Practical DevOps Hardware for Small Teams

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Welcome!

- I'm June (She/Her)
- I make plugins for Unreal Engine
- I do a huge number of Unreal Engine builds across multiple products, platforms and configurations
- I have a lot of build hardware to sustain the amount of CI/CD being done on a day-to-day basis

What will be covered

- A scalable approach to on-premises build hardware
- Can't we just use the Cloud?
- Hardware / on-premises deep dive
  - Physical rack servers
  - 10Gbe networking, power
  - Network storage server
  - Build servers
  - Etc.

A scalable approach to on-premises build hardware

- Do it once, do it right, make it easy to scale as your team's needs grow later without changing build scripts etc.
- Parallelise across build jobs / multiple platforms / multiple merge/pull requests
- However, this does make the up front cost higher than a non-scalable solution
- Minimum $6000 budget = 1 build machine + 1 network storage server
- Also maybe not for super large organisations - 1000s of build machines are logistically difficult to manage in a physical sense

Can't we just use the cloud?

- No, cloud is much more expensive.
- We also want our build machines to have disk persistence so that builds can re-use previous intermediate build artifacts (incremental builds).
    - This prevents us from using spot instances to reduce costs, or forces us to put up with much longer build times.
- How does cloud compare to on-premise for one Windows build machine?

Buying your own hardware vs. Renting in the cloud

	Your own hardware	Google Cloud, N2
CPU type	Ryzen 9 5900X (2020)	Intel Ice Lake (2019)
CPU cores/threads	24	24
GiB memory	64	64
Disk size and type	2TB NVMe M.2	2TB Network Attached
Disk speed	3.5GB/s seq read	Max 1.2GB/s seq read
GPU	NVIDIA Quadro P620	None
$ Up front	$2,683.00 AUD	$ 0.00 AUD
$ Per month	$ 14.31 AUD (power usage)	$2,855.13 AUD

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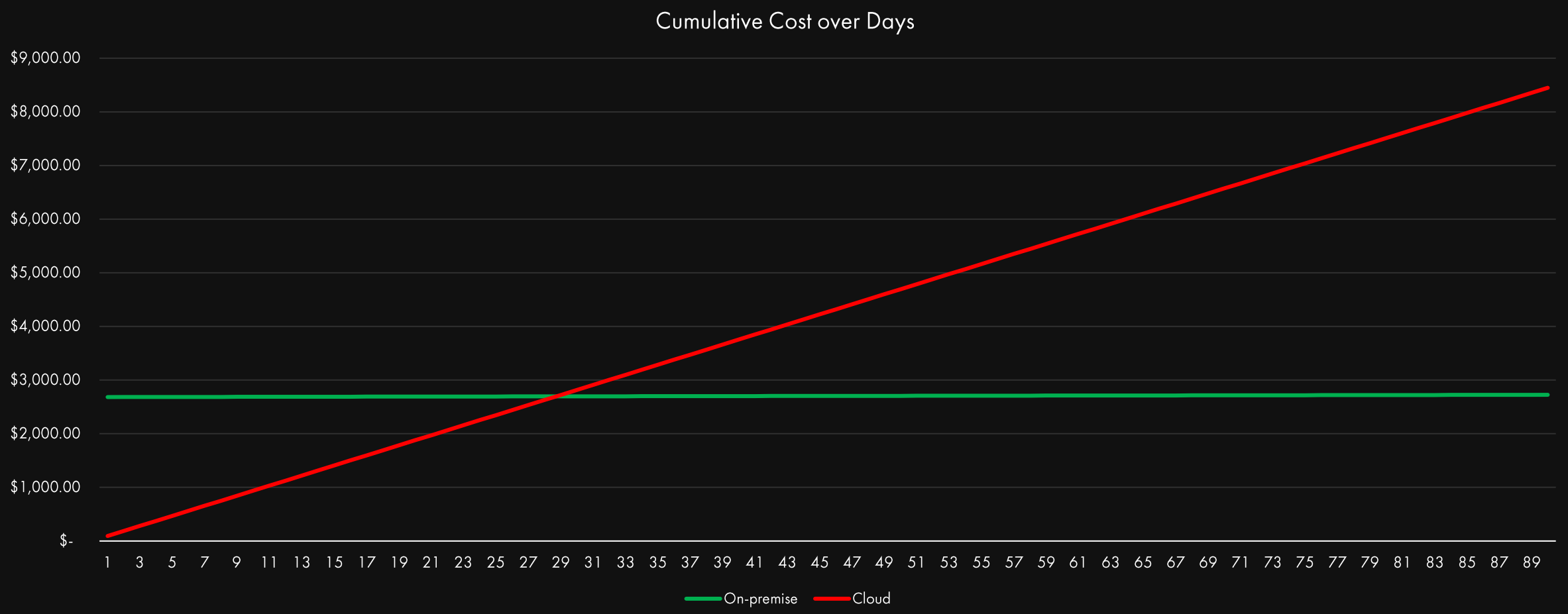
Buying your own hardware vs. Renting in the cloud



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On-premise hardware: What we need

- Server rack for physical storage
- 10Gbe networking
- Switched/metered power
- Disk storage - NAS
- Windows build machines
- macOS build machines

- Minimum/recommended setup costs tracked on bottom of screen
- Prices based on actual orders I've done

- Where are we getting things? *Mostly* Scorptec for new, eBay for second hand
- Scorptec: You can tell their sales team the specs you want and they'll build & deliver it

