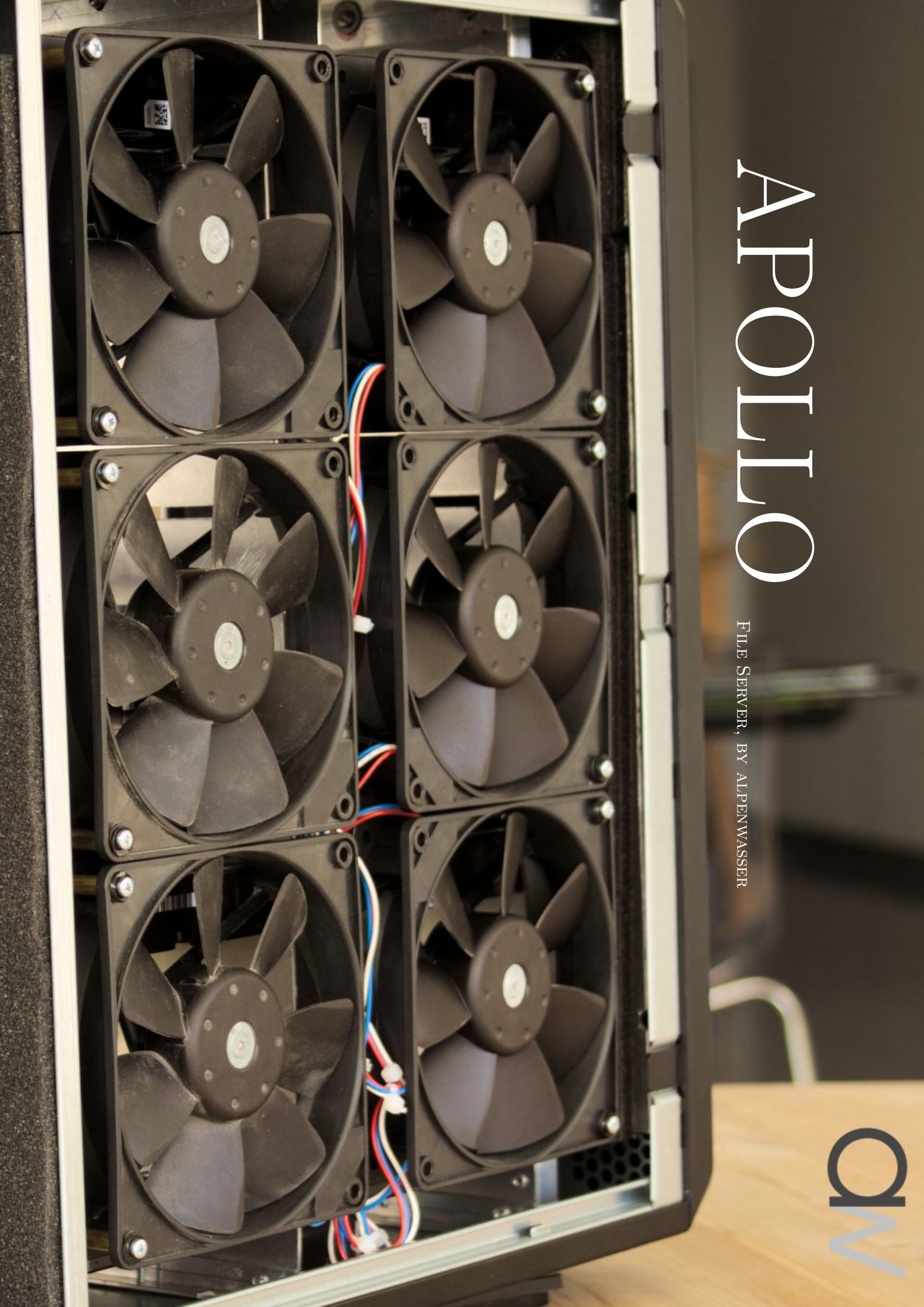


APOLLO

FILE SERVER, BY ALPENWASSER



Preface

Abstract

This document describes in chronological fashion the building process for our home server, dubbed APOLLO (short for **A**nonymity **P**rotecting **O**blivious **L**ong-**L**egged **O**striches, and no, that does not need to make sense).

Most of the content is comprised of transcripts (sometimes slightly edited) from the build logs posted on *linustechtips.com*, *themodzoo.com*, *overclock3d.net* and *overclock.net* (see [1], [2], [3], [4]), which is also why the posts are mostly written in present tense. This is not a report on the project written in retrospect, but a faithful, though not literal, transcript of the projet as it developed.

Thanks

— *George*
for lending his skill, time, dedication and machinery.

— The communities on
linustechtips.com,
themodzoo.com,
overclock3d.net
and *overclock.net*
for their great support and feedback.

Revision

Current document revision number: 1.0

Switzerland, November 2014

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Chapter 1

Prologue

Available online at [1], [2], [3], [4].

1.1 Hardware

- *CASE*: InWin PP689
- *PSU*: Enermax Platimax 600 W
- *MB*: Supermicro X8DT3-LN4F
- *CPU*: $2 \times$ Intel Xeon L5630 (quadcore, hyper-threaded)
- *HS*: Noctua NH-U9DX - Socket LGA1366
- *RAM*: 24 GB Hynix DDR3 1333 MHz ECC
- *HBA CARDS*: $3 \times$ LSI 9211-8i, flashed to IT mode
- *SSD*: Intel 520, 120 GB
- *HDD 0*: WD VelociRaptor 150 GB (2.5“)
- *HDD 1-3*: Samsung HD103UJ 1 TB F1 $\times$ 3
- *HDD 4-7*: WD RE4 2 TB $\times$ 4
- *HDD 8-13*: WD Red 3 TB $\times$ 6
- *Total Raw Capacity*: 29 TB

1.2 Purpose

So, yeah, another build. Another server, to be precise. Why? Well, as nice of a system ZEUS is, it does have two major shortcomings for its use as a server.

When I originally conceived ZEUS, I did not plan on using ZFS (since it was not yet production-ready on Linux at that point). The plan was to use ZEUS' HDDs as single disks, backing up the important stuff. In case of a disk failure, the loss of non-backed up data would have been acceptable, since it's mostly media files. As long as there's an index of what was on the disk, that data could easily be reacquired.

But right before ZEUS was done, I found out that ZFS was production-ready on Linux, having kept a bit of an eye on it since fall 2012 when I dabbled in FreeBSD and ZFS for the first time. Using FreeBSD on the server was not an option though since I was nowhere near proficient enough with it to use it for something that important, so it had to be Linux (that's why I didn't originally plan on ZFS).

So, I deployed ZFS on ZEUS, and it's been working very nicely so far. However, that brought with it two major drawbacks: Firstly, I was now missing 5 TB of space, since I had been tempted by ZFS to use those for redundancy, even for our media files. Secondly, and more importantly, ZEUS is not an ECC-memory-capable system. The reason this might be a problem is that when ZFS verifies the data on the disks, a corrupted bit in your RAM could cause a discrepancy between the data in memory and the data on disk, in which case ZFS would "correct" the data on your disk, therefore corrupting it. This is not exactly optimal IMO. How severe the consequences of this would be in practice is an ongoing debate in various ZFS threads I've read. Optimists estimate that it would merely corrupt the file(s) with the concerned corrupt bit(s), pessimists are afraid it might corrupt your entire pool.

The main focus of this machine will be

- room to install more disks over time
- ECC-RAM capable
- not ridiculously expensive
- low-maintenance, high reliability and availability (within reason, it's still a home and small business server)

1.3 Modding

Instead of some uber-expensive W/C setup, the main part of actually building this rig will be in modifying the PP689 for fitting as many HDDs as halfway reasonable as neatly as possible. I have not yet decided if there will be painting and/or sleeving and/or a window. A window is unlikely, the rest depends mostly on how much time I'll have in the next few weeks (this is not a long-term project, aim is to have it done way before HELIOS).

Also, since costs for this build should not spiral out of control, I will be trying to reuse as many scrap and spare parts I have laying around.

Chapter 2

Chronological Transcript of Building Process

2.1 First Hardware Tests & Noctua NH-U9DX 1366 November 14, 2013

Available online at [5], [6], [7], [8].

M/B, CPUs and memory have all arrived. The CPUs and M/B seem to be working OK. One of the memory modules seems to be having a bit of trouble being recognized, the other five work fine. I'll see if it's really defective or if it's just the IT gods screwing with me a bit.

2.1.1 The Noctua NH-U9DX

The Noctua NH-U9DX 1366 is a cooler from Noctua's series specifically made for Xeon sockets. For those who don't know, LGA1366 sockets have an integrated backplate, just like LGA2011, which makes them much more convenient than their desktop counterparts. It's quite a nice and sturdy backplate, too, in fact it's among the most solid backplates I've come across yet. This does, however, require a slightly different mounting system. You just have four screws which you bolt directly into the plate.

Aside from that, the cooler is identical to its desktop counterpart as far as I know. Why the 92 mm version? For one thing, it was in stock, unlike the 120 mm version of this cooler. Also, the CPUs only produce 40 W TDP each, so there really is no need for high-end cooling. And as a bonus, I got supplied some awesome San Ace fans with my case, which also happen to be 92 mm.

The Noctua fans which come with the cooler are just 3 pin fans (the newer models of this cooler for LGA2011 come with a PWM fan I think), but the San Ace fans I got with my case are actually PWM controlled! Since the M/B has a full set of PWM headers (8, to be exact, how awesome is that!?) I will try the San Ace fans and see how they play on lower rpm's (they run at 4,800 rpm on full speed). This does not need to be a super-silent machine since it will be in its own room, and since I really like the San Ace fans with regards to build quality (and I'm a total sucker for build quality) I'd love to use them

for this. The Noctuas would admittedly be better suited, but I'll see how things go with the SAs first.



Figure 2.1: The Noctua box,...

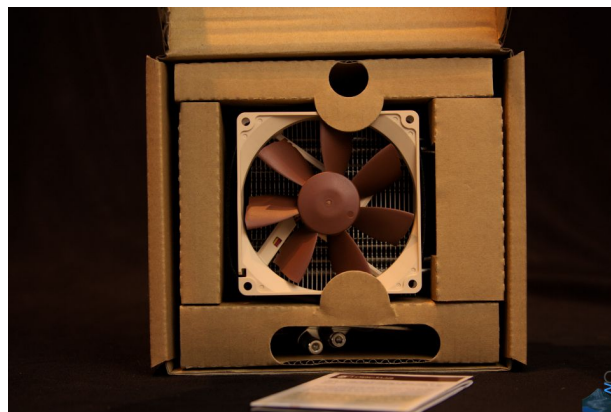


Figure 2.2: ... the contents...

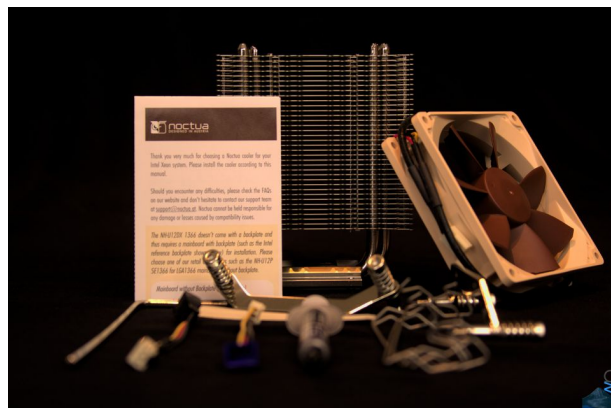


Figure 2.3: ... and unpacked.

The Box. Unlike its shiny desktop counterparts, the NH-U9DX comes in a nice and subtle (but sturdy) cardboard box with a simple sticker on it. I must admit I like this box more than the shiny ones.

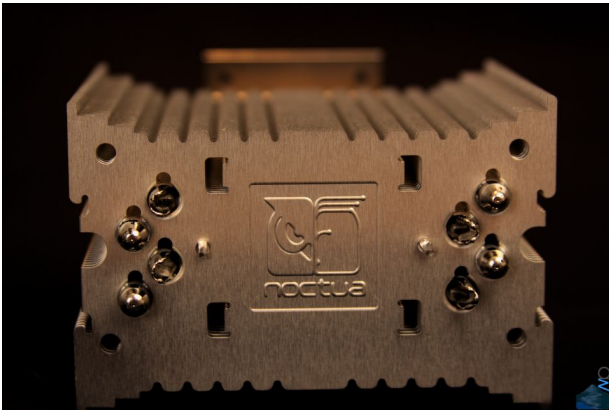


Figure 2.4: Some glory shots...

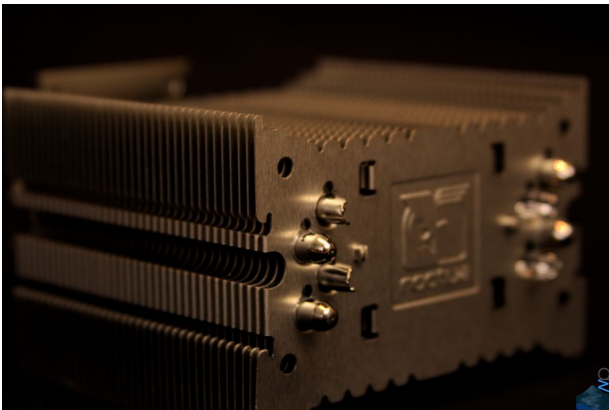


Figure 2.5: ... does look nice, doesn't it?

There is no info about this fan on the web, I'm presuming it's something San Ace makes specifically for InWin in an OEM deal.

I've hooked it up to a fan controller and got a max reading of 4,800 rpm, and the Supermicro board turns them down to 2,200 rpm on idle. They seem to be very good fans, you can only really hear the sound of the air moving, no bearing or motor noises so far. Also, they are heavy (200 g per piece), which is always nice for a build quality fetishist such as myself.

