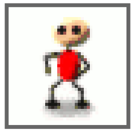
FreeBSD Enterprise Storage

Sławomir Wojciech Wojtczak



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The **`wikipedia.org/wiki/enterprise`** is just meta page with links.

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- Generally offers **higher reliability/availability/scalability**.

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- UFS (with SU/SUJ) requires traditional `fsck(8)` in background to make it clean.

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- Netflix uses UFS in 2020 for their content storage on FreeBSD.

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- Scalable design and **dynamic striping**.

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  - ZFS allows **bulletproof upgrades** with **ZFS Boot Environments** - **`https://is.gd/BECTL`** - more here.

GEOM Idea

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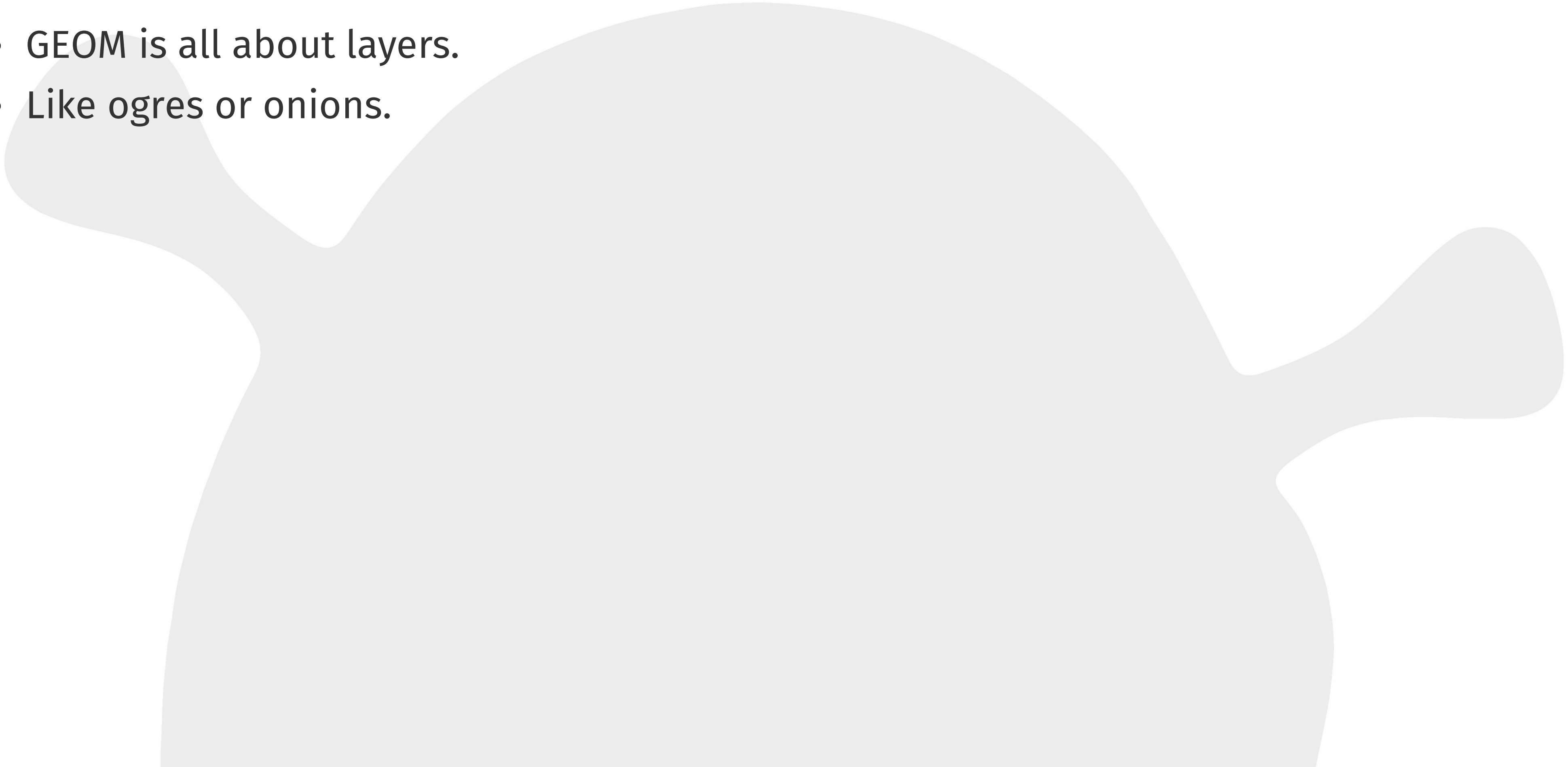