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Minimum	$0	Recommended	$0

Physical Server Rack

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Minimum	$0	Recommended	$0

Server rack for physical storage

- Physically rack mount all our hardware in one place
- Makes logistically organising/connecting everything much easier

- Measure physical dimensions
- Make sure you can get it through doors
- **Must be 1000mm deep!**
  600mm deep is not enough for servers

- Serveredge 37RU Fully Assembled,
  600w 1000d 1840h - $1,657

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Minimum	$1,657	Recommended	$1,657

Racking stuff up

- Mostly two types of different mounting:
  - Front mounted hardware such as network switches
  - Mounting rails for computers/servers

- For things that don't rack mount (e.g. macOS, dev kits), server rack comes with two trays which can be changed to any height

- Two people recommended for rack mounting things

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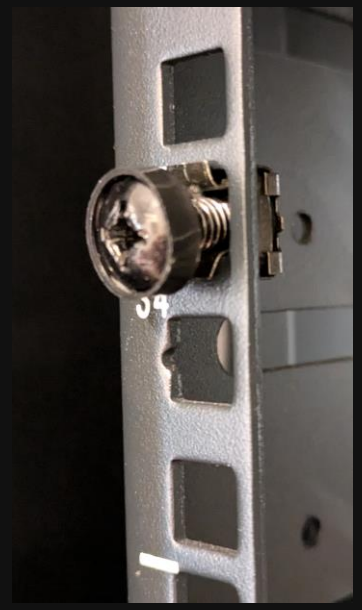
Minimum	$1,657	Recommended	$1,657

Front/rear rack mounted

- Network switches etc.



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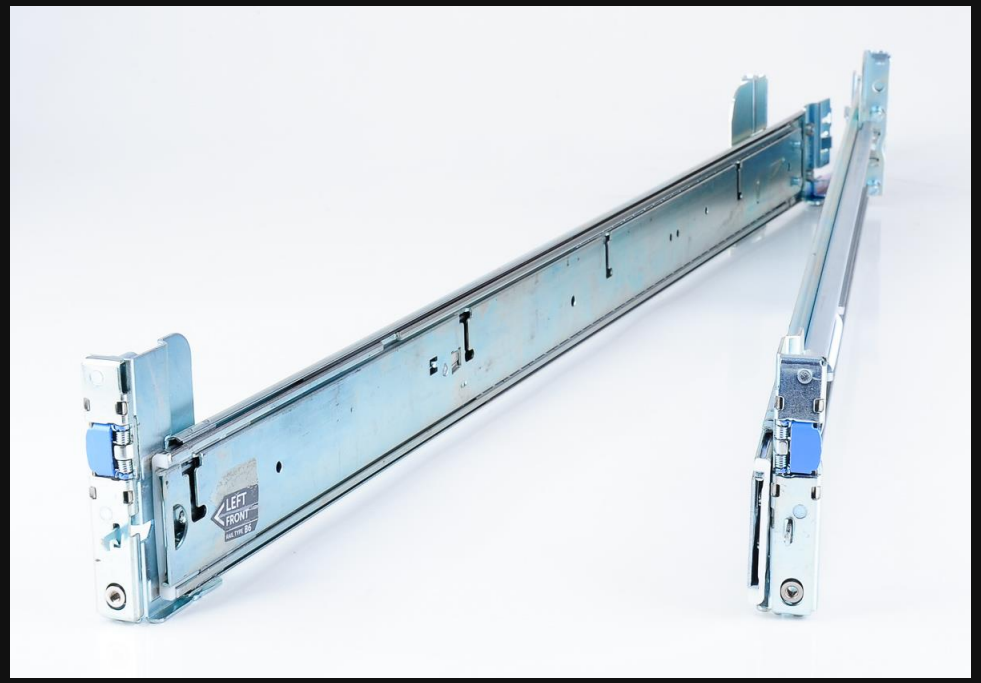
Rails for Dell enterprise servers

- Different types of rails - they are usually specific to the type of the machine you want to rack mount.

- Dell rails - extend out and then click into the rack mount holes - no screws needed.
  - Once rails are mounted, slide out inner rails.
  - Server will slot into those holes on the inner rails as it is lowered in.
  - Make sure all the points are slotted in, otherwise the server won't slide back into the rack.



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Minimum	$1,657	Recommended	$1,657

Rails for Dell enterprise servers

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Minimum	$1,657	Recommended	$1,657

Rails for Silverstone RM400

- Silverstone case - used for rack mounting our build machines
- Rails, come apart. Screw mount the outer rails into the rack.
- Screw the inner rails onto the side of the Silverstone case.
- Extend the outer rails out from the server rack, and slide the inner rails into them.
- Outer rails are very bendy so they can be hard to line up with one person.