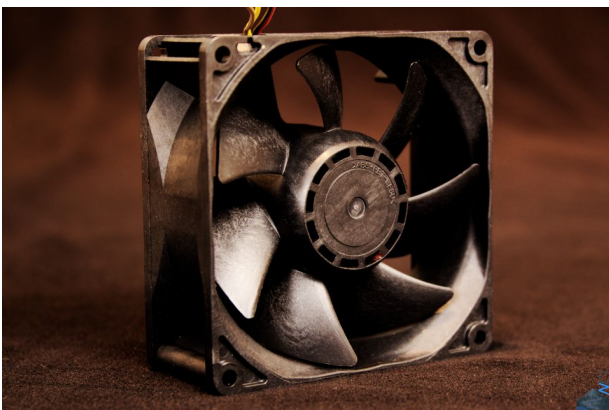


Figure 2.6: One of the San Ace 92 mm fans...

Note: Hooking such a fan up to a desktop board as its power source would not be advisable, they are rated for 1.1 A and might burn out the circuits on a desktop board. Server boards usually have better fan power circuitry since they are designed with high-performance fans in mind. Just as a side note.

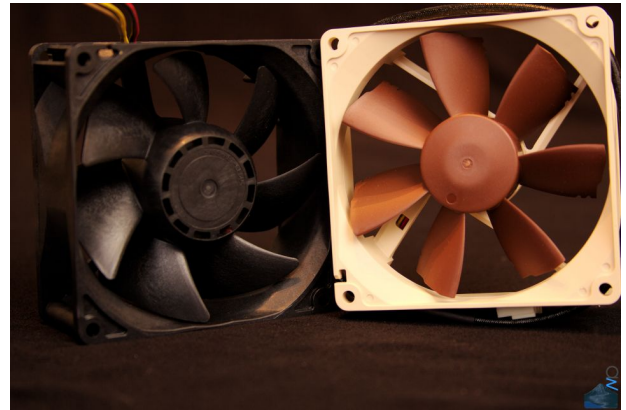


Figure 2.7: ... and compared with a Noctua fan.

I might still go with the stock Noctua fans, but it's not the plan at the moment.

I had to improvise a bit with mounting the San Ace fans to the tower. The clips which you'd use with the Noctua fans rely on the fan having open corners, which the San Ace's do not. Ah well, nothing a bit of cotton cord can't fix.

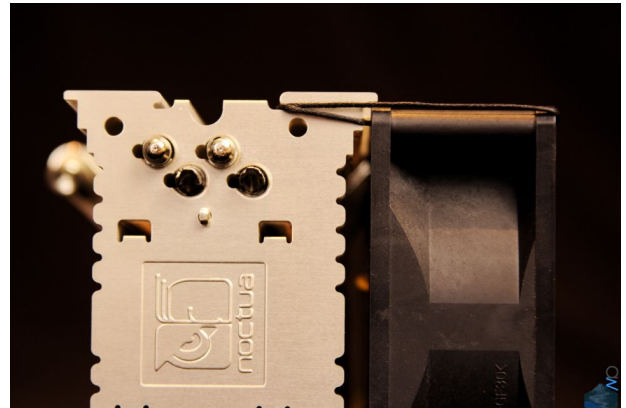


Figure 2.8: The San Ace fan mounted on Noctua heatsink.



Figure 2.9: The San Ace fan mounted on Noctua heatsink.

Side note: The coolers were actually more expensive than the CPUs.

2.2 Temporary Ghetto Setup, OS Installed

November 16, 2013

Available online at [9], [10], [11], [12].



Figure 2.10: Boinc at Work

Yeah...

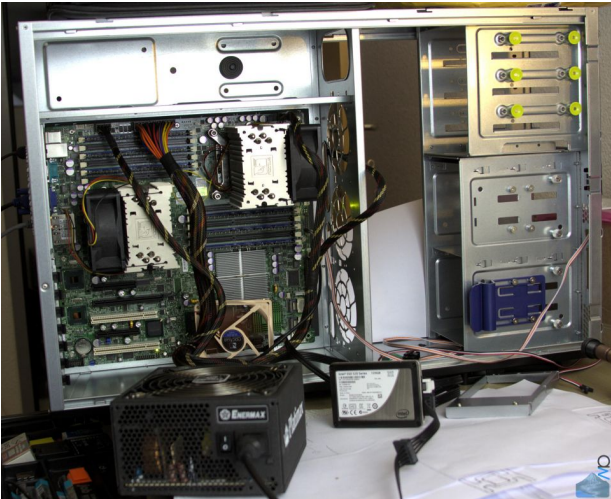


Figure 2.11: Ghetto Testing Setup

Hardware Validation. I've put the system together temporarily to validate the M/B, CPU and memory, so far all seems good. A minimal Arch Linux setup has been installed and is successfully running BOINC at the moment.

I'm not running BOINC *as* a hardware validation tool, that's not what it's designed to do. I have (mostly) validated the hardware and am now just running BOINC.

Gotta love low-power CPUs, core temps after about an hour of running BOINC on all cores are:

CPU0:	31 °C	31 °C	35 °C	30 °C
CPU1:	32 °C	26 °C	29 °C	31 °C

Table 2.1: Core temperatures during BOINC testing.

2.3 PSU Mounting & LSI Controller Testing

April 01, 2014

Available online at [13], [14], [15], [16].

Yeah, it's taking a lot longer to finish this than I'd initially hoped (doesn't it always with these sort of projects...). But I've been working on it in the last few weeks and now finally have something to share.

The PSU slides into this case through an opening from behind, and since the case isn't really made for normal ATX-sized PSUs (but server PSUs instead, it's a rather tight fit. To be more specific: The PSU in its stock config does not fit, the screws for the fan grill and the fan grill itself bump up against the case. An easy fix though, just needed to remove the fan grill on the PSU.



Figure 2.12: Bad Fit



Figure 2.13: Good Fit

Furthermore, since normal server PSUs usually blow air through along their longitudinal axis, there is no ventilation hole on the case for a fan on the top of the PSU, which most of today's PSUs have. Not to worry, I still had an old Aquacomputer rad grill laying around. A bit of dremeling should be able to fix this problem. Marking for cutting:

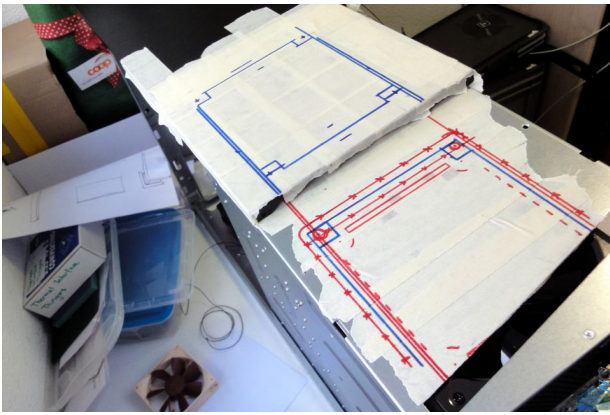


Figure 2.14: Making sure the PSU gets enough air.



Figure 2.15: And with the grill mounted.

Since this case was not designed with standard ATX PSUs in mind, some cutting was required to make it all fit nicely.



Figure 2.16: Just about does not fit.



Figure 2.17: This will be fixed...



Figure 2.18: ... like so.



Figure 2.19: And mounted.



Figure 2.20: Fits nicely now.

Needed to hook up some HDDs to test the LSI controller. Looks very ghetto, worked like a charm.



Figure 2.21: Yeah, I won't be keeping things like this, naturally...

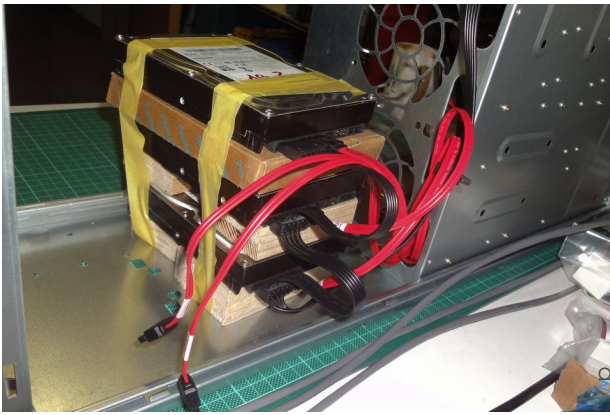


Figure 2.22: And the HDD package.

2.4 The Disk Racks

April 02, 2014

Available online at [17], [18], [19], [20].

The main part of this undertaking...

As mentioned elsewhere, one of the two main problem of our current server is that it only has seven HDD slots, and they're already all filled up. The only way to get more storage is to install larger disks, which isn't really all that optimal.



Figure 2.23: The mill.

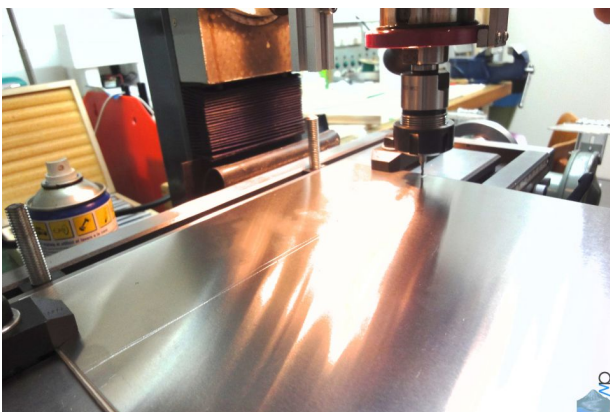


Figure 2.24: First steps...

One of the main objectives of this build is to have more disk slots. The PP689 only offers four in its stock form, which you can upgrade to a maximum of

thirteen drives. You would need to buy another four-disk enclosure (which btw. I could not find anywhere to buy), and a five-disk enclosure for the 5.25" bays.

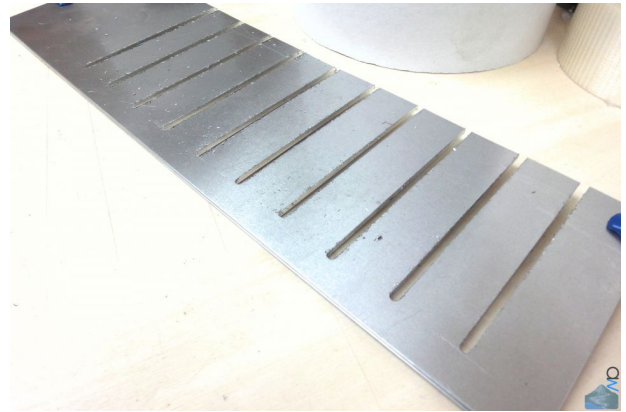


Figure 2.25: Progress...

Since 13 drives aren't really that many, and since these enclosures aren't exactly cheap, I decided to go another route.

It took me a while to figure out how to do it, but in the end this is what I came up with. I had very generous help from one of my neighbours, who has a mill and a lathe at his disposal, as well as plenty of time (he's a pensioner).

The Mill can also serve as a drill press. The drill chuck he looks ridiculously huge when you put a small drill bit into it (he said they didn't have the smaller model in stock when he needed to buy his, so he went with the large one).

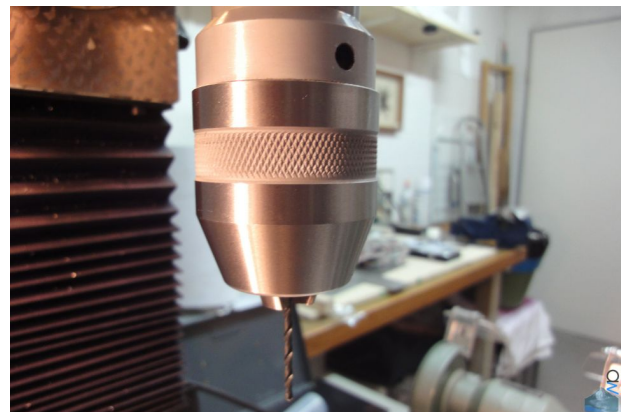


Figure 2.26: It's pretty massive...

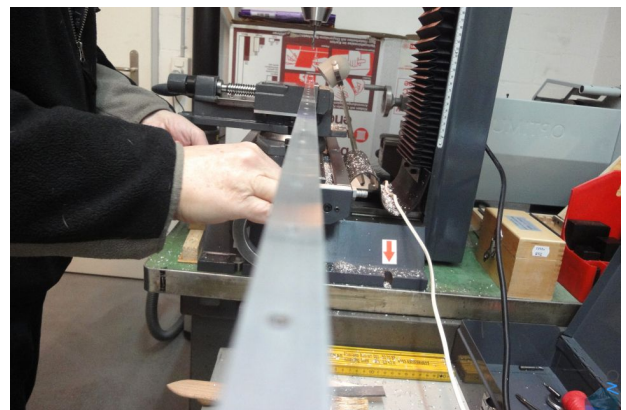


Figure 2.27: Lots of work...

Lots of holes needed to be drilled for the pop rivets that were going to hold it all together.



Figure 2.28: ... and more drilling



Figure 2.29: Milling out the slots for the screwheads.



Figure 2.30: Side panels for disk racks completed. Using some old broken HDDs to test fit.



Figure 2.31: And a different angle.



Figure 2.32: The last one of these.

This is how the construct looks on the side where you slide in the disks. You can see the pop rivets I used to assemble it, the slots which are pictured being milled above for the screwheads and the screws on the disks. You can also see the recesses into which the screws mounted on the HDDs lock. The system works very well.