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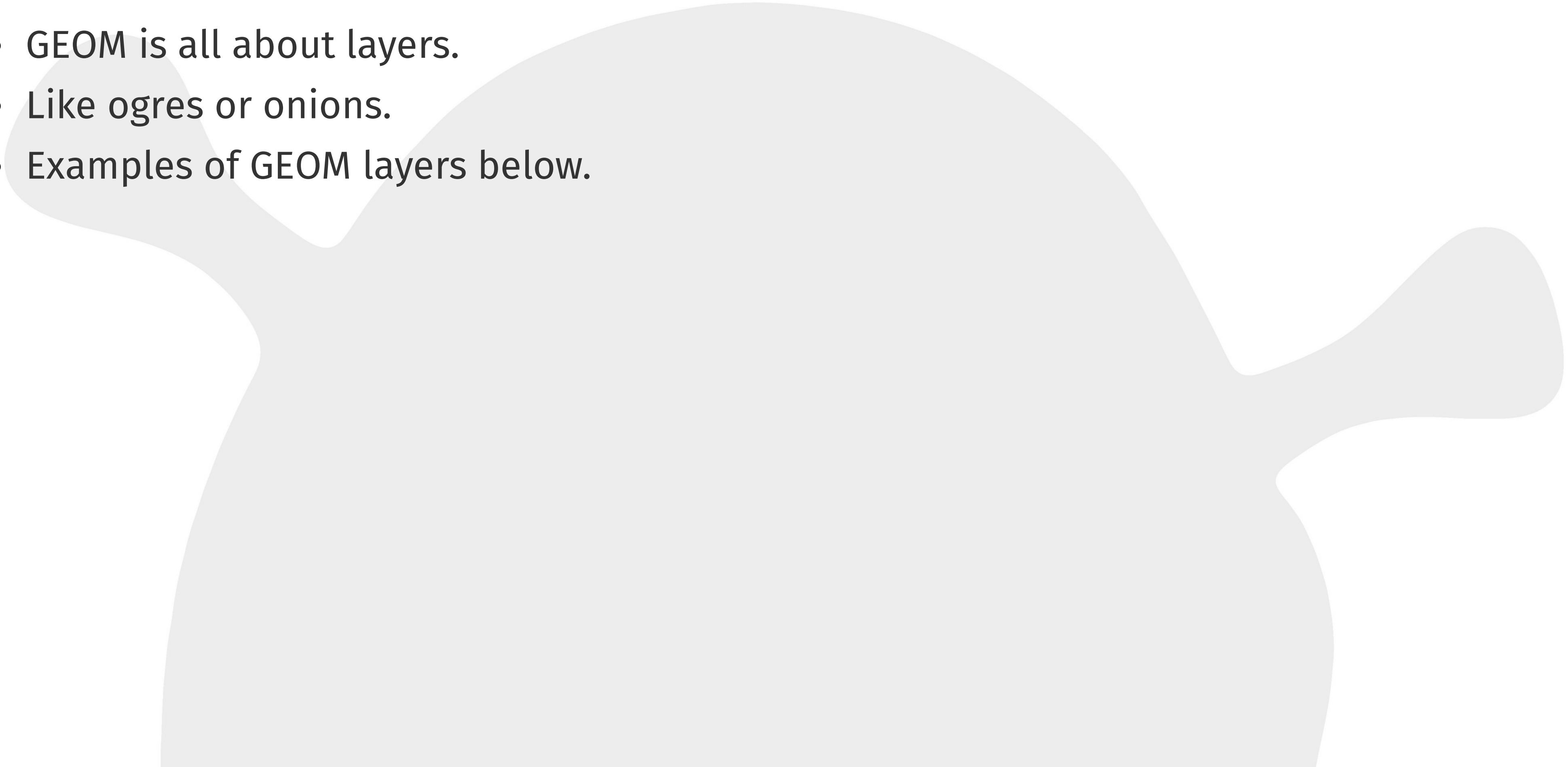

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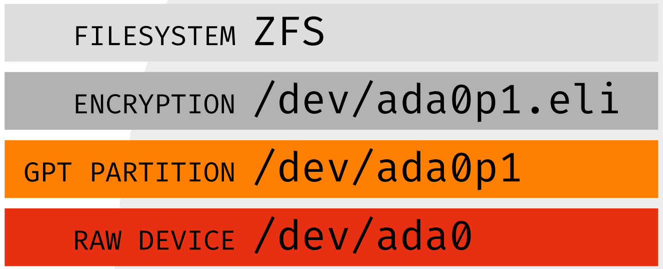

