable manufacturer and proper sizing.

Sizing guidance can be found here, but TDP of the components plus 30W per HDD is a good start.

As for efficiency, any decent contemporary PSU should do 80+ Gold. Anything less is the result of significant cost cutting, so such models should be avoided. 80+ Platinum and 80+ Titanium do not easily pay for themselves, given the significant premiums they typically demand, and are not a guarantee of a better power supply.

Recommended manufacturers

Seasonic is known for the consistent performance of its PSUs. Its G-Series models are very popular and good enough for a server. The X-Series is an established product line that has been expanded with the Seasonic Platinum range (they use the same internal design, with minor component differences) and has the advantage of being the only line of power supplies to stick to top-notch fans, namely Sanyo Denki San Ace Double Ball Bearing fans. The Snow Silent range is a variant of the Platinum range, but with FDB fans. More recently, the Seasonic Prime Titanium line has also been made available. These new models are slightly improved and achieve higher efficiency, but use FDB fans instead of the traditional San Ace fans.

Corsair has traditionally been a popular choice, but their products do not stand out as they once did. The low-end, Corsair VS, CX and CS, should be avoided. Corsair RM and better should be decent choices. In particular, AX (not AXi) models are rebadged Seasonic X-Series.

EVGA is a newly-popular high-end option, with several excellent rebadged Seasonic and Super Flower units. Care must be taken to choose a model by one of these OEMs, as the lower-end units are adequate, at best, for a desktop environment.

Supermicro PSUs, included with their chassis, are generally top-notch and not a cause for concern. Older models have less-than-ideal (if any) fan control, making for *extremely* noisy environments. Newer models do have better fan control and bring noise down to acceptable levels under most conditions.

Notes on Y-cables and connectors

Overloading cables and connectors can have serious consequences. Many el-cheapo Y-cables have also been known to catch fire, even outside of overload conditions.

Traditional hard drive connectors, frequently referred to as Molex connectors, are designed for significant currents (up to 11A). On the other hand, SATA power connectors are designed only for up to 4.5A. Considering a roughly 2.5A spin-up current per drive, this makes the SATA connector suitable only for a single drive. Backplanes typically use one SATA connector per 1.5 drives.

A practical consequence is that Y-cables should connect to the source using a Molex connector, not a SATA connector, and should be limited to 3-4 drives.

Additional SATA/SAS connectivity

If more connectivity than is available from the PCH is desired, or if SAS is required (due to the use of expanders, for instance), the only reliable solution is to add an LSI/Avago/Broadcom SAS controller.

Some motherboards recommended above provide equivalent functionality to the cards described below.

SAS2

By far the most popular option, SAS controllers based on the LSI SAS2008 or SAS2308 chips provide up to eight lanes of SAS connectivity and are available in a number of configurations, with external and/or internal ports.

Some cards are configured as RAID controllers and require a crossflash to standard HBA mode.

Popular models include the LSI SAS 9211, SAS 9240 and SAS 9207 series, the IBM/Lenovo M1015/M1115 and the Dell H200 and H310. All of these, except for the LSI SAS 9211 and 9207, must be crossflashed.

An additional option is the LSI SAS 9201, a 16-port card which uses the LSI SAS2116 controller, which is also known to work well and only supports HBA usage, not hardware RAID. It is not very popular because it is more expensive than a pair of 8-port HBAs.

SAS3

A more recent alternative, but not quite as mature, LSI's SAS3 controllers can generally be viewed as straight upgrades. Compatibility with older hardware has been questioned, though, particularly SATA 1.5Gb/s HDDs, which do not seem to be supported with current firmware versions.

The only known-good chip is the SAS 3008 and the most popular card model is the LSI SAS 9300.

LSI SAS firmware and drivers

The firmware used with these controllers must be flashed to the appropriate version required by the driver version used by FreeNAS. Currently-supported versions of FreeNAS provide a warning that indicates the correct firmware to use.

SAS expanders

SAS allows for expanders, which act much like network switches and effectively multiplex several drives into the available SAS channels to the HBA.

More information on this subject can be found here.

Interoperability with SATA devices

SAS HBAs and expanders can talk to SATA disks. Any links with SATA devices are subject to the same restrictions imposed on any SATA connection, in particular the 1m maximum cable length.

More information on this subject can be found here.