Figure 2.33: A closeup of the rails for the HDDs

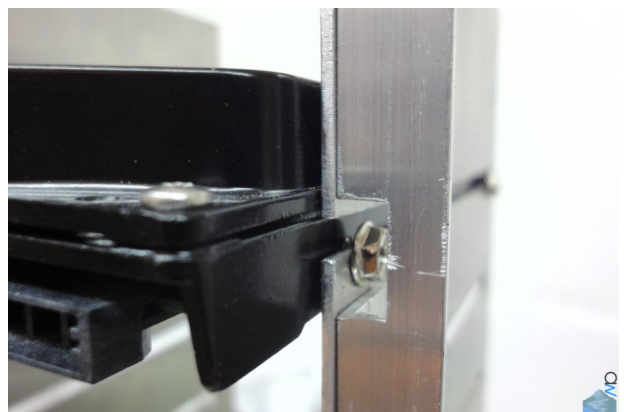


Figure 2.34: Note the cutout for the bolt head to go through when sliding the drive in.

Obviously, 24 HDDs are going to put out some heat, so some ventilation is required. I'm using six Papst fans for that. The fans will be bolted onto the panels with some L profiles.

Because the fans have a hole spacing of 105 mm and the HDDs are roughly 100 mm wide, each fan can only be mounted on one side with two screws.



Figure 2.35: Taking measurements for the fan mounting holes.



Figure 2.36: ... and all three.



Figure 2.37: Without bushings...



Figure 2.38: ... and with.

Since the fan screws need to be tightened rather heavily, the screws exert significant pressure on the

fan frames. To reduce the stress on the fan frames, we made some brass bushings that take the brunt of the pressure.

The panels are mounted to the bottom and top of the case with screws. To have some leeway in adjusting things, there are slots instead of round holes in some places.

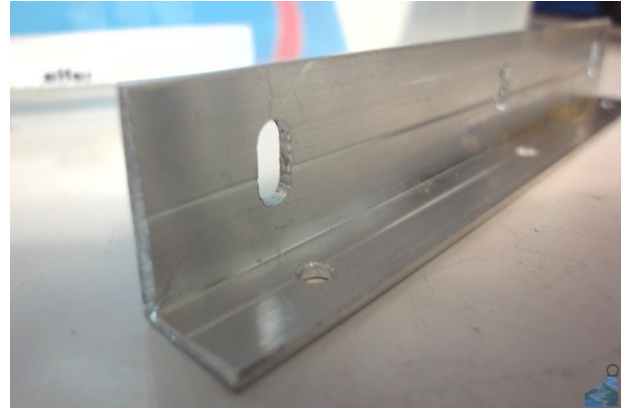


Figure 2.39: One of the brackets with slots for adjustment.



Figure 2.40: Mounted – top side.

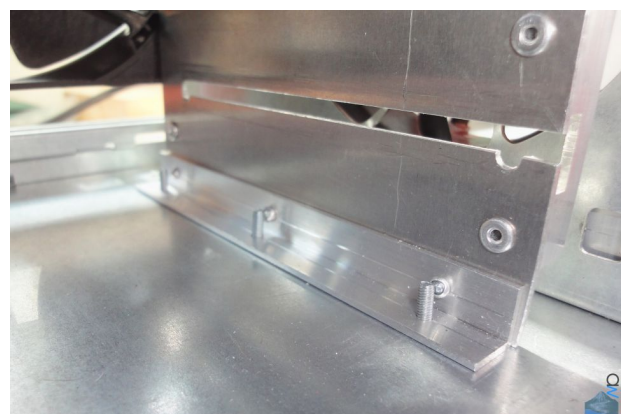


Figure 2.41: Mounted – bottom side.

The Disks just slide into the slots and lock into place in the recesses you can see above. Since I can't tighten the screws, I'm using Loctite to prevent them from falling out due to vibration. I tried to get some screws similar to those Lian Li use for their HDD mounting, but the only ones I could find were so expensive that they'd have cost me more than 100 USD. So yeah, nope...



Figure 2.42: Simple, reliable, no need to make things more complicated than needed.

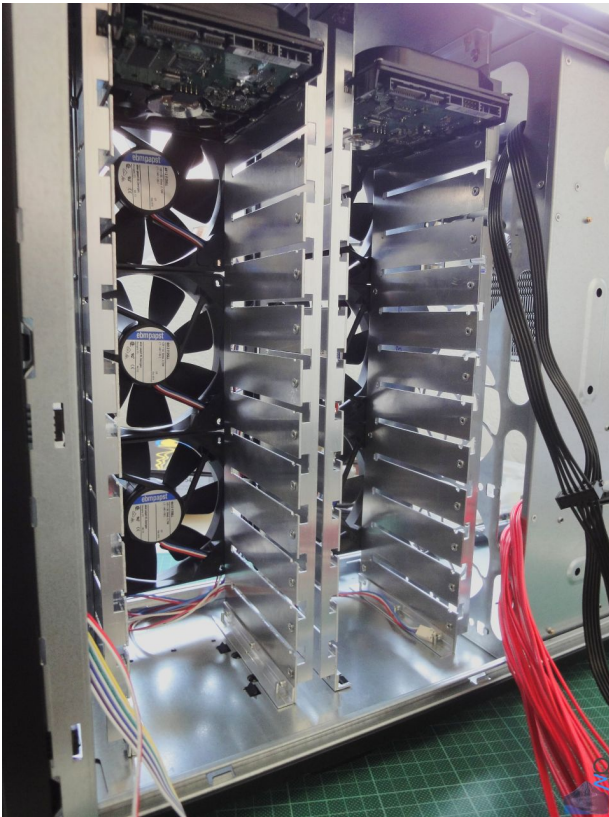


Figure 2.43: Finally, mounted in the case. Fits nicely. Very happy with the result.

2.5 Chipset Cooling and Adventures in Instability

April 08, 2014

Available online at [21], [22], [23], [24].

As some may be aware, I originally had some issues when trying to get this machine to run stable. While stress testing with mprime, it repeatedly and reproducibly crashed after less than an hour, sometimes even already after a few minutes. Each time after crashing, it took me several tries and about 10 to 20 minutes to get the board to POST again.

After some troubleshooting and running a few diagnostics, it turned out that the 5520 chipset was running really hot. Its temperature threshold as indicated by the system is 95 °C, and when I was last able to check on it before a crash, it had already passed 85 °C, so I suspected that it was bumping up against the threshold, upon which the board did an emergency shutoff and mandated a cooldown period until it would run again.

As an emergency fix, I took the 80 mm San Ace fan that came with the case and mounted it to the chipset heatsink with some waxed cotton cord, and voilÃ, somewhere slightly above 70 °C maximum.

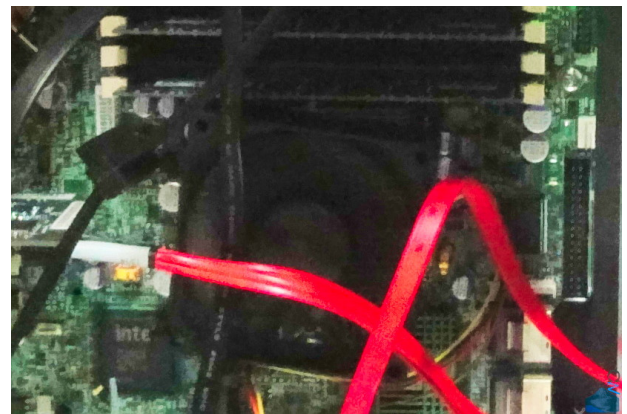


Figure 2.44: My temporary solution to stability issues. Apologies for the horrid picture quality; this is a blowup out of a larger picture.

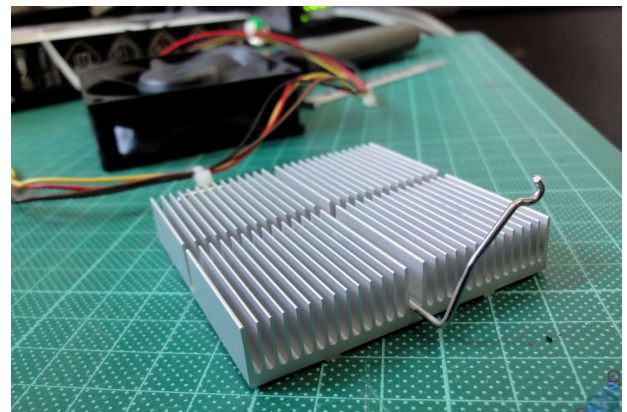


Figure 2.45: The stock heatsink.

Unfortunately I forgot to take pictures of that rather ghetto setup before dismantling it again and replacing it with something more solid, but I have

managed to blow up some sections from another picture that should at least give you an idea of how it looked.

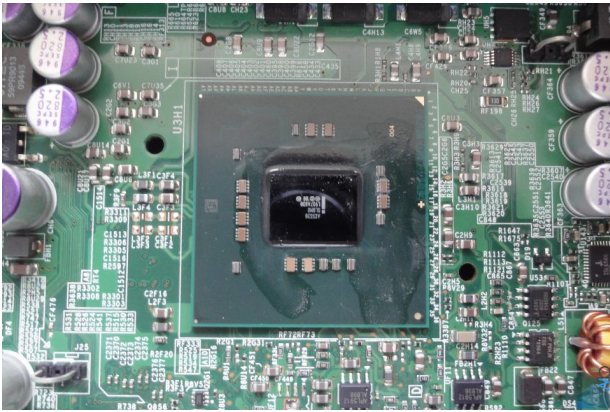


Figure 2.46: The naked chipset after cleaning off the TIM (rather annoying as it had dried).

Since the 80 mm fan is quite a bit larger than the chipset heatsink itself, I needed to either replace the heatsink or modify it in order to be able to mount the fan to it. I took a rather crude, but very effective approach: I took an L piece of aluminium, drilled two holes across the heatsink, cut some M4 threads on those two holes (which worked despite the holes only going through the fins and not being continuous), then bolted the L piece to the heatsink with two M4 screws. Works like a charm.

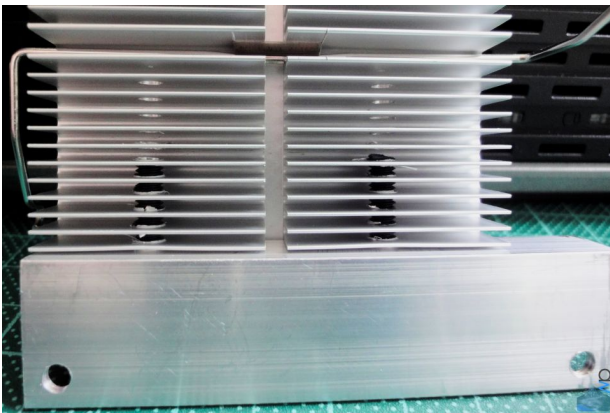


Figure 2.47: The holes are a bit unclean, but it's not possible to debur them unfortunately.

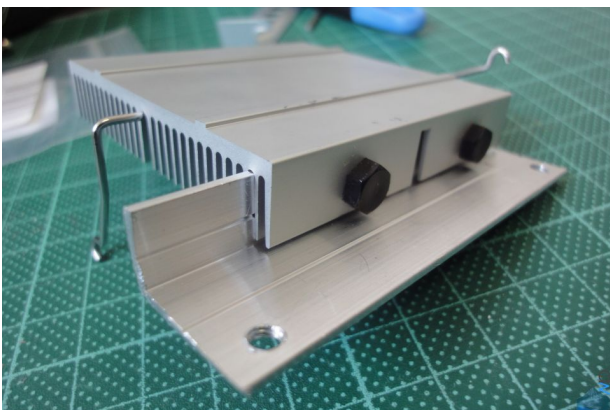


Figure 2.48: ... and from the other side.



Figure 2.49: The fan is held down by three screws, two in the L piece...



Figure 2.50: ... and one in the corner of the heatsink itself. Some fins are bent from the drilling.



Figure 2.51: And the complete chipset cooling package.



Figure 2.52: For mounting it on the M/B, it needs to be mounted first without the fan...

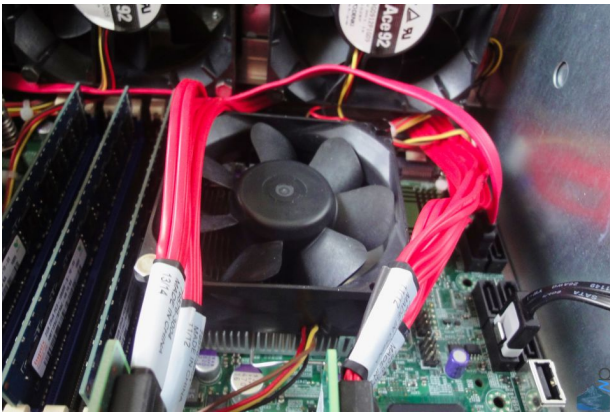


Figure 2.53: ... then the fan is mounted on top, and done.

2.6 Disk Ventilation

April 09, 2014

Available online at [25], [26], [27], [28].

Although disks have become quite frugal when it comes to power consumption these days (at least some of them) and HDD cooling is not really a huge issue for most people, packing 24 disks as closely together as in this build will cause heat issues without ventilation. There is no need for 3k rpm Delta fans though, a whiff of cool air breezing over the disks should do the job nicely.

For this purpose, as you may have seen in some previous pics, I have chosen 6 120 mm Papst fans, specifically the 4412 GLL model, and am running them at 7 V. The fans draw air in through a vent area, and it then gets passed through the M/B compartment and out the back.

Each fan is fixed to a rail riveted to one of the disk rack panels with two screws.

You've seen this before, but for completeness' sake I'm adding the pics of the bushings used to prevent the fan frames from being crushed to this update as well:



Figure 2.54: Closeup of the brass bushings. Works nicely.