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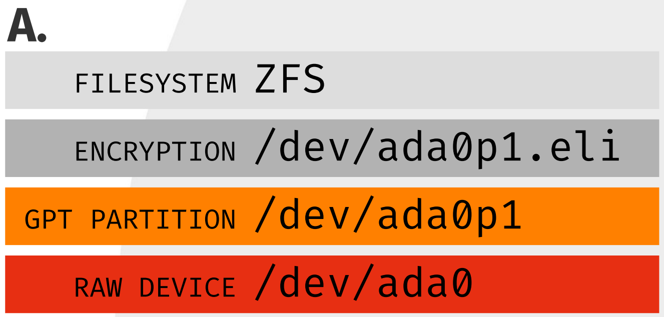
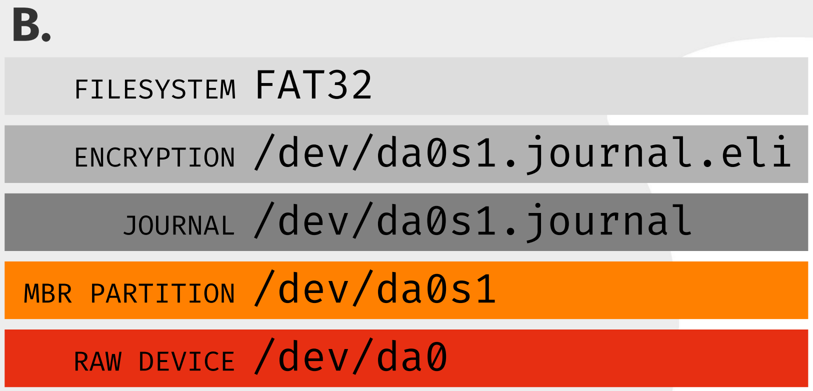
- **A.** ZFS on GELI (encryption) on GPT (p1) partition.
- **B.** FAT32 on GELI on GJOURNAL (journaling) on MBR (s1) partition/slice.





GEOM Classes/Providers (1/2)

• **CACHE**	`/sbin/gcache`	Optional read cache for GEOM RAID3 **`graid3(8)`** class.
• **CONCAT**	`/sbin/gconcat`	Concat multiple devices into one virtual device.
• **DBE**	`/sbin/gbde`	GEOM based disk encryption (older).
• **ELI**	`/sbin/geli`	Block device disk encryption (modern).
• **GATE**	`/sbin/ggate*`	Export block device over network (like NFS for block).
• **JOURNAL**	`/sbin/gjournal`	Generic block device level journal provider.
• **LABEL**	`/sbin/glabel`	Manual and automatic labelization provider.
• **MIRROR**	`/sbin/gmirror`	Mirror (RAID1) provider.
• **MOUNTVER**	`/sbin/gmountver`	Queues I/O requests and waits for provider.
• **MULTIPATH**	`/sbin/gmultipath`	Device multipath configuration provider.

GEOM Classes/Providers (2/2)

• **NOP**	`/sbin/gnop`	Provider to example emulate different blocksize.
• **PART**	`/sbin/gpart`	Partition (BSD/MBR/GPT/...) GEOM device providers.
• **RAID**	`/sbin/graid`	Software RAID management (Intel/JMicron/SiI/Promise/...).
• **RAID3**	`/sbin/graid3`	RAID3 provider.
• **RAID5**	`sysutils/graid5`	RAID5 provider (available from FreeBSD Ports).
• **SCHED**	`/sbin/gsched`	Change scheduling policy of requests going to provider.
• **SHSEC**	`/sbin/gshsec`	Setup shared secret between given providers.
• **STRIPE**	`/sbin/gstripe`	Stripe (RAID0) provider (RAID10 with **`gmirror(8)`** provider).
• **VIRSTOR**	`/sbin/gvirstor`	Like *Virtual Memory* allows overcommit for block devices.
• **VINUM**	`/sbin/gvinum`	RAID 0/1/10/5 provider (older VxVM style volume manager).

GEOM Examples (1/2)

```
# geom disk list // 12 TB Toshiba 7200RPM

Geom name: da0
Providers:
1. Name: da0
   Mediasize: 12000138625024 (11T)
   Sectorsize: 512
   Stripesize: 4096
   Stripeoffset: 0
   Mode: r1w1e2
   descr: ATA TOSHIBA MG07ACA1
   lunid: 50000398e8c9d3d5
   ident: 98G0A10CF95G
   rotationrate: 7200
   fwsectors: 63
   fwheads: 255
```

```
# geom disk list // 4 TB Samsung SSD

Geom name: ada0
Providers:
1. Name: ada0
   Mediasize: 4000787030016 (3.6T)
   Sectorsize: 512
   Mode: r1w1e2
   descr: Samsung SSD 860 QVO 4TB
   lunid: 5002538e40f16748
   ident: S4CXNF0M404495P
   rotationrate: 0
   fwsectors: 63
   fwheads: 16
```