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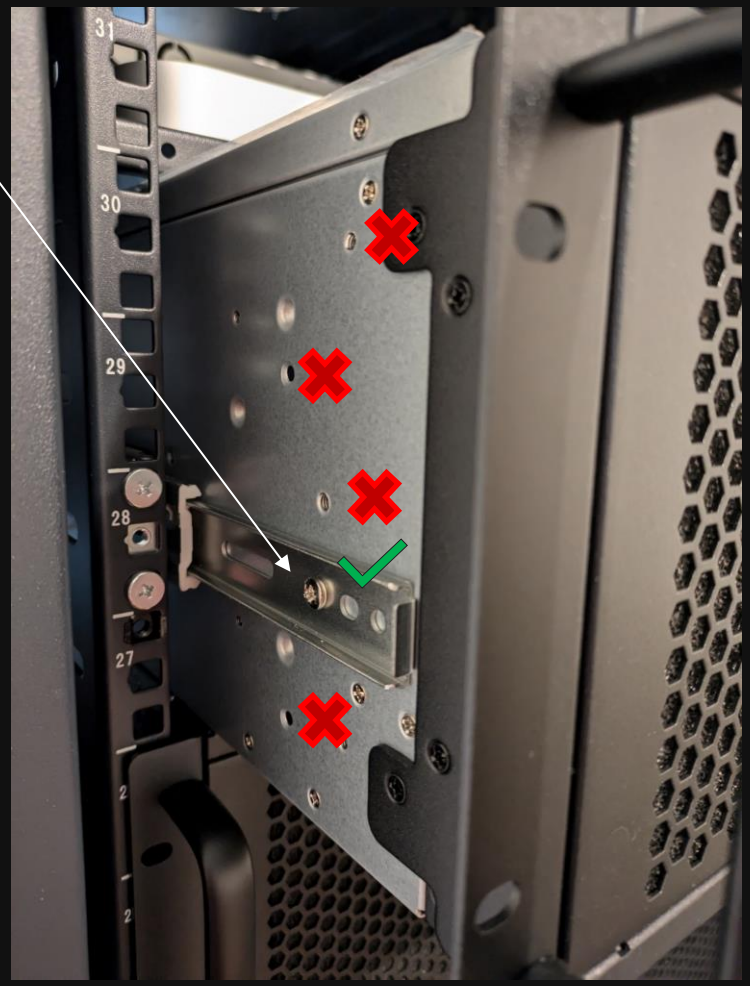
Minimum	$1,657	Recommended	$1,657

Rails for Silverstone RM400

Note which screw holes we've used on the side of the case for the inner rails!



Rails are positioned behind rack mount holes, and then screwed in.

(No need for the "clips" we had for network switches etc.)

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Minimum	$1,657	Recommended	$1,657

Air conditioning & cooling

- Note that you'll need air conditioning or some kind of cooling in the room that your servers are located in (at least during summer)
- Servers are also relatively loud - you'll want them in a separate room from where you're working
- Window mounted / portable air conditioners work just fine for small-medium scale.
- Avoid air conditioners that work by increasing humidity.

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10Gbe Networking

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Minimum	$1,657	Recommended	$1,657

10Gbe Networking

- Optional, but highly recommended if you have large builds/intermediate files/assets/etc
- 10x faster network transfer compared with normal Ethernet setups
- 1.25 GB/s instead of 125 MB/s, or "transfer 20 GB in 16 seconds instead of 2 minutes 40 seconds"

- RJ-45 or SFP+?
  - RJ-45: conventional ethernet port
  - SFP+: fiber optic

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Minimum	$1,657	Recommended	$1,657

10Gbe Networking

- RJ-45:
  - 10Gbe switch is more expensive
  - But cables and Ethernet cards for PCs are cheap
- SFP+
  - 10Gbe switch is much cheaper
  - But cabling and SFP connectors/cards are expensive

- RJ-45 switch is more expensive up front, but works out to be cheaper in the long run

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Minimum	$1,657	Recommended	$1,657

10Gbe Networking

RJ-45 Connections

- Ubiquiti Enterprise XG Managed 24 Port 10Gbe Switch
  - $2,299

- Per PC costs:
  - 10Gbe PCI-E card TP-Link TX401:
    - $129
  - 10Gbe Cat6A 2m cable:
    - $11

SFP+ Connections

- Ubiquiti Pro Aggregation 24 Port SFP+ Switch
  - $1,749

- Per PC costs:
  - 10Gbe PCI-E card TP-Link TX401:
    - $129
  - SFP+ -> RJ-45 Adapter:
    - $72
  - 10Gbe Cat6A 2m cable:
    - $11

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Minimum	$1,657	Recommended	$3,956

10Gbe Networking - macOS Machines

- Cannot upgrade Mac Mini networking later!
- If deferring 10Gbe networking, you'll still need to opt for 10Gbe Ethernet when buying Mac Minis (+ $150)