I've exchanged the copper screws for some silver ones, and in the process added some dampening foam between the mouning rails and the fan frame.

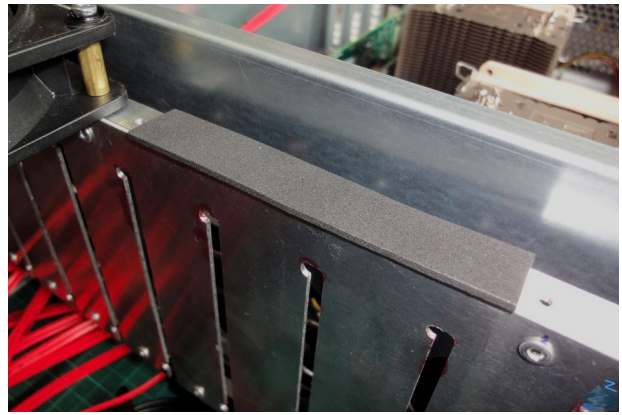


Figure 2.55: Just some foam.

The complete fan panel assembly:

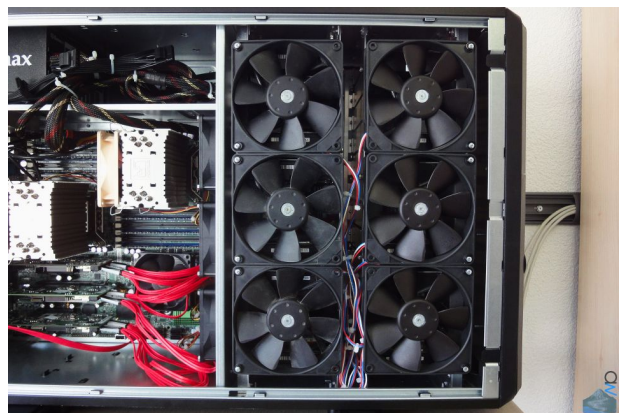


Figure 2.56: Looks neat, doesn't it?

While doing some test runs, I noticed that a rather large amount of air was being expelled through the front of the case instead of going into the M/B compartment and out the back (I wasn't really surprised by this seeing as how open the front was). Obviously, this was not optimal. So I took a 1.5 mm panel of alu and bolted it to the front.

Because the existing front has a few folds in it, I needed to do some cutting on the case first.

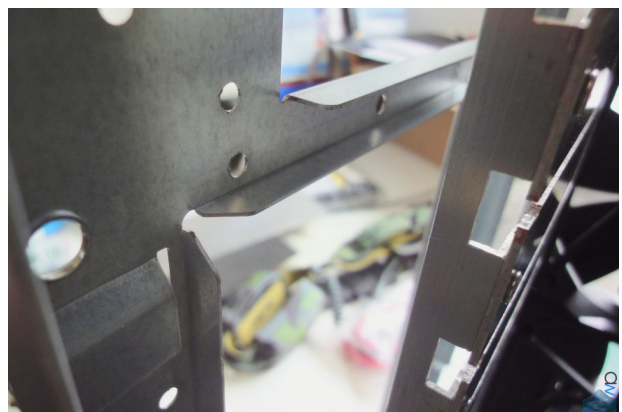


Figure 2.57: Can't mount a panel to the front of the frame with these folds.

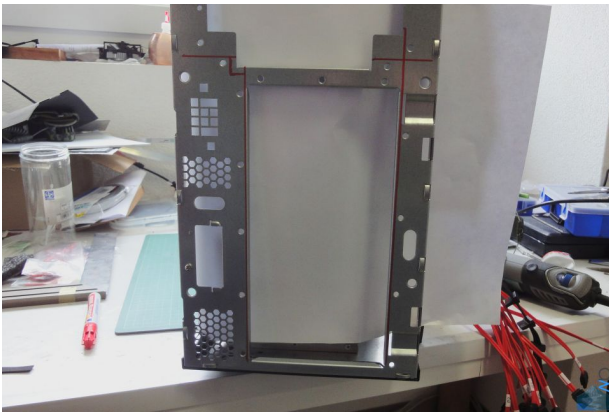


Figure 2.58: Making some marks for where I need to cut.

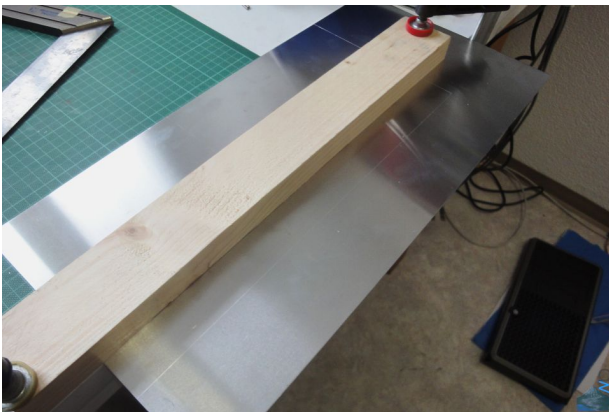


Figure 2.59: Making sure it's bolted down nicely.

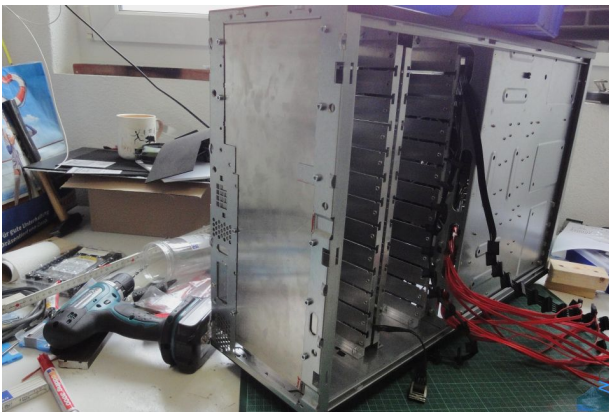


Figure 2.60: Cut and mounted.

After having done that, I turned my attention to the side panel, making an opening for the ventilation. I thought of several ways of doing this, but all of them were a bit more complicated than I'd have liked them to be. Cutting such a big hole with a dremel isn't really practical, so I considered doing it with our jigsaw, but after doing a few test cuts I didn't really like the result as I couldn't get a straight enough cut. And the cut needed to be clean, because there's no space to fit a U channel over the edge, and I don't really like the idea of covering it up on the outside.

Anyway, the guy just used a nice big angle grinder for the cut, and since he's a metal worker by trade, it turned out almost perfectly straight (not 100but it's still cut by hand, after all). After that, I painted

the bare edge with some model paint to not have the blank metal staring at me.

I thought about painting the mesh, but at the moment I don't really have the time, plus I kind of like the look of this bare piece of alu, so I've left it as-is.

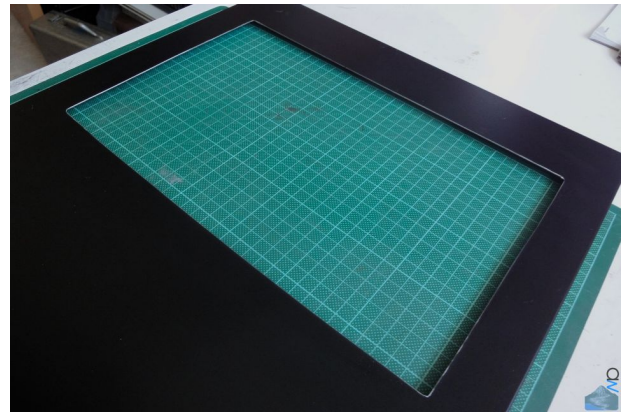


Figure 2.61: The opening for the mesh

The mesh doesn't cover the entire fan area (nor is it very open with those rather narrow slots), but there is no need for high-power ventilation here, so this is not a big deal.



Figure 2.62: Checking if it all fits.

It's fixed to the inside of the panel with some double-sided adhesive tape.

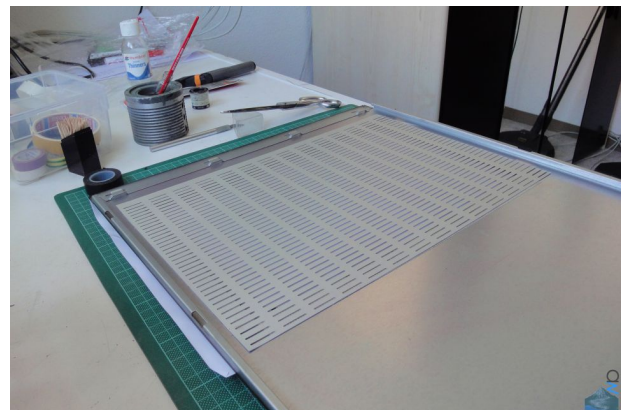


Figure 2.63: The mesh from the inside.

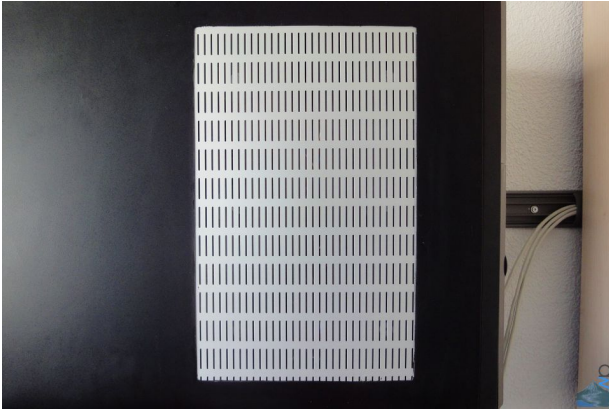


Figure 2.64: And the end result.

Drive temperatures hover between 28 °C and 35 °C at the moment, ambient is about 23 °C.

2.7 Fan Unit for Main Compartment Ventilation

April 11, 2014

Available online at [29], [30], [31], [32].



Figure 2.65: Stock configuration. The blue cages can be easily swapped out if needed... (Credit: tweaktown.com [33])

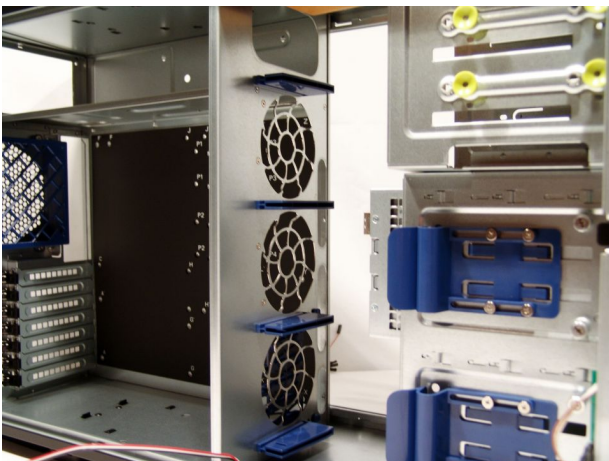


Figure 2.66: ... as seen here. (Credit: tweaktown.com [33])

As hinted at earlier, the airflow in this build will go from the front compartment through the middle wall into the M/B compartment and out the back.

This is pretty much how the stock configuration works, except in that the air gets in through the front panel, not through the side panel.

Unfortunately I forgot to take pics of the stock config, but luckily tweaktown.com did a review on this case and took them for me, see [33].

In the stock config, the 92 mm fans are mounted inside some plastic fan cages that allow quick and toolless fan replacement in case of failure.

Originally I simply bolted the fans to two aluminium L profile bars.



Figure 2.67: M4 screws and alu profiles.

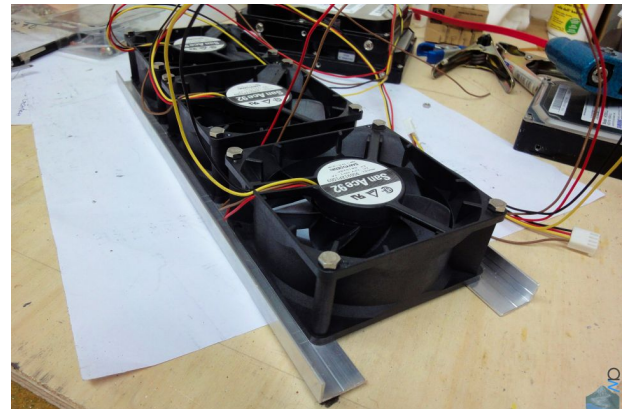


Figure 2.68: The other side.

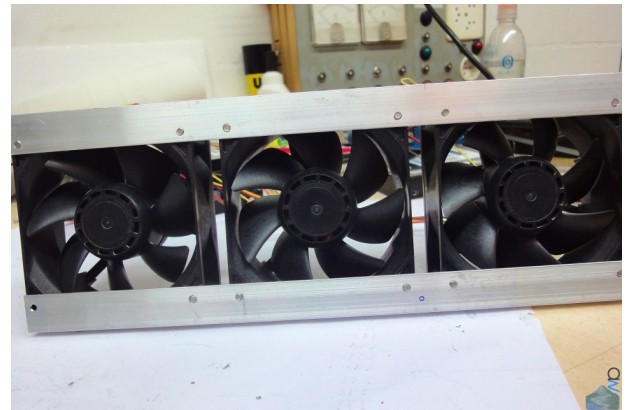


Figure 2.69: Intake side.

It was fixed to the middle wall with double-sided adhesive tape. It's very strong stuff, so the fan unit falling off was not a concern. Additionally, the tape

has some thickness to it, which should provide some dampening between the fan unit and the middle wall.



Figure 2.70: Just a few strips of double-sided adhesive tape.

Unfortunately, due to some bumps on the middle wall getting in the way, the tape on the rear angle didn't make proper contact with the wall. It held, but not very well.

Additoinally, I noticed that there were rather strong vibrations on the middle wall. It turned out that the tape did indeed offer some decoupling, but it also did not offer any additional strength to the middle wall (i.e. no additional stiffness), which meant the wall could easily vibrate.