GEOM Examples (2/2)

```
# gpart show da0
⇒          40  23437770672  da90  GPT  (11T)
           40  23435673600     1  freebsd-zfs  (11T)
  23435673640      2097072        - free -  (1.0G)
```

```
# gpart show ada0
⇒         40  1953525088  ada1  GPT  (932G)
          40      409600     1  efi  (200M)
      409640        1024     2  freebsd-boot  (512K)
      410664         984        - free -  (492K)
      411648  1953112064     3  freebsd-zfs  (931G)
  1953523712        1416        - free -  (708K)
```

```
# geli status
      Name  Status  Components
ada1p3.eli  ACTIVE  ada1p3
ada0p1.eli  ACTIVE  ada0p1
 da0p1.eli  ACTIVE  da0p1
```

```
# glabel status
        Name  Status  Components
gpt/efiboot0     N/A  ada1p1
gpt/gptboot0     N/A  ada1p2
```

Internal Solutions - Summary

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UFS

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UFS

ZFS

Internal Solutions - Summary

UFS

ZFS

FreeBSD Ecosystem

GEOM/FUSE/HAST/CARP/UFS/ZFS/...

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- **Minio** - Amazon S3 compatible distributed object storage server.
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- **Ganesha** - NFS file server that runs in userspace mode.
  - **https://nfs-ganesha.github.io/** - FreeBSD Ports - `net/nfs-ganesha` + `net/nfs-ganesha-kmod`

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- **Samba** - free SMB/CIFS and AD/DC server and client.
  - **https://samba.org/** - FreeBSD Ports - `net/samba410`

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- **FreeBSD Services Control** - monitoring and automatic restarting for services.
  - **https://github.com/bsdtrhodes/freebsd-fscd/** - FreeBSD Ports - `sysutils/fsc`

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  - **https://github.com/bsdtrhodes/freebsd-fscd/** - FreeBSD Ports - `sysutils/fsc`
- **Daemontools** - utilities for controlling and automatic restarting of processes.
  - **http://cr.yp.to/daemontools.html** - FreeBSD Ports - `sysutils/daemontools`

External Solutions - Listing

The **sysutils/lsblk** port provides similar to Linux block storage list tool on FreeBSD.

```
# lsblk
DEVICE          MAJ:MIN SIZE TYPE                                        LABEL MOUNT
da0               0:79  3.6T GPT                                             - -
  da0p1           0:92  3.6T dragonfly-hammer                                - -
  da0p1.eli       2:160 3.6T zfs                                             - -
ada1              0:99  932G GPT                                             - -
  ada1p1          0:101 200M efi                                  gpt/efiboot0 -
  ada1p2          0:102 512K freebsd-boot                         gpt/gptboot0 -
  <FREE>          -:-   492K -                                               - -
  ada1p3          0:103 931G freebsd-zfs                              gpt/zfs0 <ZFS>
  ada1p3.eli      0:106 931G zfs                                             - -
  <FREE>          -:-   708K -                                               - -
```

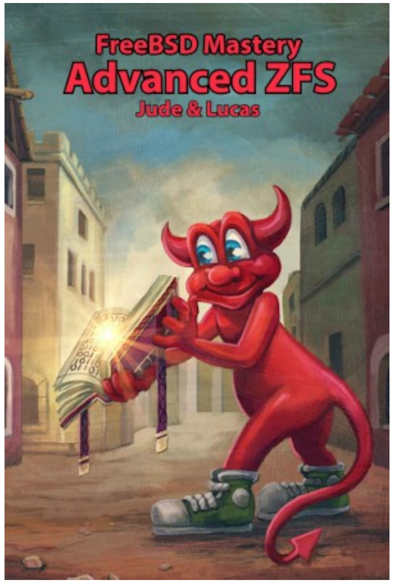
Commercial FreeBSD Storage Appliances

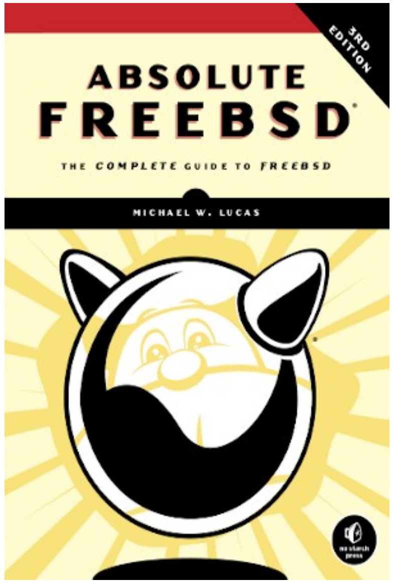
- **Spectra Verde Array** - https://spectralogic.com/
- **SGI ArcFiniti MAID Disk Arrays** - https://sgi.com/
- **QNAP Enterprise Storage (QES)** - https://qnap.com/qes/
- **Panasas ActiveStor Solutions** - https://panasas.com/
- **Netflix Open Connect Appliance** - https://netflix.com/
- **NetApp ONTAP Storage** - https://netapp.com/
- **Dell EMC Isilon OneFS Clustered Scale-Out Storage** - https://dellemc.com/
- **Dell Compellent Enterprise Storage** - https://dellemc.com/
- **Great Lakes SAN** - https://glsan.com/homeport/
- **RawDR** - https://rawdr.org/
- **iXsystems TrueNAS** - https://ixsystems.com/

Free/Open FreeBSD Storage Appliances

- **iXsystems FreeNAS** - https://freenas.org/
- **XigmaNAS** (NAS4Free) - https://xigmanas.com/
- **ZFSguru** - http://zfsguru.com/

Books on FreeBSD Storage





All written by **Michael W. Lucas** accompanied by **Allan Jude** for ZFS filesystem.