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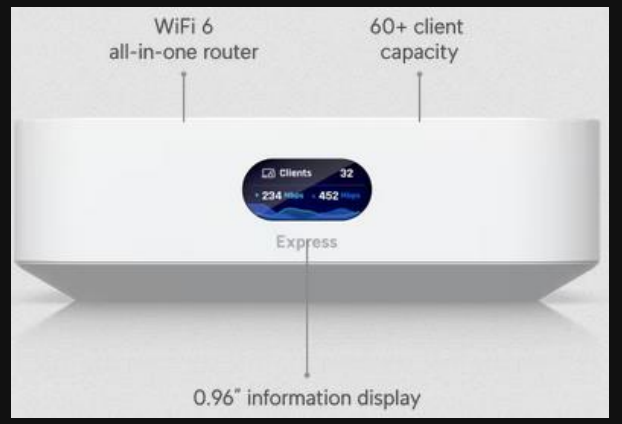
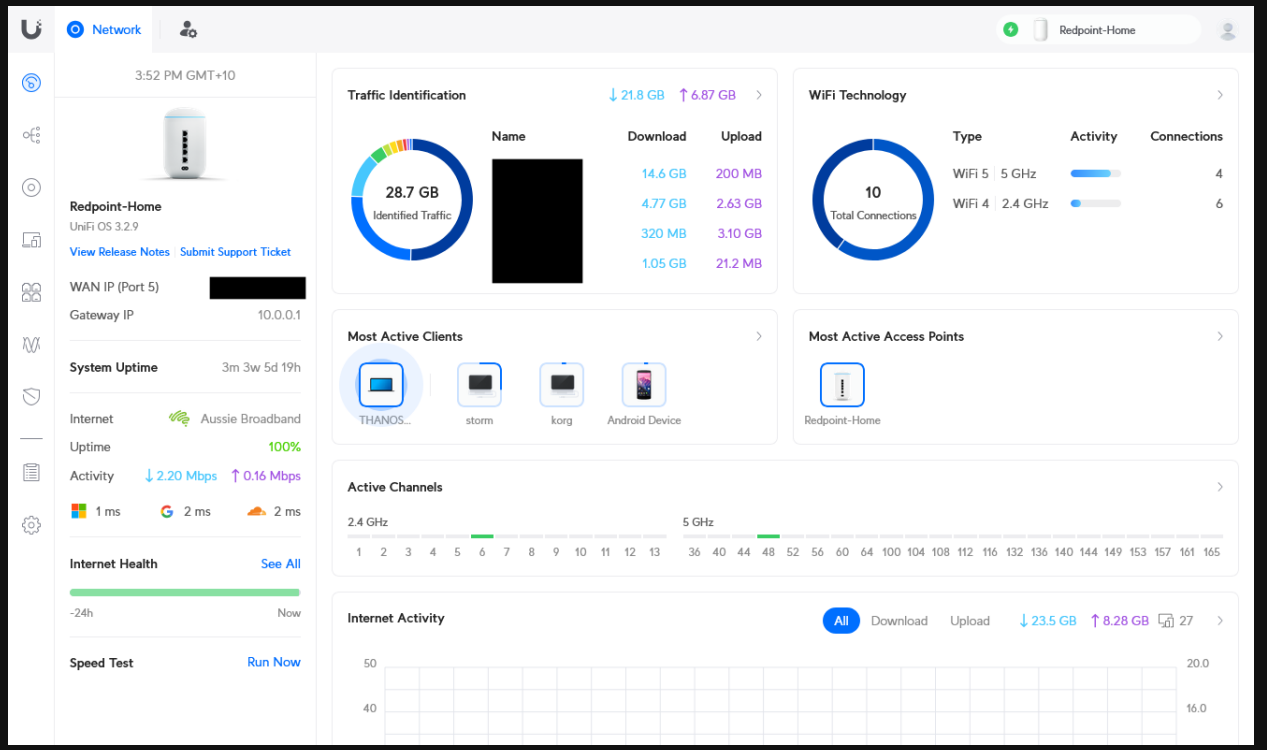
Minimum	$1,657	Recommended	$3,956

Internet Connectivity

- Dependent on your location / available Internet options
- UniFi Dream Machine* - WiFi + Internet Routing
- Works well with the 10Gbe UniFi Switch





* Seems to be replaced with UDM Pro or UniFi Express. Look for products under UniFi "Cloud Gateways" which run the UniFi OS for you.

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Switched Power

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Power distribution unit (PDU)

- Another one of those optional things that will make your life easier…

- Allows you to:
  - Remotely turn devices on/off
  - Measure how much power each device is using

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Power distribution unit (PDU)

You can start out with a cheaper option:

- CyberPower 8 Port Switched
  - *(not metered - remote on/off only)*
  - $669

- CyberPower 24 Port Switched Metered Power Distribution Unit
  - $1,499

Or forgo entirely when starting out.

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Minimum	$1,657	Recommended	$5,455

Power distribution unit: Tips & Tricks

Set PC BIOS to "turn on after power failure".
This will ensure that machines always turn on again when you power cycle them via the PDU.

PDU can also set schedules.
Turn off build machines overnight and save power.

Don't schedule macOS machines.
Their "turn on after power failure" isn't reliable in my experience, and their idle power usage is so low that fully turning them off doesn't save much.

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Minimum	$1,657	Recommended	$5,455

Network Storage Server

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Minimum	$1,657	Recommended	$5,455

Network Storage Server

- We need some kind of centralised data storage for sharing build artifacts between build machines.
- You can also use it for storing general data, like SDKs, etc.
- We'll need:
  - Lots of drive slots to scale/expand later
  - SSDs so they can keep up with network requests
- Consumer PC hardware can't handle the number of drives.

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Minimum	$1,657	Recommended	$5,455

Network Storage Server

Second hand hardware from eBay!
Surprisingly cheap and reliable.

Dell R720
16x 2.5" drive bays.

- Existing drives don’t matter. We'll be buying new drives regardless.
- CPU core count is not super important. We're not running builds on this machine.
- Memory, aim for at least 128GB. This will be used as disk I/O cache to improve performance.

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Minimum	$1,657	Recommended	$5,455

Network Storage Server

Might need to hunt for a bargain. Price + specs I found in 2023 were:

$660
256GB RAM
2x Intel Xeon E5-2670v2 CPU
16 drive slots

Might need to buy rackmount rails separately (depends on the listing).

Buying equivalent hardware new from Dell can easily be $8,000 - $10,000.