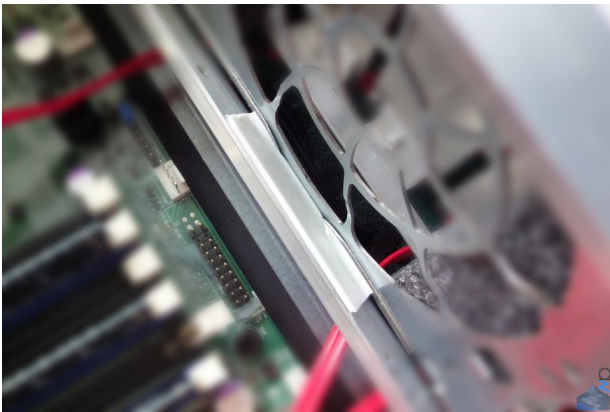


Figure 2.71: Tape did not make proper contact.

So, I took the unit out, and while I was at it, I also cut out some recesses for the fans which I didn't bother doing before. I also put some dampening foam between the fans and the alu angles.

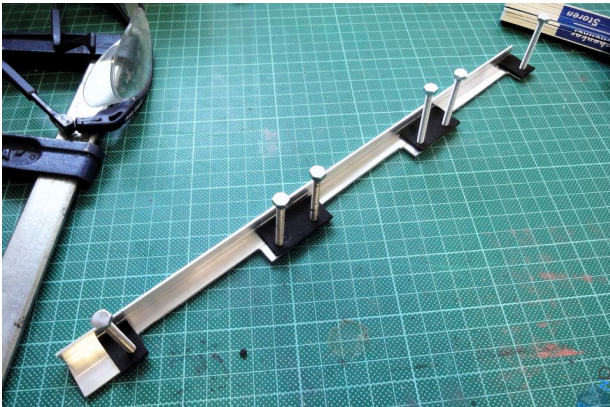


Figure 2.72: Cutouts for fans, dampening foam.

Aaand of course I mounted the fans the wrong way around at first. Sigh.

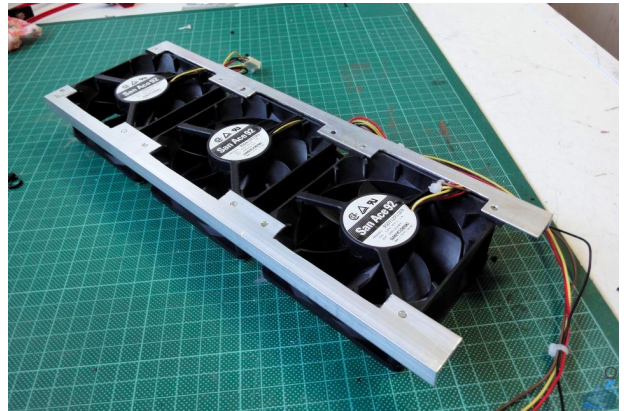


Figure 2.73: If there's a wrong way to do things, they will be done the wrong way at first...

Disassemble again, reassemble.

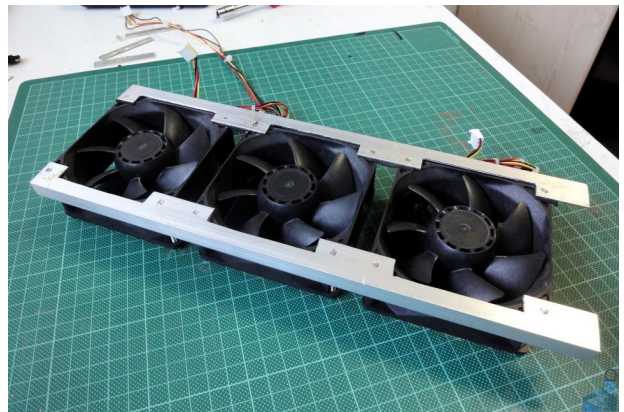


Figure 2.74: Finally.



Figure 2.75: Also: Foam between the alu angles and the wall itself.

This time I bolted it to the wall with some screws. Much more solid now, no more vibrations.

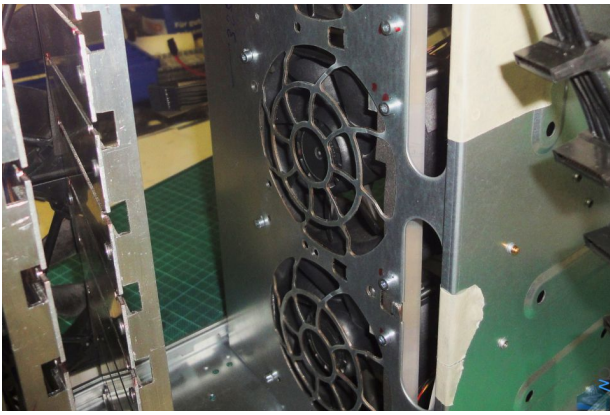


Figure 2.76: Nice and solid now.

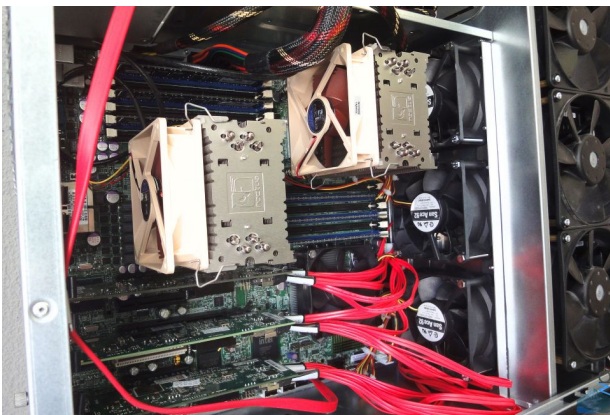


Figure 2.77: And from the other side.

2.8 Storage Topology and Cabling

April 12, 2014

Available online at [34], [35], [36], [37].

An overview diagram of the storage topology at this stage in the build can be found in appendix A.1.

The idea behind the storage topology is based on wpirobotbuilder's post about reducing single points of failure (see [38]). Any one of the three LSI controllers can fail and I still have all my data available.

You'll see below that I haven't yet gotten around to installing the Velociraptor.

I use coloured zip ties to mark the cables that go to the different controllers.

BLUE = controller 0

YELLOW = controller 1

GREEN = controller 2

There isn't really any space to hide the cables, so this was rather tricky and required three attempts until I was satisfied with the result. In the end I hid the extra cable behind the triple fan unit, good thing they're 38 mm fans, which makes the space behind them just about large enough to fit the extra cable bits.

The power cables for the disks are two cables that came with the PSU and onto which I just put a lot more connectors while taking off the stock connectors because those were neither placed in the correct locations nor facing in the right direction.

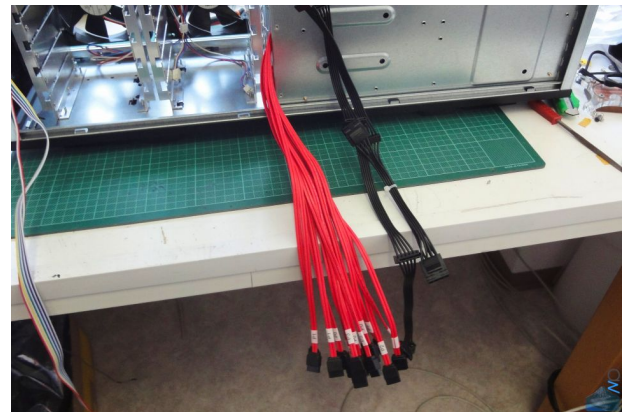


Figure 2.78: Looks harmless, right? Yeah...



Figure 2.79: And the disks.

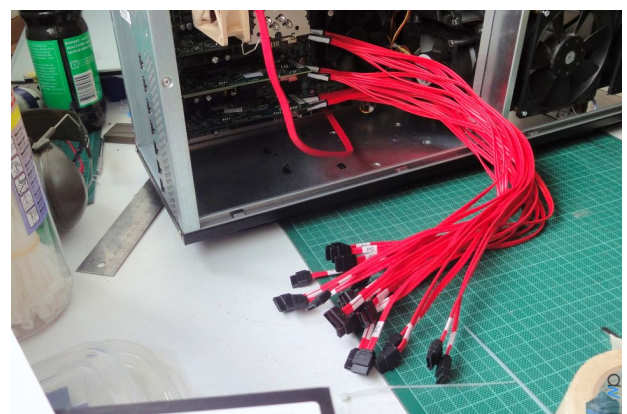


Figure 2.80: OK then, first try...

I soon realized that this wasn't going to work. The problem was that I had the disks arranged in the same way as they will be set up in the storage pool layout, so the disks which go into the same storage pool were also mounted below each other. Sounds nice in theory, but if you want to have disk from each pool distributed among the different controllers, you'll get quite the cable mess.

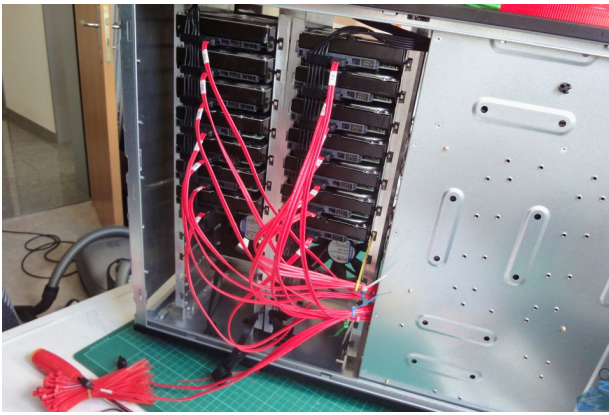


Figure 2.81: Not exactly a splendid result

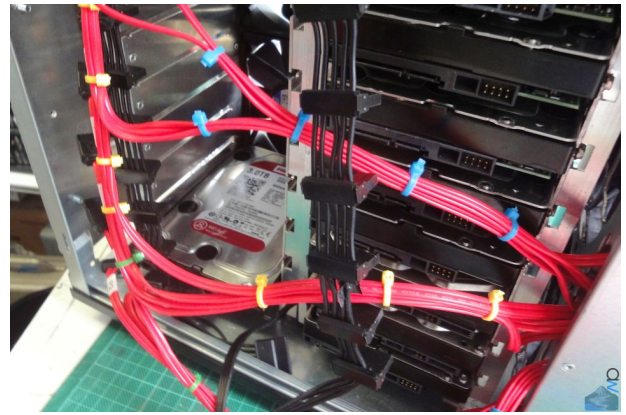


Figure 2.85: Better than the first attempt.



Figure 2.82: Different angle.

On the second try, I arranged the disks to that the cables to the controllers could be better laid out.



Figure 2.83: Round 2, so far so good...



Figure 2.84: Hail Hydra?

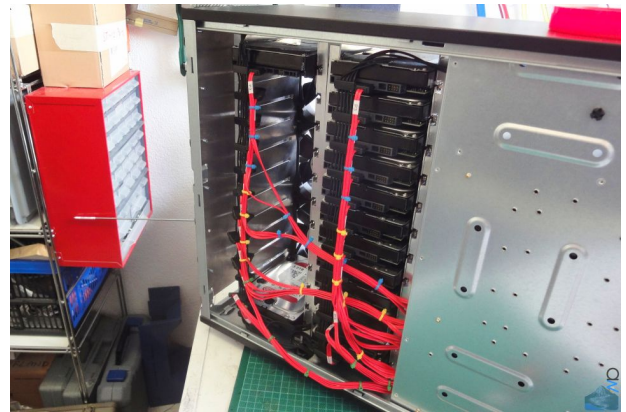


Figure 2.86: Different Angle.

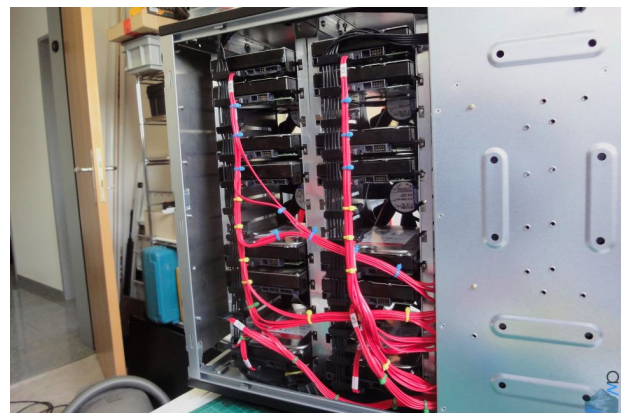


Figure 2.87: The disks are distributed in the cages for improved airflow and easier cable management.



Figure 2.88: Closeup of the connectors. All in all though, I still wasn't quite happy, mainly because...

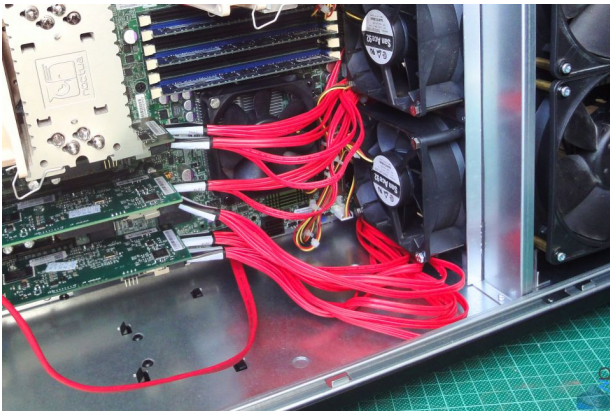


Figure 2.89: ... of this.

Third time's the charm. ... This time, I hid the extra cable length behind the triple fan unit.