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  - More Here: **KDE Almost Lost All of Their Git Repositories - Phoronix**
    `https://www.phoronix.com/scan.php?page=news_item&px=MTMzNTc`

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- ZFS almost *"first class citizen"* in **Ubuntu** but **ZFS Boot Enviroments still not available**.

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  - Not possible with RHEL7 or RHEL6 versions of Red Hat Enterprise Linux.

Example Implementation of FreeBSD Storage

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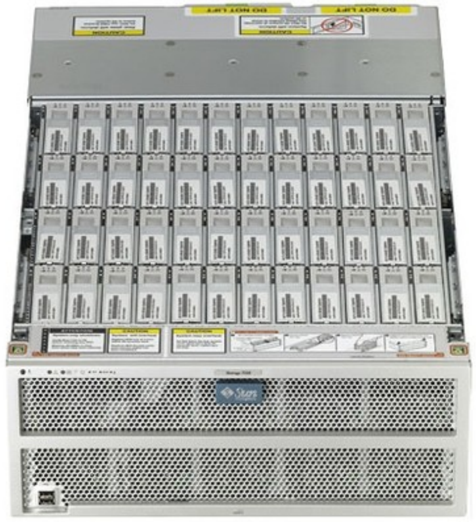

Example Implementation of FreeBSD Storage

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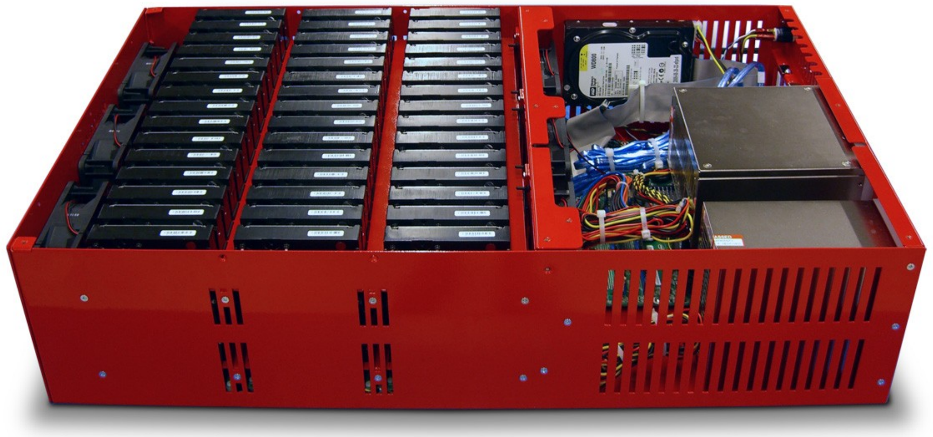
  - **Backblaze Storage Pod**
    - `https://www.backblaze.com/b2/storage-pod.html`



Idea Taken to the Extreme

Thunder SX FA100-B7118 (100 Bays)

Supermicro 6048R-E1CR90L (90 Bays)

Zstor GS41100 (100 Bays)

Inspur NF5486M5 (104 Bays)

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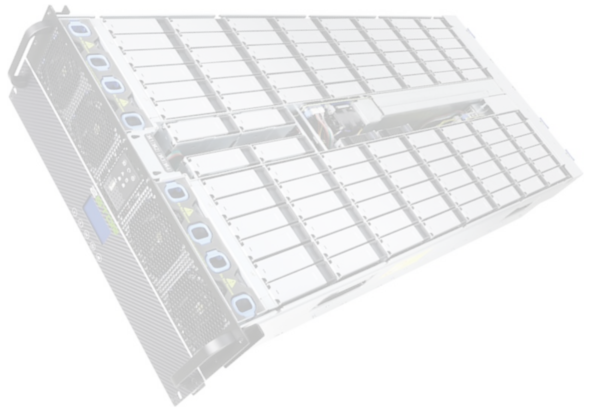