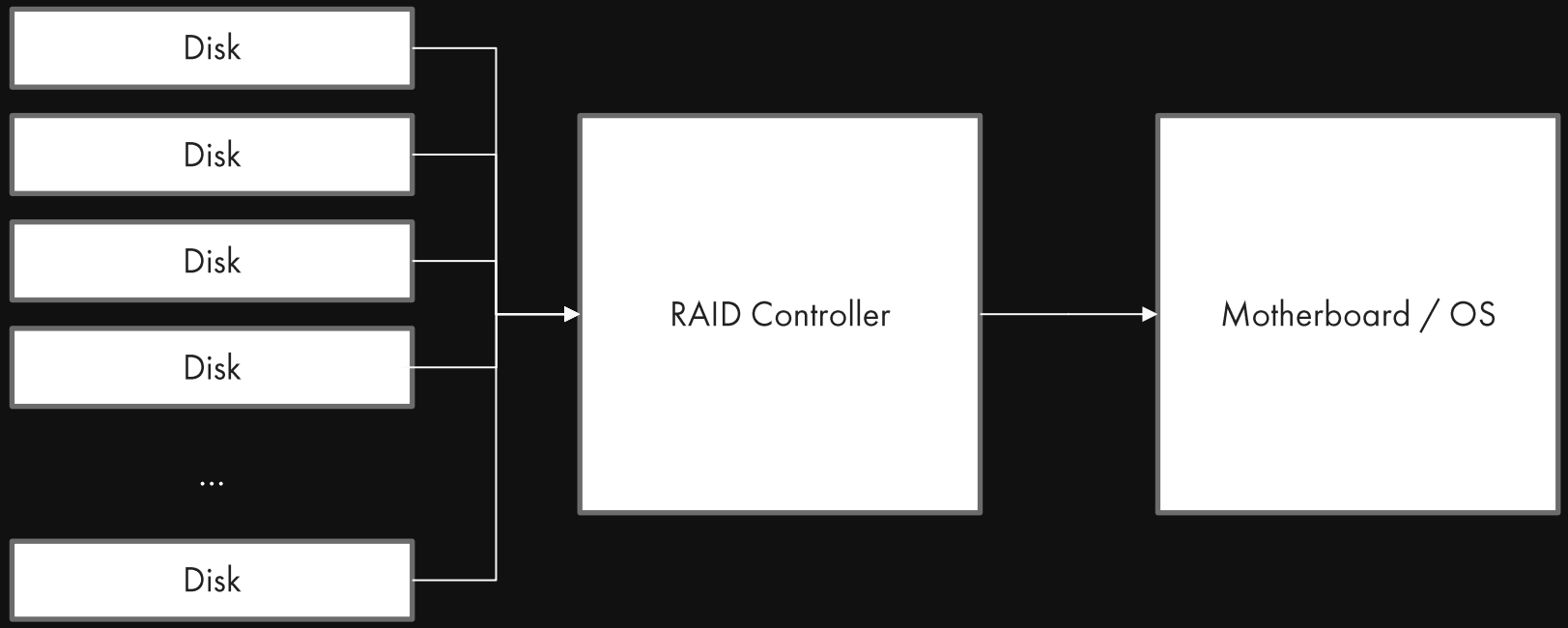
Network Storage Server - How RAID Controllers Work

We have lots of disks.

Enterprise hardware provides hardware RAID controllers (branded as PERC for Dell).

Minimum	$2,317	Recommended	$6,115

Network Storage Server - How RAID Controllers Work



Problem: Hardware RAID controllers can get in between the disks and OS, and prevent the OS from seeing individual disks.

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Minimum	$2,317	Recommended	$6,115

Network Storage Server - How RAID Controllers Work

We need the RAID controller to support "passthrough" mode. **Not all Dell hardware RAID controllers support this (especially older versions), and will try to force you to make a hardware RAID out of drives.**

When purchasing, pay attention to the hardware PERC RAID controller, and find the reference manual to see what it supports.

If not specified, contact the seller.

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Minimum	$2,317	Recommended	$6,115

What if the RAID controller doesn't support passthrough?

For some PERC controllers, we can flash them with different firmware to get support for it.

So even if Dell wouldn't normally let you do "passthrough" mode, we can swap out the firmware.

Guide: https://fohdeesha.com/docs/perc.html

Avoid this if you can though.

Picking the wrong firmware or doing the steps wrong can brick the RAID hardware permanently, and you won't be able to use your server.
It also requires physically disconnecting the RAID battery backup on the motherboard.

Network Storage Server - Disks

2x 1TB Samsung 870 EVO SSDs for Operating System (mirror, RAID 1)

2x $129 = $258

7x 4TB Samsung 870 EVO SSDs for Data Storage (ZFS RAID w/ 2 drive redundancy)

7x $399* = $2,793

20TB SSD Storage!

You might want to start out with smaller array/disk size to reduce costs.

If so, server will have enough free disk slots to migrate data to a bigger array later.

* This specific model seems to have gone up in price from $399 to $699 in 12 months. There are other 4TB SSDs on Scorptec for $359.

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Minimum	$3,373	Recommended	$9,166

Network Storage Server - Operating System

TrueNAS Scale
Free, very good NAS software

https://www.truenas.com/download-truenas-scale/

Fully manages storage, with support for:

- Setting up Windows network shares (you'll probably need this)
- Backup / replication off site
- Data redundancy
- Etc.