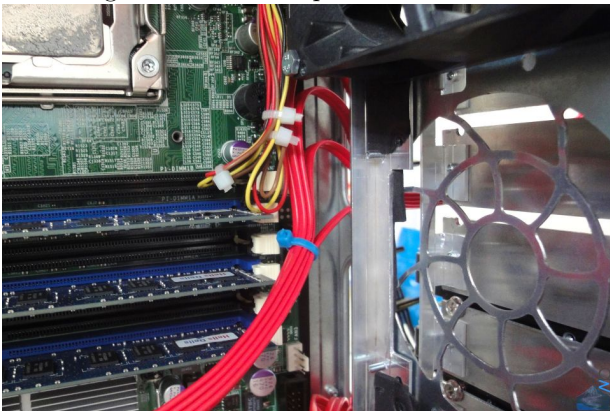


Figure 2.90: Attempt 3. Coiling up extra cable length.



Figure 2.91: Loop of for the topmost cable loom.

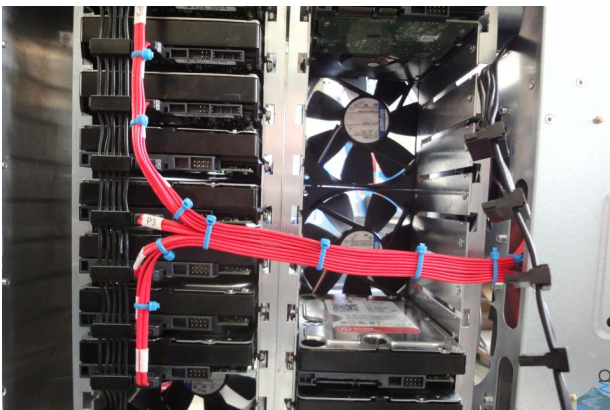


Figure 2.92: And the cable loom for controller 0, from the disk side. ...

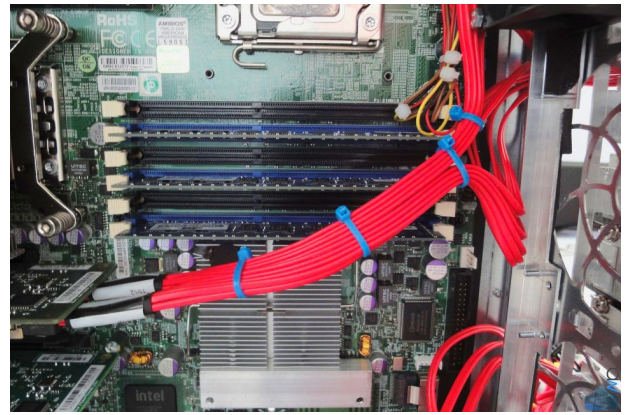


Figure 2.93: ... and the M/B side. Much better in my humble opinion.



Figure 2.94: The bottom controller had a bit more extra cable length to hide, so that part is a bit messier.

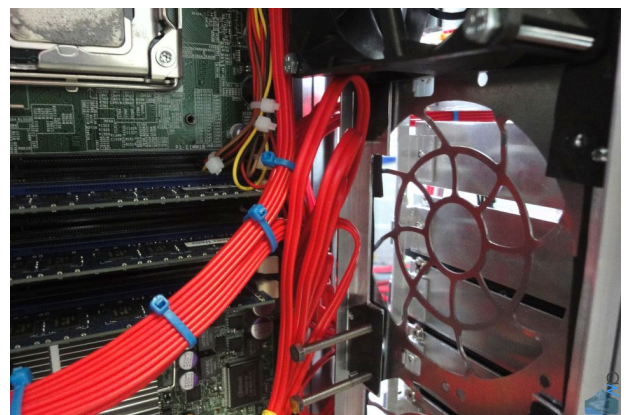


Figure 2.95: And the middle one.

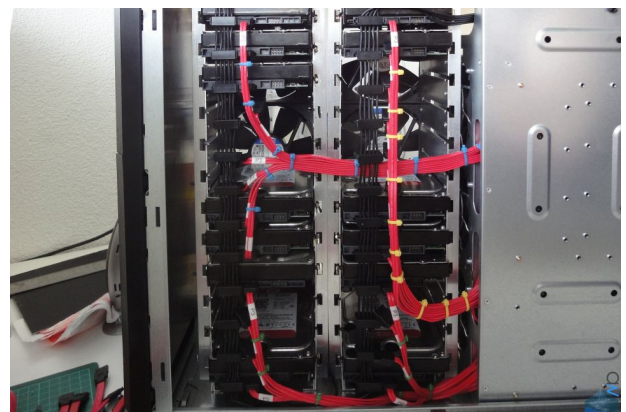


Figure 2.96: Much nicer than before methinks.

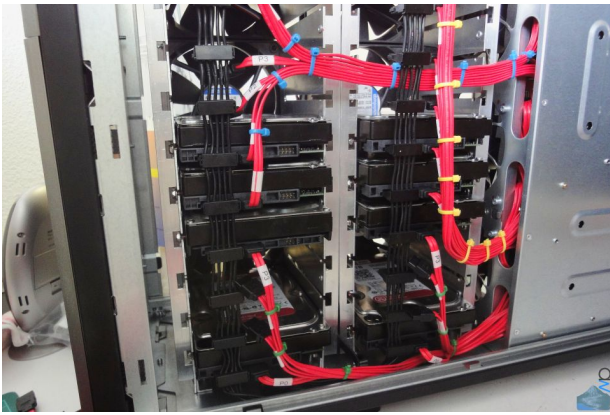


Figure 2.97: Different angle.

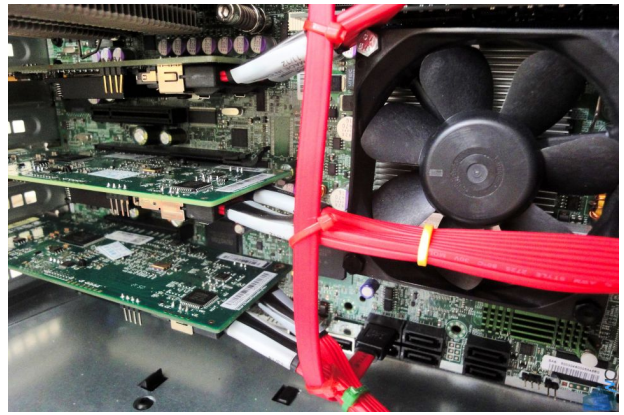


Figure 2.101: The SATA cable for the system SSD.



Figure 2.98: Closeup.

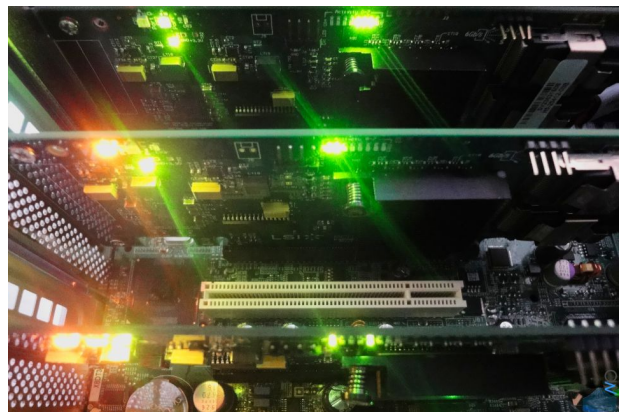


Figure 2.102: And the controller LEDs when there's some activity.

While not completely flawless, I am rather happy with the result now.

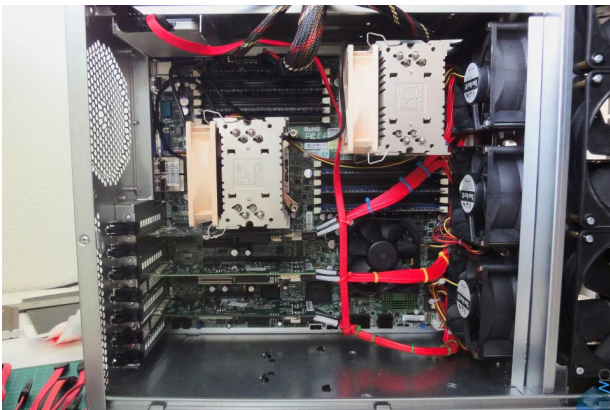


Figure 2.99: And the other side. Significant Improvement I'd say.

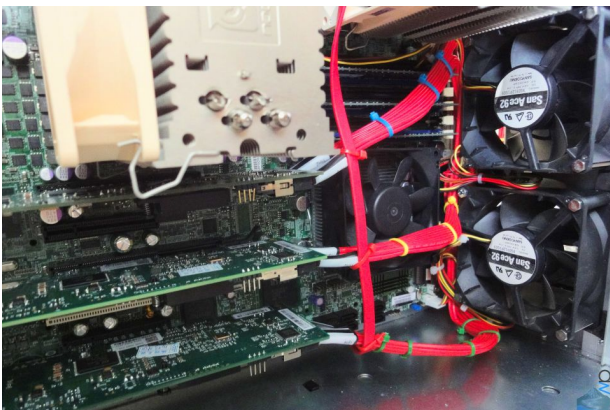


Figure 2.100: The cable looms going off the controllers.

2.9 Storage and Networking Performance

April 26, 2014

Available online at [39], [40], [41], [42].

An update storage topology diagram for this stage of the build can be found in appendix A.2.

Beware: This section will be of little interest to those who are primarily in it for the physical side of building. Instead, this update will be about the performance and software side of things. So, lots of text, lots of numbers.

These results are still somewhat preliminary since I'm not yet 100% the hardware config will remain like this for an extended period of time (I really want to put another 12 GB of RAM in there, for example, and am considering adding some SSD goodness to my ZFS pools), nor am I necessarily done with tuning software parameters, but it should give some idea of what performance I'm currently getting.

As you may recall from my previous update, I'm running three VMs on this machine, two of which are pretty much always on (the media VM and my personal VM), and the third of which is only active when I'm pulling a backup of my dad's work machine (apollo-business).

The storage setup has been revised somewhat since the last update. I now have a mirrored ZFS pool in ZEUS for backing up my dad's business data (so, in total his data is on six HDDs, including the one in his work machine). His data is pulled onto the apollo-business VM from his work machine, and then pulled onto ZEUS. The fact that neither the business VM nor ZEUS are online 24/7 (ZEUS is turned off physically most of the time) should provide some decent protection against most malheurs, the only thing I still need to implement is a proper off-site backup plan (which I will definitely do, in case of unforeseen disasters, break-ins/theft and so on).

For convenience's sake, I was planning on using NFS for sharing data between the server and its various clients on our network. Unfortunately, I was getting some rather disappointing benchmarking results initially, with only $60 \text{ MiB}\cdot\text{s}^{-1}$ to $70 \text{ MiB}\cdot\text{s}^{-1}$ transfer speeds between machines.

I'm not really a storage benchmarking expert, and at the moment I definitely don't have the time to become one, so for benchmarking my storage I've used `dd` for the time being. It's easy to use and is pretty much standard for every Linux install. I thought about using other storage benchmarks like `Bonnie++` and `FIO`, and at some point I might still do that, but for the time being `dd` will suffice for my purposes.

For those not familiar with this: `/dev/zero` basically serves as a data source for lots of zeroes, `/dev/null` is a sink into which you can write data without it being written to disk. So, if you want to do writing benchmarks to your storage, you can grab data from `/dev/zero` without needing to worry about

a bottleneck on your data source side, and `/dev/null` is the equivalent when you wish to do reading benchmarks. To demonstrate this, I did a quick test below directly from `/dev/zero` into `/dev/null`.

Basically. It's a bit of a simplification, but I hope it's somewhat understandable.

Before doing storage benchmarks across the network, we should of course get a baseline for both the storage setup itself as well as the network.

The base pipe from `/dev/zero` into `/dev/null` transfers has a transfer speed of $9 \text{ GiB}\cdot\text{s}^{-1}$. Nothing unexpected, but it's a quick test to do and I was curious about this.

2.9.1 Networking Baseline Performance

The networking performance is where I hit my first hiccup. I failed to specify to the VM which networking driver it was supposed to use, and the default one does not exactly have stellar performance. It was an easy fix though, and with the new settings I now get pretty much the same networking performance across all my machines (except the Windows ones, those are stuck at $500 \text{ Mbit}\cdot\text{s}^{-1}$ for some reason as you can see above, but that's not hugely important to me at the moment TBH). When using the default QEMU networking card, I got about $520 \text{ Mbit}\cdot\text{s}^{-1}$ typical transfer speed, when switching to the *virtio* driver, it increased to roughly $930 \text{ Mbit}\cdot\text{s}^{-1}$ typically.

PARTNER MACHINE	PARTNER O/S	BANDWIDTH
Office PC	Windows 7	$513.0 \text{ Mbit}\cdot\text{s}^{-1}$
HELIOS	Windows 7	$517.0 \text{ Mbit}\cdot\text{s}^{-1}$
ZEUS	Arch Linux	$931.0 \text{ Mbit}\cdot\text{s}^{-1}$
Dell XT2, WiFi	Arch Linux	$12.7 \text{ Mbit}\cdot\text{s}^{-1}$
APOLLO (Host)	Arch Linux	$939.0 \text{ Mbit}\cdot\text{s}^{-1}$
APOLLO (VM 2)	Arch Linux	$885.0 \text{ Mbit}\cdot\text{s}^{-1}$
APOLLO (VM 3)	Arch Linux	$858.0 \text{ Mbit}\cdot\text{s}^{-1}$

Table 2.2: Example from one run with `iperf` (*not averages*). Measured from a KVM/QEMU virtual machine running Arch Linux.