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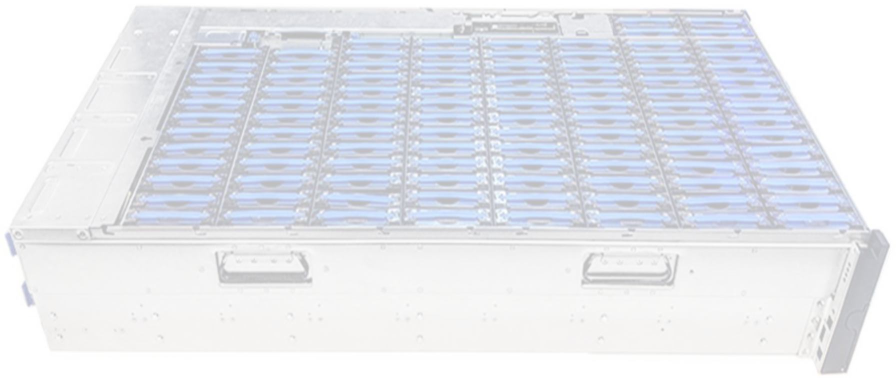
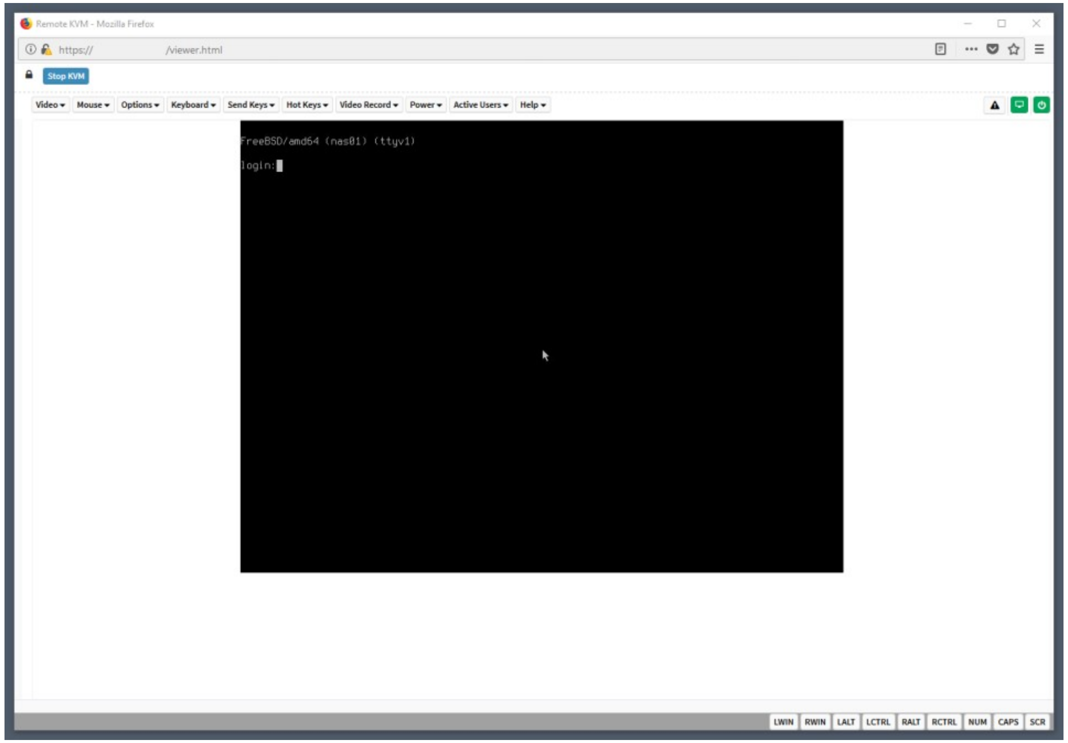


Idea Taken to the Extreme

Thunder SX FA100-B7118 (Management)

- Provides HTML5 based plugin free **Remote Control**.



```
FreeBSD/amd64 (nas01) (ttyv1)

login:
```

Idea Taken to the Extreme

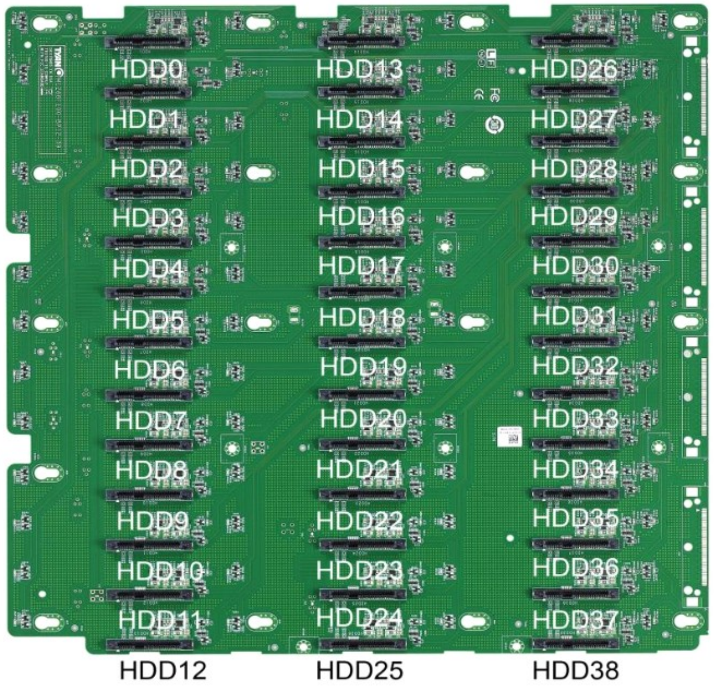
Thunder SX FA100-B7118 (Hardware)