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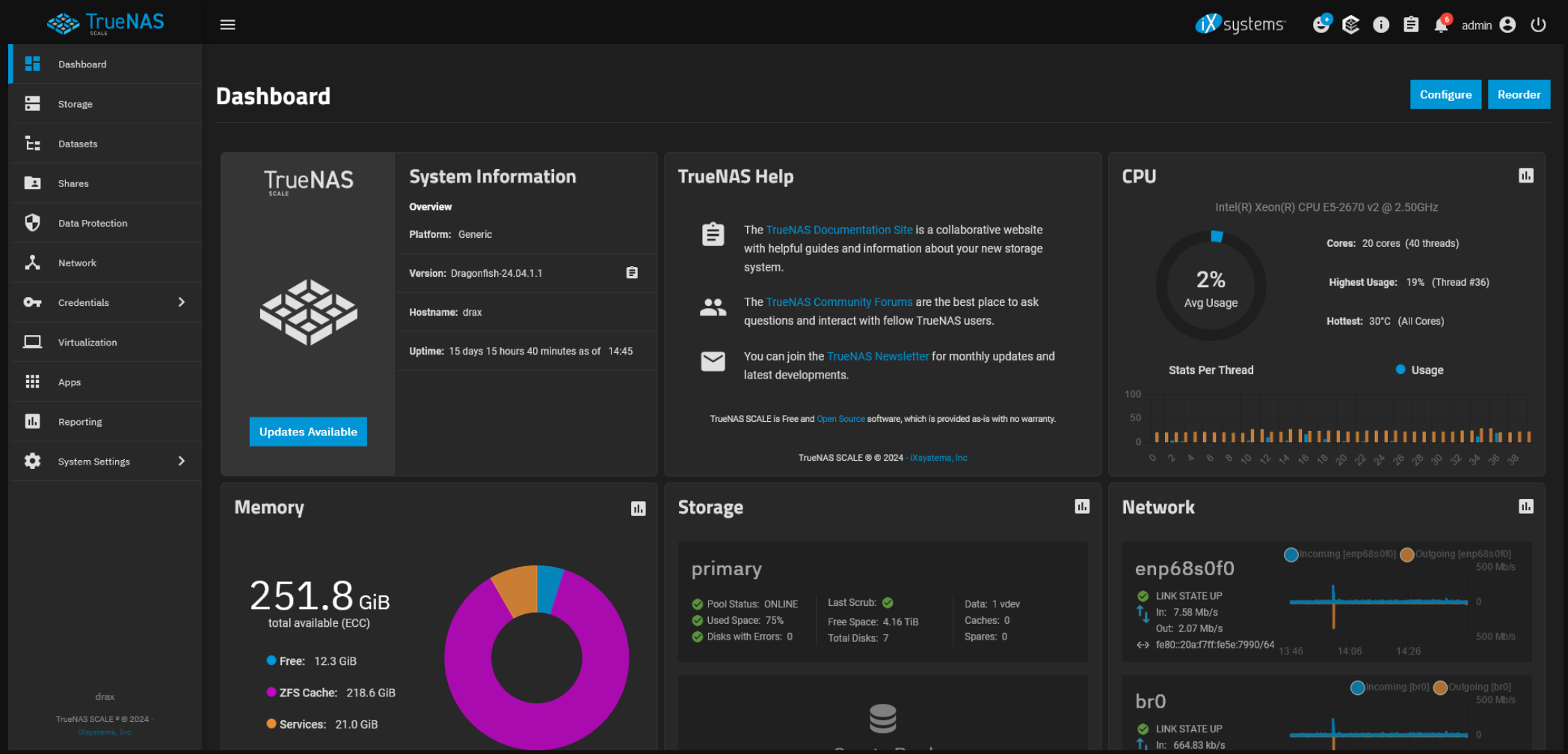
Network Storage Server - OS - Overview



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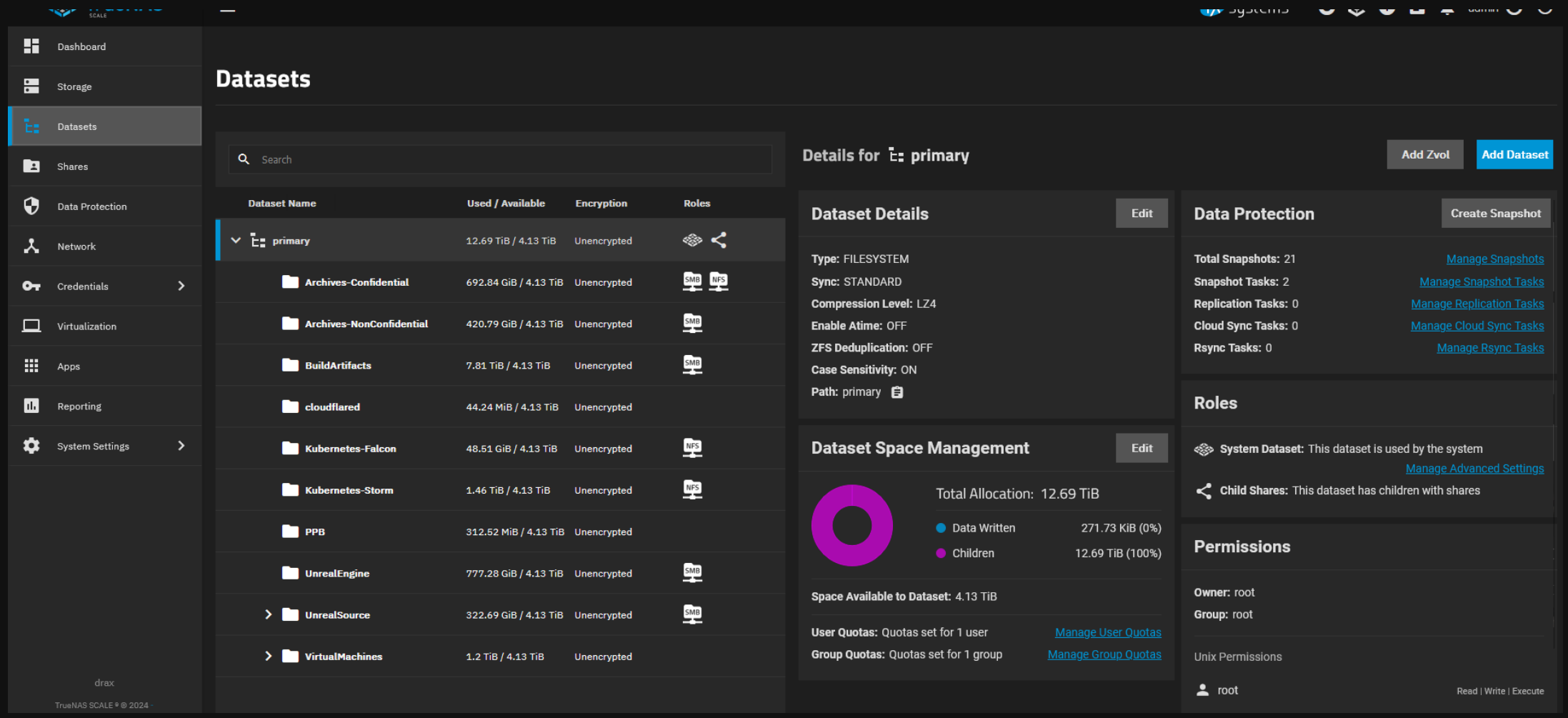
Network Storage Server - OS - Datasets