2.9.2 Storage Baseline Performance

I had a similar issue with the storage subsystem at first, the default parameters for caching were not very conducive to high performance and resulted in some pretty bad results. Writing to a ZPOOL of $4 \times 2 \text{ TB}$ `WD RE4` resulted in speeds of a miserable $50 \text{ MiB}\cdot\text{s}^{-1}$ at first (with option flag `cache writethrough`). Reading from the pool was possible at a nice $240 \text{ MiB}\cdot\text{s}^{-1}$ though.

Once I fixed that though (setting the `writethrough` option to `none`), much better, and sufficient to saturate a gigabit networking connection.

QEMU CACHE FLAG	ZPOOL	READ (MiB·s ⁻¹)	WRITE (MiB·s ⁻¹)
writethrough	4×2 TB RE4	50	240
none	4×2 TB RE4	155	210
none	6×3 TB Red	240	240

Table 2.3: Read/Write speeds depending on QEMU's cache flag for my two main ZFS pools.

2.9.3 Actual Performance over Network

The results can be found in appendix A.3.

Initially, I got only around **60 MiB·s⁻¹** for NFS, after that the next plateau was somewhere between **75 MiB·s⁻¹** and **80 MiB·s⁻¹**, and lastly, this is the current situation. I must say I find the results to be slightly... peculiar. Pretty much everything I've ever read says that NFS should offer better performance than CIFS, and yet, for some reason, in many cases that was not the result I got.

I'm not yet sure if I'll be going with NFS or CIFS in the end to be honest. On one hand, CIFS does give me better performance for the most part, but I have found NFS more convenient to configure and use, and NFS' performance at this point is decent enough for most of my purposes.

In general, I find the NFS results just rather weird to be honest. But they have been reproducible over different runs on several days, so for the time being I'll accept them as what I can get.

As an alternative, I've also tried FTP on recommendation of Whaler_99, but results were not really very satisfying, only yielding slightly more than **50 MiB·s⁻¹** on average.

2.9.4 ZFS Compression

Also, for those curious about ZFS' compression (which was usually disabled in the above tests because zeroes are very compressible and would therefore skew the benchmarks), I did a quick test to compare writing zeroes to a ZFS pool with and without compression.

This is CPU utilization without compression (the grey bars are CPU time spent waiting for I/O, not actual work the CPU is doing):

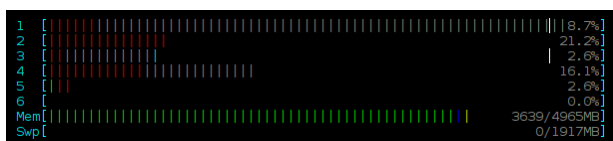


Figure 2.103: CPU load without compression.

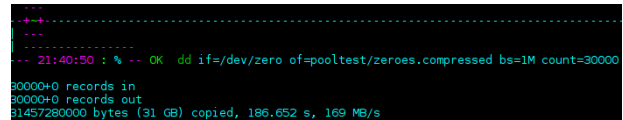


Figure 2.104: And the write speed for that specific test run.

With lz4 compression enabled, the CPU does quite a bit more work, as expected (though it still seems that you don't really need a very powerful CPU to make use of this):

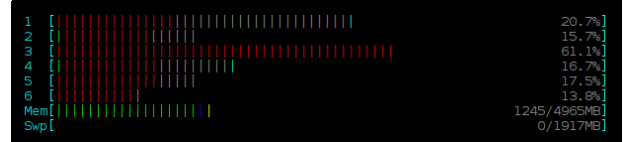


Figure 2.105: CPU load with compression.

The transfer speed for a zero-file goes up to almost **1 GiB·s⁻¹** with lz4 compression enabled; pretty neat if you ask me.

Side note: ZFS' lz4 compression is allegedly smart enough not to try to compress incompressible data, such as media files which are already compressed, which should prevent such writes from being slowed down. Very nice IMHO.

Chapter 3

Result and Closing Thoughts

June 23, 2013

Available online at [43], [44], [45], [46].

As mentioned previously, the 92 mm fans are rather noisy, but I didn't want to replace them. For one thing, I do actually need some powerful fans to move air from the HDD compartment into the M/B compartment, on the other hand I didn't feel like spending more money on expensive fans.

For this purpose, I ordered some AcoustiPack foam in various thicknesses (12 mm, 7 mm and 4 mm) and lined parts of the case with them. I wasn't quite sure how well they would work, as my past experiences with acoustic dampening materials weren't all that impressive, but to my surprise, they're actually pretty damn effective.

I have also put in another 12 GB of RAM. I was lucky enough to get six 2 GB sticks of the exact same RAM I already had for 70 USD (plus shipping and fees, but still a pretty good price IMHO) from eBay. 24 GB should easily suffice for my purposes.

Lastly, I've repurposed the 2.5" drive cage from my Caselabs SMH10; cleaner than the rather improvised mount from before.

For the time being, the build is now pretty much complete.

One of the original goals was to not have this become ridiculously expensive. Uhm, yeah, you know how these things usually go...

Total system cost: 5,000 USD of which were HDDs: 2,500 USD

My share of the total cost is 42%, the remainder was on my dad, which is pretty fair I think. In the long run, my share will probably rise as I'll most likely be the one paying for most future storage expansions (at the moment I've paid for 54% of the storage cost, and 31% of the remaining components).

One thing to keep in mind though is that some of these costs go back a while as not all HDDs were bought for this server but have been migrated into it from other machines. So the actual project costs were less by about 1,300 USD.

Overall I'm still pretty happy with the price/performance ratio. There aren't really that many areas where I could have saved a lot of money without also taking noticeable hits in performance or features.

I could have gone with a single-socket motherboard, or a dual socket one with fewer features (say, fewer onboard SAS/SATA ports as I'm not using nearly all of the ones this one has due to the 2 TB disk limit), but most of the features this one has I wouldn't want to miss TBH (the four LAN ports are very handy, and IPMI is just freaking awesome). And let's be honest: A dual-socket board just looks freaking awesome (OK, I'll concede that that's not the best argument, but still, it does!).

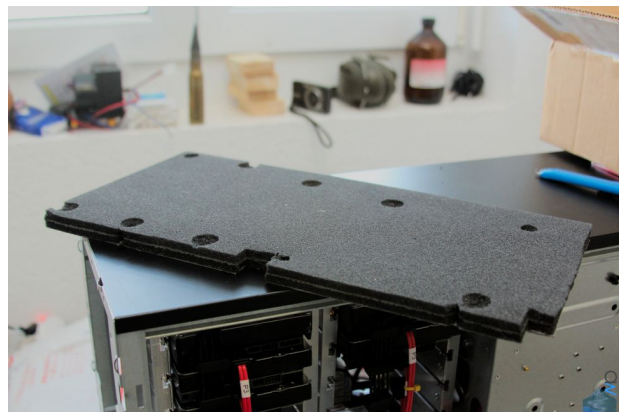


Figure 3.1: The inner side of the front panel with sound dampening.



Figure 3.2: That Caselabs drive cage I mentioned, the top drive is the WD Velociraptor.

Other than that, I could have gone with some cheaper CPU coolers as the 40 W CPUs (btw., *core voltage is 0.9 V, nice!*) don't really require much in that area, but the rest is pretty much what I want need for an acceptable price.



Figure 3.3: The box in its closed state.

Figure 3.4: And open on the CPU side.



Figure 3.5: Quite a few fans in there...



Figure 3.6: Some more cable shots, because why not...

Figure 3.7: ... and more...

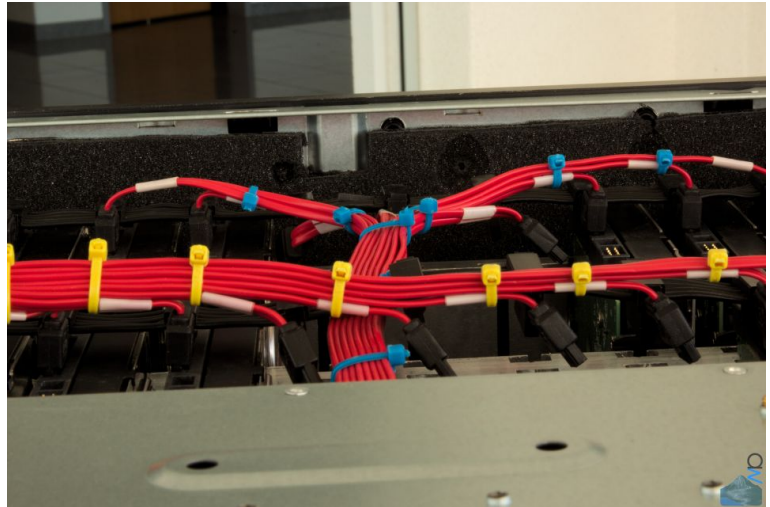


Figure 3.8: Connectors...



The power connectors look crooked because they're not all connected to a drive, so the ones which are floating freely in the air don't align perfectly. Once the build is filled up with drives, this will look much better.

Figure 3.9: One of the cable looms fanning out to the drives.

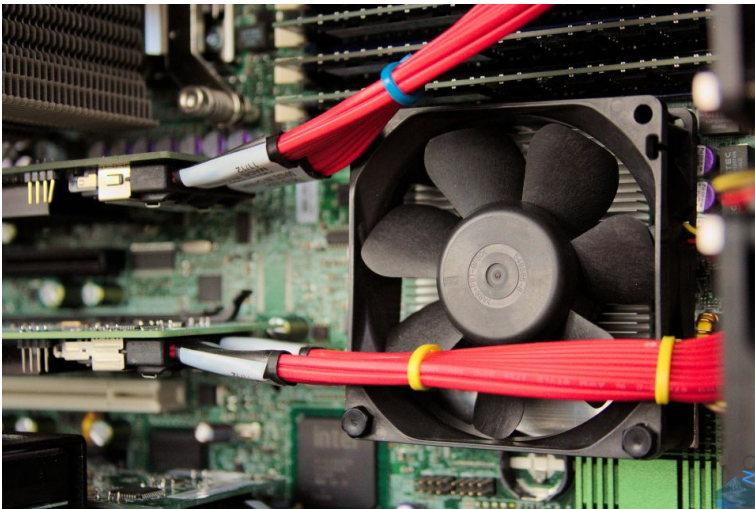
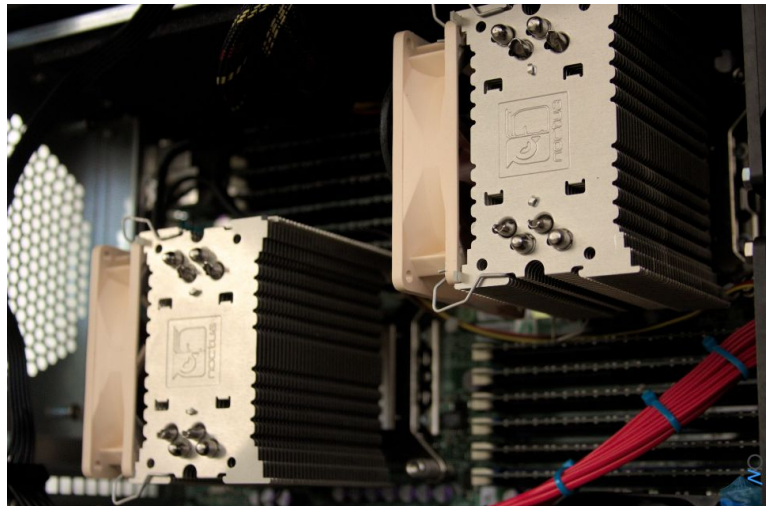


Figure 3.10: The Chipset cooler and data cables. Not too much room in there now.

Figure 3.11: Switched the Noctua fans back on the coolers since I'm using the San Ace ones for compartment ventilation.



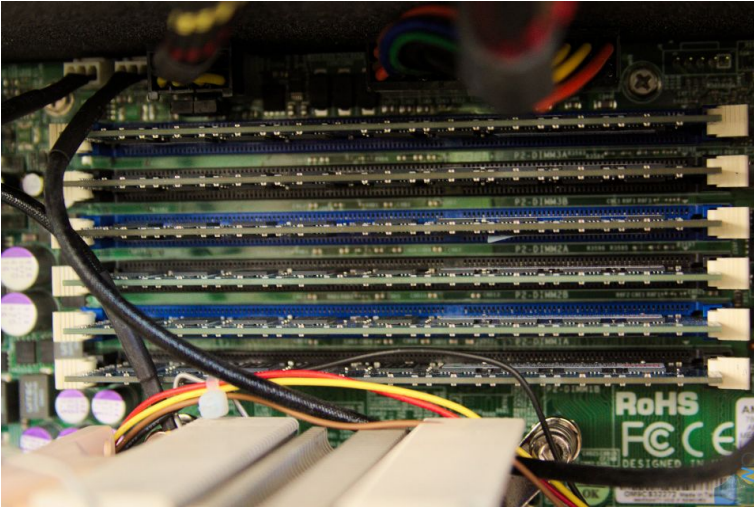


Figure 3.12: Looks better with six sticks in there I'd say.

Figure 3.13: The back side.