- 2 x 10-Core Intel Xeon Silver 4114 CPU @ 2.20GHz (**20 Cores Total**)
- 4 x 32 GB RAM DDR4 (**128 GB Total**)
- 2 x Intel SSD DC S3500 240 GB (**System**)
- 90 x Toshiba HDD MN07ACA12TE 12 TB (**Data**)
- 2 x Broadcom SAS3008 Controller
- 2 x Intel X710 DA-2 10GE Card (**4 x 10GE Total**)
- 2 x Power Supply
- 8 x Free Disks Slots

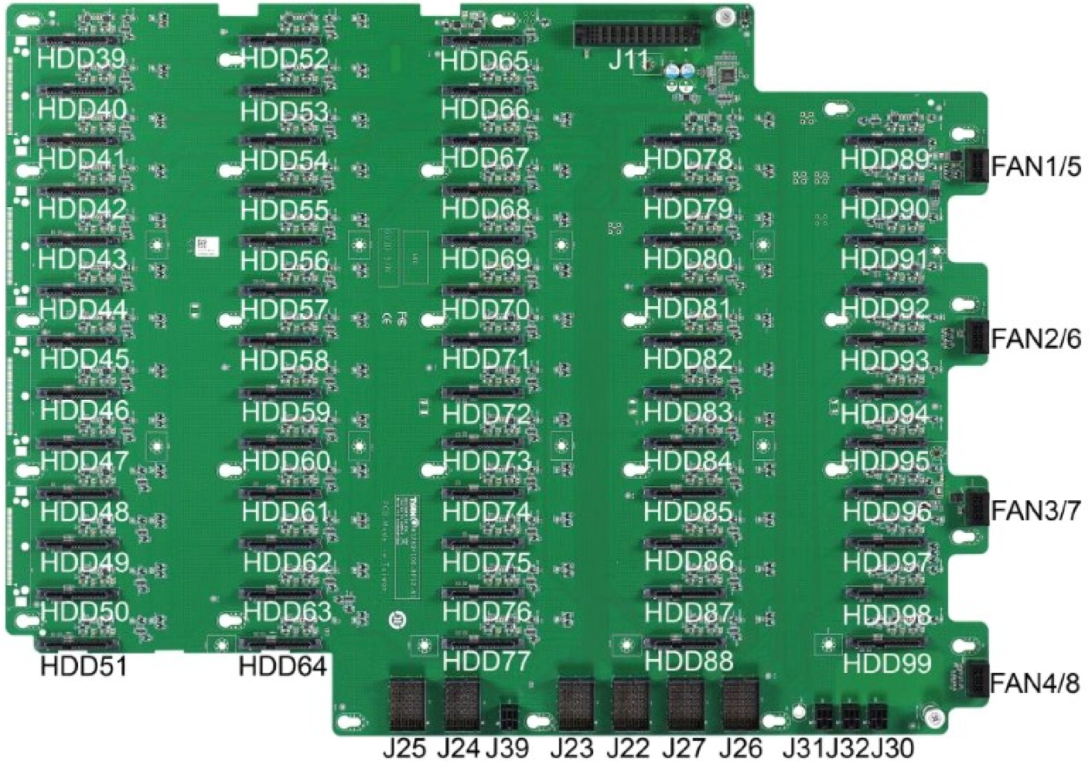
Idea Taken to the Extreme

Thunder SX FA100-B7118 (Disks Split Between Controllers)

M1288F100-BP12-39 (39 Disks)



M1289F100-BP12-61 (61 Disks)



Idea Taken to the Extreme

Thunder SX FA100-B7118 (ZFS Configuration)

- ZFS Pool - System - **RAID1** (ZFS Mirror) - **One SSD Disk Per Controller**

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Thunder SX FA100-B7118 (ZFS Configuration)

- ZFS Pool - System - **RAID1** (ZFS Mirror) - **One SSD Disk Per Controller**
- ZFS Pool - Data - **RAID60** (ZFS Striped RAIDZ2) - **36:48 Data Ratio** - **2:4 Spare Ratio**

```
DISKS  CONTENT
   12  raidz2-0
   12  raidz2-1
   12  raidz2-2
   12  raidz2-3
   12  raidz2-4
   12  raidz2-5
   12  raidz2-6
    6  spares
   90  TOTAL
```