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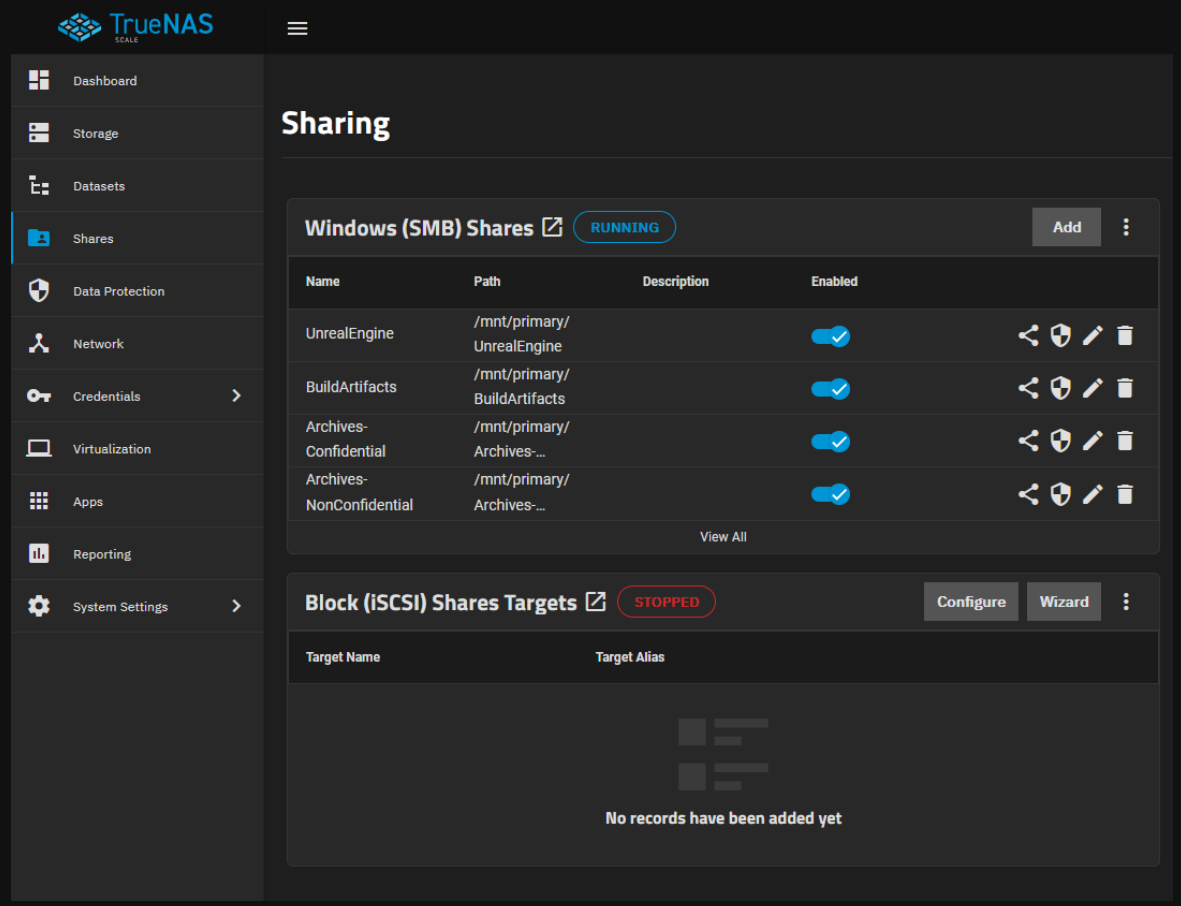
Network Storage Server - OS - Network Shares