Common mistakes

The following are common mistakes which should be avoided at all costs:

- Using any SATA controller card. These are universally crap.
- Using SATA port multipliers. Intel SATA controllers do not support these, they are built down to a price and are generally unreliable.
- Using any sort of hardware RAID
    - Exporting individual drives as RAID0 volumes is **not** a good solution
    - The vast majority of hardware RAID controllers is not appropriate for FreeNAS

SAS1 (and why it should be avoided)

LSI SAS1 devices are well-supported in FreeNAS. However, due to hardware limitations, these HBAs are limited to drive sizes of 2.2TB or below. Bandwidth to expanders is naturally lower as well, which makes SAS1 devices even less viable.

Finally, due to their age, SAS1 devices may have weird quirks when used with modern hardware.

Boot Devices

FreeNAS is installed on a ZFS pool. This allows for boot device mirroring, among other features.

USB Flash Drives

The traditional boot device for FreeNAS has been a USB flash drive. These can be easily mirrored for increased reliability and are cheap. Unfortunately, reliability can be very bad and random write performance (which gets exercised during updates and other boot environment manipulations) is almost as bad.

These are certainly a workable solution, but not the ideal one. USB Flash Drives are most useful where using up an additional SATA port would add a significant cost (such as the cost of an HBA). Using drives from reputable manufacturers (SanDisk, Toshiba, Lexar) should improve the expected quality.

SSDs

More recently, SSDs have become popular boot devices. These solve all of the problems associated with USB flash drives, at the expense of a higher price tag and a SATA or M.2 port.

Cheap, low-end SSDs from reputable brands work very well.

SATA DOMs

A sort of compromise between SSD and USB flash drive, these employ a more compact form factor than most SATA SSDs and generally include provisions for being powered from compatible SATA ports (available on newer Supermicro motherboards, for instance). Their main disadvantage is cost, which tends to be much higher than that of SSDs.

Sizing

Since FreeNAS 9.3 introduced ZFS on the boot device, install size has been slowly creeping up. 16GB is a reasonable minimum that allows for a decent amount of boot environments to fit comfortably. 32GB is not an unreasonable target.

Networking

Most users following this document's recommendations will not have to worry about networking hardware, since all recommended Motherboards include at least two Intel GbE controllers.

Gigabit Ethernet

For Gigabit Ethernet, the recommendation is simple: Intel. Any Intel 1GbE controller will work fine.

Intel I217/I218/I219-series

The I217/218/219 series of NICs is actually just a PHY for the gigabit Ethernet hardware present in the PCH. These are basic adapters that will be fine for most users but lack certain features that may be useful in more complex environments. Note that -V models are not officially supported under FreeBSD (and thus FreeNAS), whereas the -LM models are officially supported.

Intel I210

The I210 NIC is a very popular model, close to a standalone I217 with some additional features (notably the ability to be multiplexed between host and BMC).

Intel I350

The I350 NIC is Intel's high-end GbE model and supports high-end features such as Virtual Machine Device Queues (VMDq) and Single-Root I/O Virtualization (SR-IOV). It is available in both two- and four-port models.

10 Gigabit Ethernet

10 Gigabit networking is slowly (finally) becoming viable for most applications and is the natural upgrade path for most scenarios – for many users, it is the only upgrade path that provides tangible benefits.

Intel 10GbE NICs are said to suffer from a less-than-perfect FreeBSD driver that makes it difficult for them to achieve the speeds expected from 10GbE.

Currently, Chelsio 10GbE NICs are the preferred choice for use with FreeNAS, and are the models shipped with iXsystems hardware.

More information on this topic can be found here.

Storage

Hard Drives

NAS hard drives are generally recommended, as their firmware is tuned for server workloads, with desktop-oriented features disabled or set to more appropriate timings.

5400RPM drives are recommended, as 7200RPM drives produce more heat, use more power and have dubious performance benefits.

SLOG devices

SLOG devices should be high-end PCIe NVMe SSDs, such as the Intel P3700. The latency benefits of the NVMe specification have rendered SATA SSDs obsolete as SLOG devices, with the additional bandwidth being a nice bonus.

Most importantly, SLOG devices must include full power loss protection (note that some older consumer designs only supported power loss protection for drive metadata, which is not enough). UPS protection is not an alternative to this requirement.

The specifics of SLOG and ZIL are explained here.

L2ARC devices

L2ARC is more forgiving, mostly because it is read-oriented. Large SSDs from reputable manufacturers should do well (though care should be taken when sizing L2ARC).

It should be noted that it is preferable to maximize RAM before adding L2ARC. In particular, since L2ARC consumes ARC for its metadata, L2ARC usage with less than 64GB of RAM is discouraged, as performance may degrade.