Idea Taken to the Extreme

Thunder SX FA100-B7118 (ZFS Data Pool Status)

```
# zpool status
  pool: nas02
 state: ONLINE
  scan: scrub repaired 0 in 0 days 00:00:05 with 0 errors on Fri May 31 10:26:29 2019
config:

        NAME          STATE     READ WRITE CKSUM
        nas02         ONLINE       0     0     0
          raidz2-0    ONLINE       0     0     0
            da0p1     ONLINE       0     0     0
            da1p1     ONLINE       0     0     0
            da2p1     ONLINE       0     0     0
            da3p1     ONLINE       0     0     0
            da4p1     ONLINE       0     0     0
            da5p1     ONLINE       0     0     0
            da6p1     ONLINE       0     0     0
            da7p1     ONLINE       0     0     0
            da8p1     ONLINE       0     0     0
            da9p1     ONLINE       0     0     0
            da10p1    ONLINE       0     0     0
            da12p1    ONLINE       0     0     0
          raidz2-1    ONLINE       0     0     0
            ( ... )
```

Idea Taken to the Extreme

Thunder SX FA100-B7118 (ZFS Data Pool Status)

```
          ( ... )
          da71p1  ONLINE       0     0     0
          da72p1  ONLINE       0     0     0
          da73p1  ONLINE       0     0     0
          da74p1  ONLINE       0     0     0
        spares
          da36p1    AVAIL
          da37p1    AVAIL
          da85p1    AVAIL
          da86p1    AVAIL
          da87p1    AVAIL
          da88p1    AVAIL

errors: No known data errors

# zpool list nas02
NAME    SIZE  ALLOC   FREE  CKPOINT  EXPANDSZ   FRAG    CAP  DEDUP  HEALTH  ALTROOT
nas02   915T  1.42M   915T        -         -     0%     0%  1.00x  ONLINE  -

# zfs list nas02
NAME    USED  AVAIL  REFER  MOUNTPOINT
nas02    88K   675T   201K  none
```

Idea Taken to the Extreme

Thunder SX FA100-B7118 (Storage Performance)

- FreeBSD's builtin `diskinfo(8)` tool.

```
# diskinfo -ctv /dev/zvol/nas02/iscsi/test
( ... )
Transfer rates:
        outside:       102400 kbytes in   0.036938 sec =  2772213 kbytes/sec
        middle:        102400 kbytes in   0.043076 sec =  2377194 kbytes/sec
        inside:        102400 kbytes in   0.034260 sec =  2988908 kbytes/sec
```

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- Eight concurrent `dd(8)` processes.

```
# dd if=/dev/zero of=FILE${X} bs=128m status=progress
174214610944 bytes (174 GB, 162 GiB) transferred 385.042s, 452 MB/s
1302+0 records in
1301+0 records out
174617264128 bytes transferred in 385.379296 secs (453104943 bytes/sec)
```

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```

- About **3 GB/s** of sustained disk subsystem performance.

Idea Taken to the Extreme

Thunder SX FA100-B7118 (FreeBSD Network Configuration)

```
# head -5 /etc/rc.conf
  defaultrouter="10.20.30.254"
  ifconfig_ixl0="up"
  ifconfig_ixl1="up"
  cloned_interfaces="lagg0"
  ifconfig_lagg0="laggproto lacp laggport ixl0 laggport ixl1 10.20.30.2/24 up"

# ifconfig lagg0
lagg0: flags=8843 metric 0 mtu 1500
        options=e507bb
        ether a0:42:3f:a0:42:3f
        inet 10.20.30.2 netmask 0xffffff00 broadcast 10.20.30.255
        laggproto lacp lagghash l2,l3,l4
        laggport: ixl0 flags=1c
        laggport: ixl1 flags=1c
        groups: lagg
        media: Ethernet autoselect
        status: active
        nd6 options=29
```

Idea Taken to the Extreme

Thunder SX FA100-B7118 (Network Performance)

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  - Output below from one of the **Windows Server 2016** machines.

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# C:\iperf-3.1.3-win64>iperf3.exe -c nas02 -P 8
( ... )
[SUM]   0.00-10.00  sec  10.8 GBytes  9.26 Gbits/sec                  receiver
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- The **FreeBSD** machine had two 10GE interfaces configured in LACP mode.

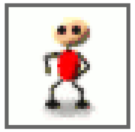
Idea Taken to the Extreme

Thunder SX FA100-B7118 (More Tests and Details)

- More details on dedicated blog post on **`https://vermaden.wordpress.com`** page.
  - **FreeBSD Enterprise 1 PB Storage**
  - `https://vermaden.wordpress.com/2019/06/19/freebsd-enterprise-1-pb-storage/`

Questions?

Sławomir Wojciech Wojtczak



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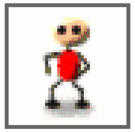
bsd.network/@vermaden

https://is.gd/bsdstg

Thank You!

Sławomir Wojciech Wojtczak



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