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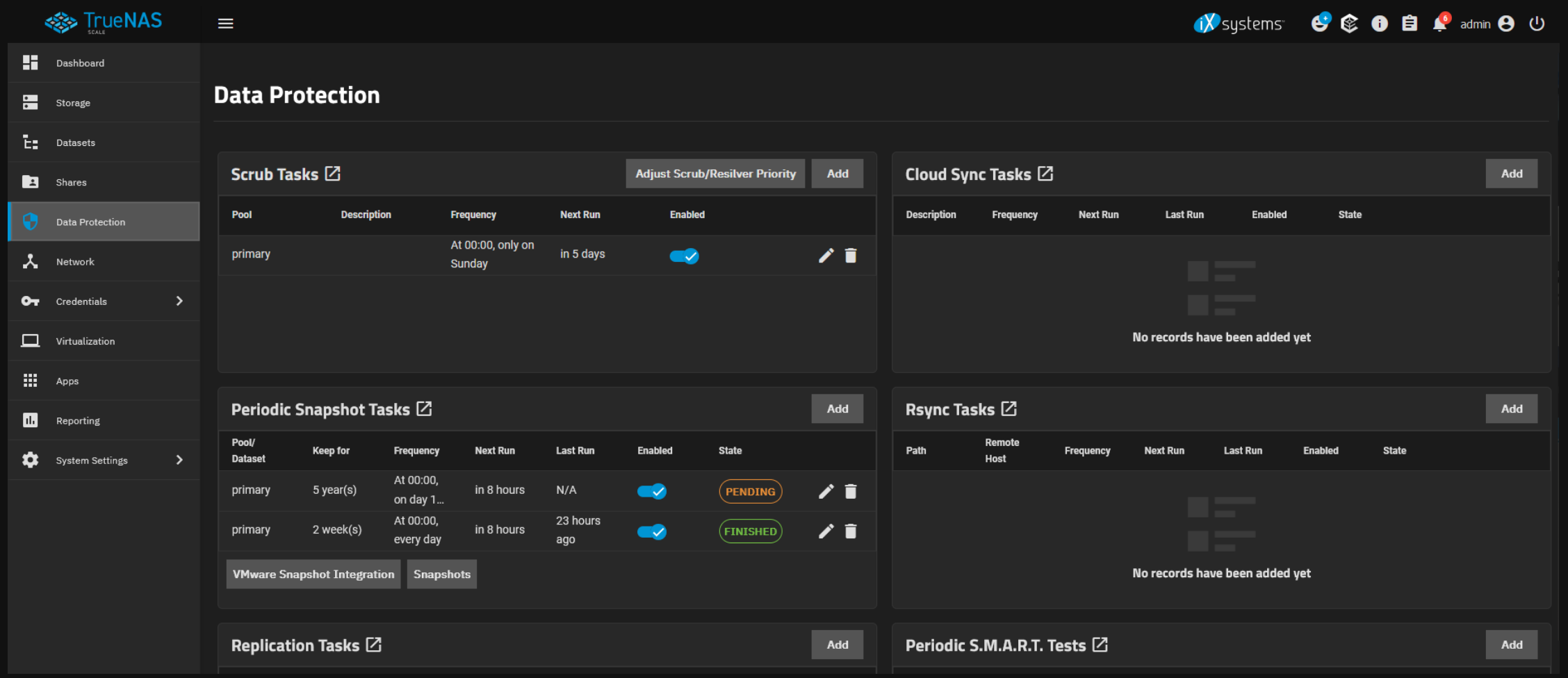
Network Storage Server - OS - Backups / DR



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Build Machines

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Minimum	$3,373	Recommended	$9,166

Windows build machines

Specs will depend on your workload

For Unreal Engine, I find these are optimal:

- 12 core, 24 thread AMD Ryzen
- 64GB RAM
- 2TB NVMe
- (+ 10Gbe PCI-E network card if doing 10Gbe network)

64 core Threadripper: $134 per core
12 core Ryzen 9: $41 per core

Cheaper to horizontally scale number of machines than have big machines with lots of cores!

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Minimum	$3,373	Recommended	$9,166

Windows build machines

For 12-core spec'd machines on previous slide:

$2,495 PC including rackmount case (RM400)

+ $129 10Gbe card

+ $79 rackmount rails

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Minimum	$5,947	Recommended	$11,869

macOS Build Machines

I use Mac Minis for Unreal builds.

Horizontal scaling (buying multiple Macs) is really the only option to get lots of macOS "cores".

$2,049 Mac Mini (16GB RAM, 1TB SSD, 10Gbe Ethernet)

+ $299 4TB NVMe

+ $149 NVMe PCIe USB4 Enclosure
(for extra storage - cheaper than paying for a bigger built-in SSD on Mac)

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Minimum	$5,947	Recommended	$11,869

Summary

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Minimum	$5,947	Recommended	$11,869

Setup Price/Infrastructure Comparison

Minimal Setup

- Physical rack server + $1,657

- Network server (2x4TB) + $1,716
- Windows build machine + $2,574

- Total $5,947

Recommended Setup

- Physical rack server + $1,657
- 10Gbe switch + $2,299
- Switched power + $1,499
- Network server (7x4TB) + $3,711
- Windows build machine + $2,703

- Total $11,869

Optional:

- macOS build machine + $2,497

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Questions?

Important Links

- Slides: junerhodes.au/history
- Scorptec: www.scorptec.com.au
- PERC Flash Guide: fohdeesha.com/docs/perc.html
- TrueNAS: www.truenas.com/download-truenas-scale
- UniFi Hardware: ("Cloud Gateways") store.ui.com/us/en/category/all-unifi-cloud-gateways/products/ux

Social

- Mastodon: https://mastodon.social/@hq

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