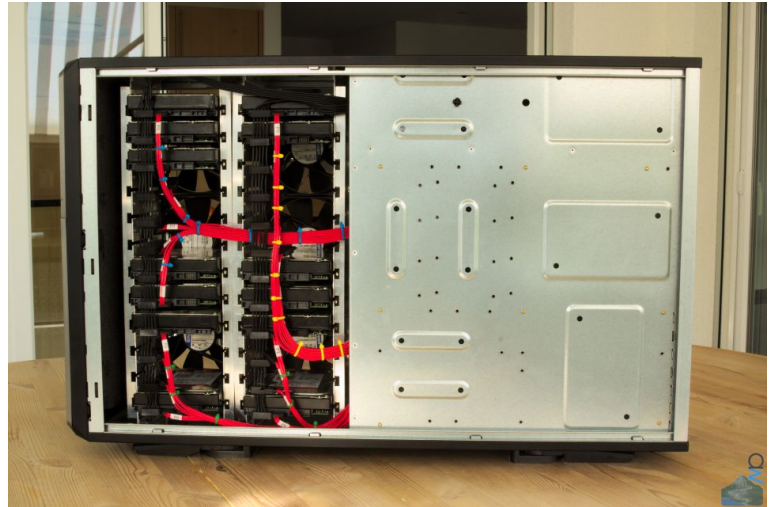
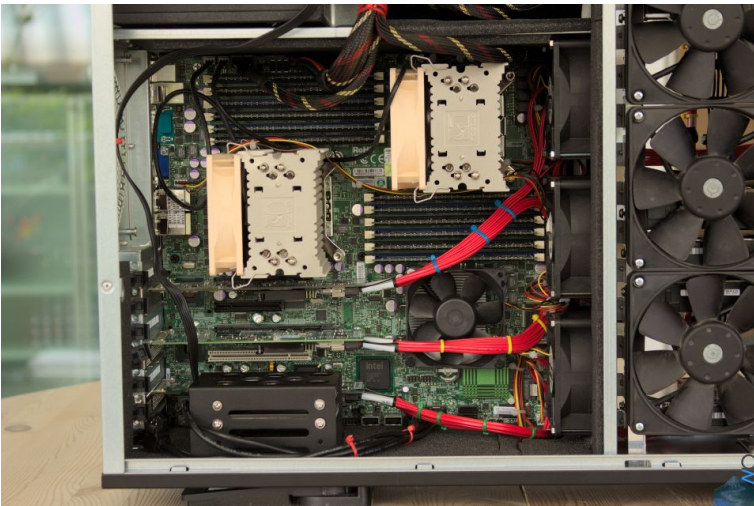


Figure 3.14: And the motherboard compartment.



It's kinda funny: Considering how large the M/B compartment actually is, it's pretty packed now with everything that's in there. The impression is even stronger in person than on the pics.

And that's it, we're done. Thanks for reading, see you next time.

Appendix A

Diagrams

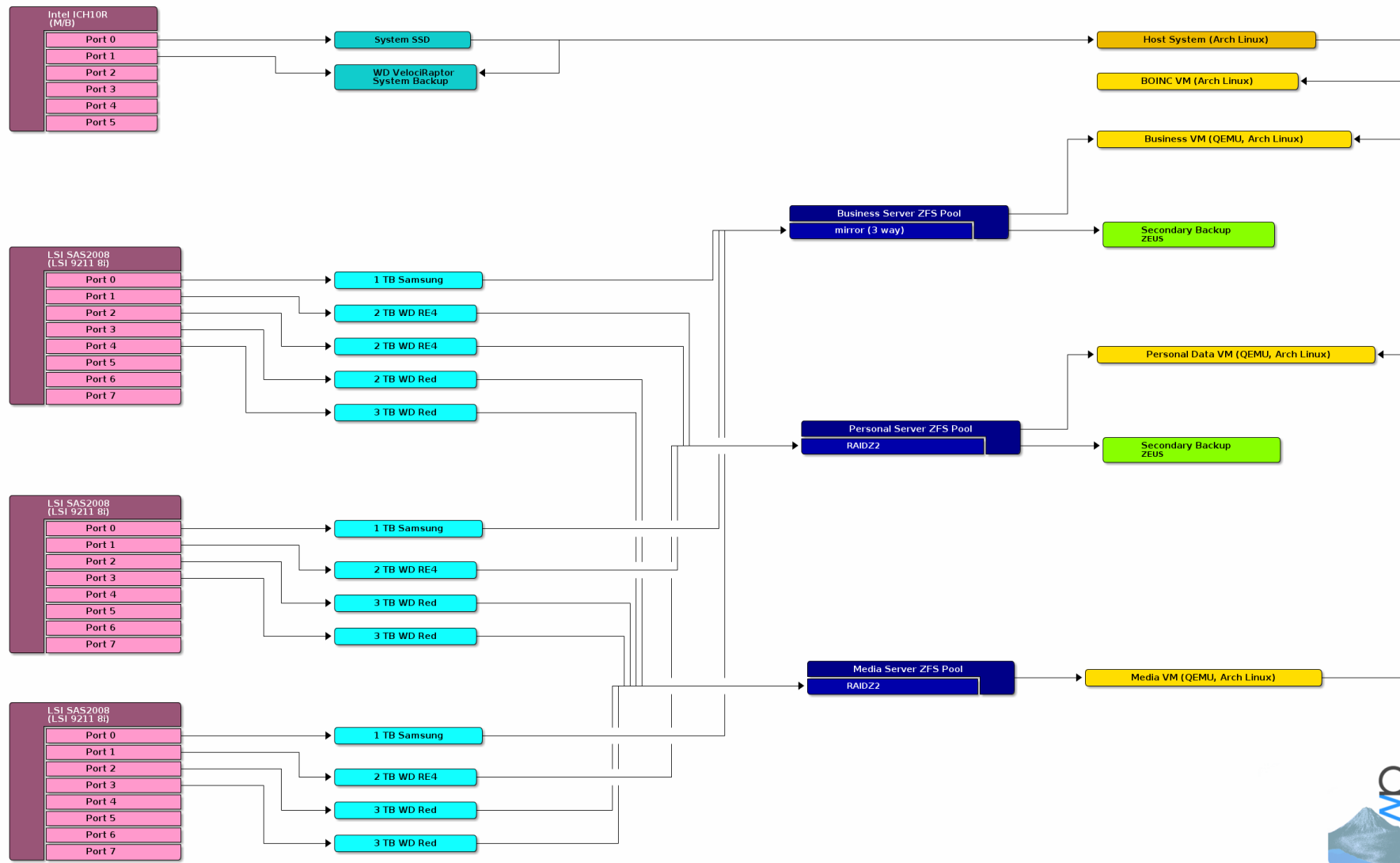


Figure A.1: Diagram of APOLLO's storage topology.

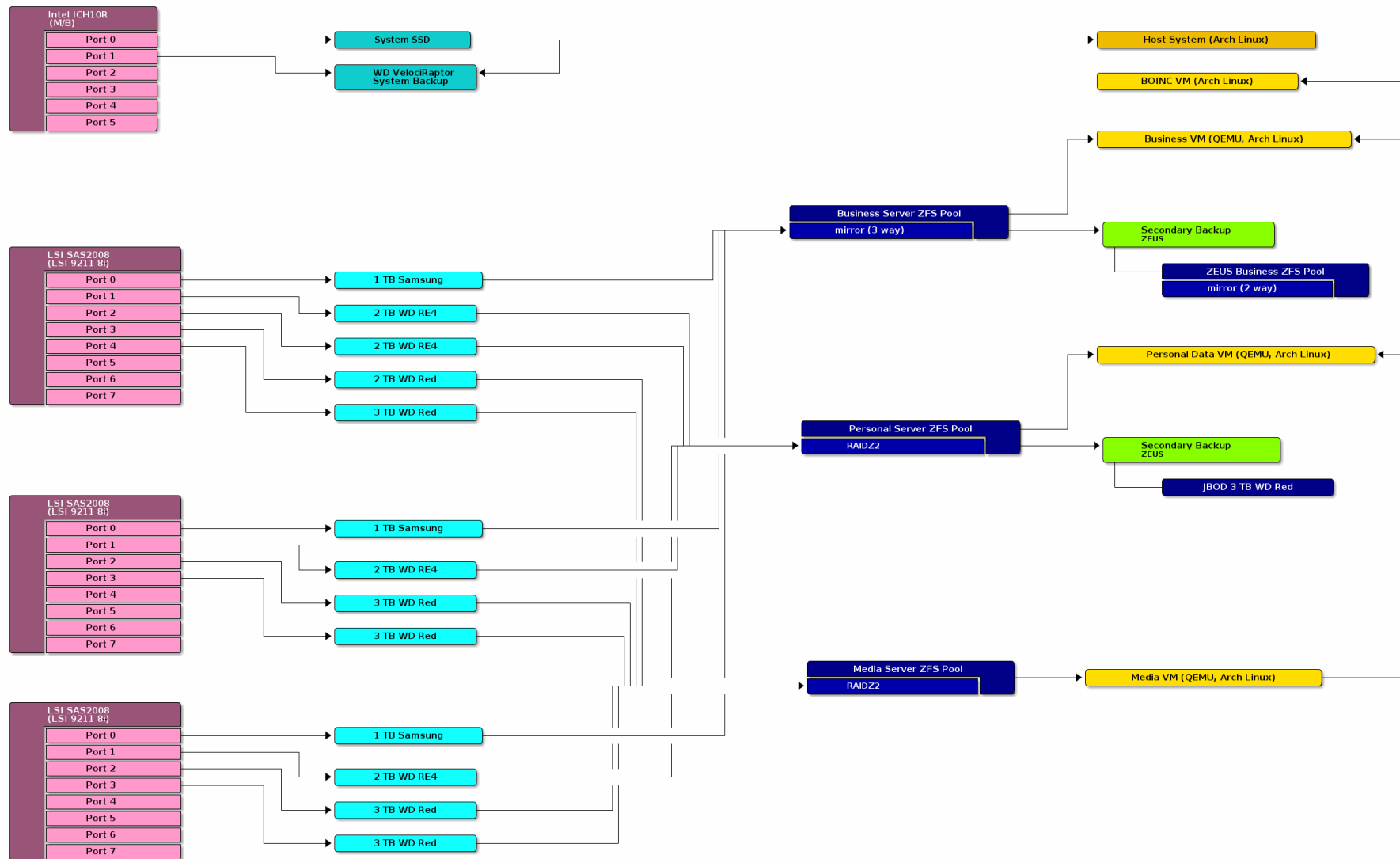
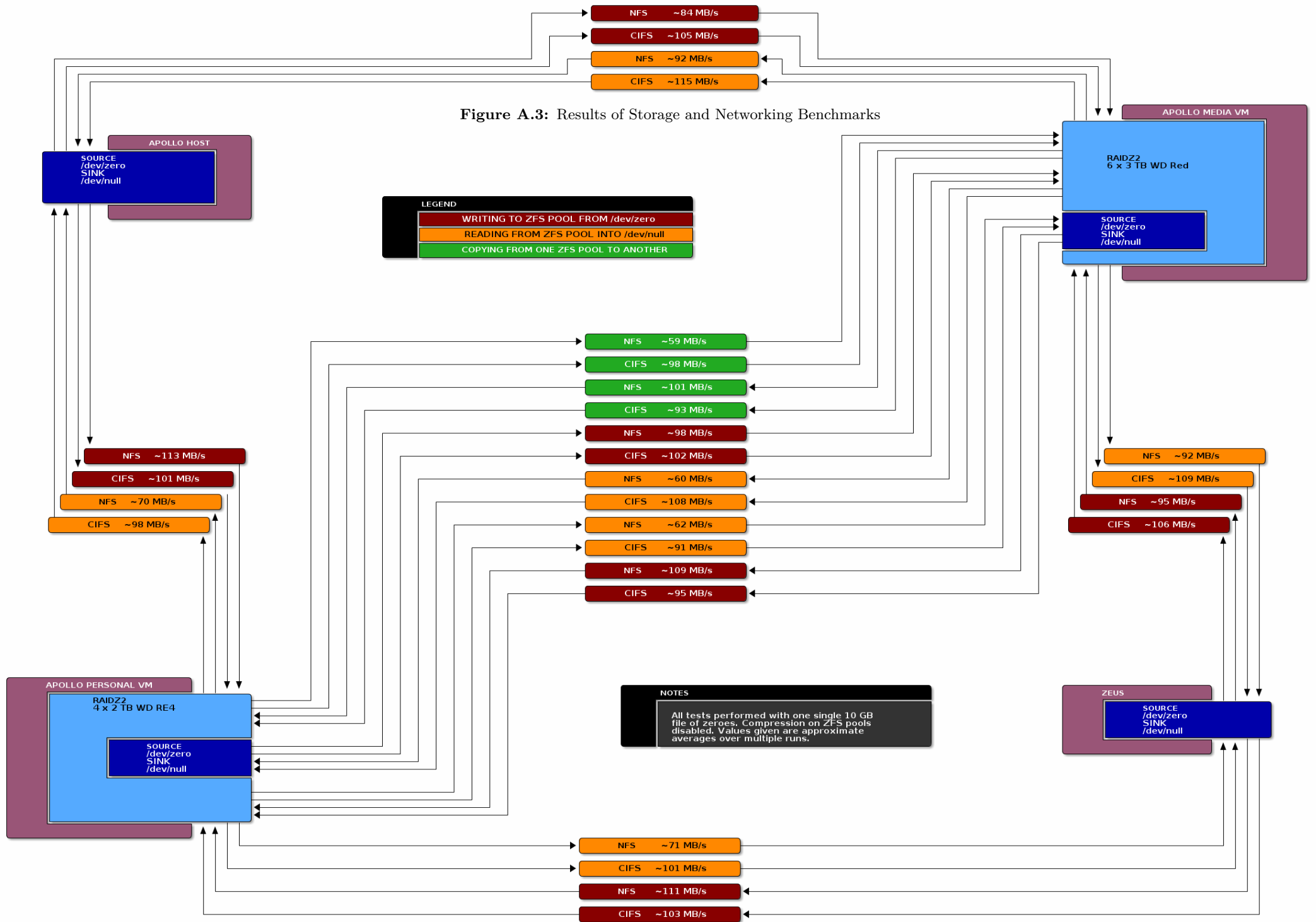


Figure A.2: Diagram of APOLLO's storage topology, revised version.



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