Finally, L2ARC is only useful if the ARC hit rate is low.

Advice on what not to do

Consumer-grade hardware

Consumer-grade hardware, especially motherboards, can be divided into two categories:

- Cheap, held together by a prayer and fragile Windows drivers
- Just as expensive as server-grade

The supposed fact that these hardware suggestions are expensive is very deceiving. Consumer hardware with equivalent functionality to the suggestions listed here will easily cost as much as proper server hardware – quite often, it'll be *more* expensive.

Cheap motherboards, in particular, are disasters. Realtek NICs, power distribution built down to a price and the obvious lack of ECC support are the most common problems.

Hardware RAID Controllers

Mixing ZFS with Hardware RAID is a genuine *Very Bad Idea™*. Exporting individual RAID0 volumes does not solve anything.

Hardware RAID controllers that allow for direct access to disks are theoretically supported, but no such product exists which is recommended: LSI's drivers are by far the most stable, but their Hardware RAID controllers generally do not support direct access to disks.

Old Hardware

Repurposing old hardware is not nearly as straightforward as some resources on the internet make it seem. There are a few cases that should be avoided:

Repurposing an old gaming rig

Gaming systems have rather different requirements than servers, so this option is hardly ideal.

Ancient hardware

Amazingly, there is a steady stream of people who show up at the FreeNAS forums wanting to repurpose their Pentium 4 systems. The Pentium 4 is not as much a processor as it is a space heater that happens to (slowly) do useful calculations. The system around it is generally just as inadequate as the processor itself.

Not-quite-ancient Hardware

Core 2-era hardware sounds reasonably new. While the microarchitecture used in these processors is still quite adequate, the platform is not. Performance will be **seriously** impacted by the FSB, through which *every single operation* in and out of the CPU goes through – this includes operations between the two halves of a quad-core model. In the very best cases (which are rare), bandwidth is of the order of 10GB/s. This may sound like a lot, but it is easily saturated by dual-channel DDR2 RAM.

Additionally, large servers may require FB-DIMMs, which are extremely power-hungry and expensive.

NAS appliances

The vast majority of embedded NAS devices does not even have an architecture that can support FreeNAS. Of those that do, only a minority comes close to meeting the requirements for FreeNAS.

Pressing Hardware into service

It is extremely important to test hardware before putting it into production. Hard drives, in particular, should be subjected to rigorous tests before being used for storage – this naturally applies equally to drives kept as spares.

SATA Port Multipliers

These really deserve a category of their own. They're universally crap. Beyond that, there are a few additional reasons why they would never be a good choice:

- Intel SATA, which is the only 100% reliable SATA solution out there, explicitly does not support port multipliers.
    - Even WD knows this. When they released a hybrid 120GB SSD/1TB HDD, they could not use a port multiplier to connect them both to a single SATA port. They were forced to use a custom controller that handled both spinning rust and NAND flash and mapped the first LBAs onto flash and the rest onto disk.
- The most common application for SATA port multipliers are eSATA chassis. *Those* are also universally crap in their own right, with issues from bad cooling to dodgy PSUs.
- They're cheap alternatives to SAS expanders. They're just a cash grab.
- Many also do even more horrible stuff, like hardware RAID for the enclosures mentioned above – yes, on tiny chips with essentially no resources. Yes, they're a disaster.

ASRock Rack C2750D4I/C2550D4I mass die-off

Recently, these specific ASRock motherboards employing the Intel Avoton platform have been experiencing a surge of failures. Most are related to the BMC configuration flash device being worn out to the point of failure by a software bug.

ASRock has finally issued an IPMI update, version 00.30.00, that fixes this behavior. It should be urgently flashed on all C2x50D4I boards.

Intel C2000 mass die-off

Though it has gone to great lengths to mask the issue, Intel's C2000 SoCs manufactured up to early 2017 were prone to degrade in a way that disables some of the chip's low-speed I/O, the LPC bus. Many motherboard designs use the LPC bus to connect to essential devices, most commonly the serial flash device containing the system firmware. The end result is an unbootable system.

This issue requires a hardware fix – either a fixed SoC or a workaround that unloads the bus. Most products manufactured starting February 2017 should no longer be affected and many vendors of C2000 products have extended their warranties to cover this issue.

iXsystems, in particular, has extended the warranty on the FreeNAS Mini motherboard to three years, for units manufactured before February 2017.