Proxmox VE

- Auditing Proxmox
- CEPH
- High Availability
- Nested Virtualization Benchmarks
- Troubleshooting
- Useful additions
- ZFS
- Install VirtIO Drivers

Auditing Proxmox

VM network connections

To simply see all of the network connections for all of the VMs on a Proxmox server, use the following command:

```
grep "bridge=" /etc/pve/qemu-server/*.conf
```

If you want only the VMs with connections to specific bridge interfaces simply add the name of the bridge.

CEPH

Useful commands

```
# quick status check
ceph status

# summary of storage pools, raw usage, and estimated capacity
ceph df

# utilization per osd
ceph osd df
```

Adding CEPH Manager Dashboard

Source

```
# run this on all service manager nodes
apt install ceph-mgr-dashboard

# run this to configure ceph mgr

echo "admin-password" > ~/ceph-dashboard-admin-password.txt

ceph mgr module enable dashboard
ceph dashboard ac-user-create cephdash administrator -i ~/ceph-dashboard-admin-password.txt
```

```
ceph config-key set mgr/dashboard/server_addr ::
ceph dashboard create-self-signed-cert
ceph mgr module disable dashboard
ceph mgr module enable dashboard

systemctl restart ceph-mgr@[servername].service

# Then https://[IP or FQDN]:8443 or http://[IP or FQDN]:8080
```

Shutting down entire Proxmox cluster

If you need to shutdown your entire Proxmox cluster for any reason (maintenance, power issues, moving to a new site, whatever):

```
# prep for shutdown
ceph osd set noout
ceph osd set nobackfill
ceph osd set norecover

# shutdown all VMs and containers
```

```
# prep for service resumption
ceph osd unset norecover
ceph osd unset nobackfill
ceph osd unset noout

# start desired VMs and containers
```

Upgrading Proxmox running CEPH

This has not yet been tested and verified, but adding it here for future reference.

Source

```
# Node maintenance

# stop and wait for scrub and deep-scrub operations

ceph osd set noscrub
ceph osd set nodeep-scrub

ceph status

# set cluster in maintenance mode with :

ceph osd set noout

# for node 1..N

#  migrate VMs and CTs off node

# (GUI or CLI)

# run updates

apt update && pveupgrade

reboot  # if required, e.g., kernel update

# wait for node to come back on line and quorate

# next N

# restore

ceph osd unset noout
```

```
# when all the PGs are active, re-enable the scrub and deep-scrub operations

ceph status

ceph osd unset noscrub
ceph osd unset nodeep-scrub

# done
```

High Availability

Proxmox Documentation: High Availability

Below are relevant excerpts from the above source materials for quick access to necessary commands for various tasks. Please consult the source material for more documentation related to the concepts and commands referenced there.

Error Recovery

```
ha-manager set vm:100 --state disabled
```

Node Maintenance

Maintenance Mode

```
ha-manager status

ha-manager crm-command node-maintenance enable [NODENAME]

ha-manager crm-command node-maintenance disable [NODENAME]
```

Nested Virtualization Benchmarks

Disk benchmark tests

fio simple write test

```
fio --name=sequential_write --rw=write --bs=1M --size=10G --filename=/root/testfile --direct=1
```

fio random read job file

```
[global]
ioengine=libaio
direct=1
group_reporting
runtime=60
time_based

[random_read_job]
rw=randread
bs=4k
iodepth=64
filename=/root/testfile
size=10G
```

fio sequential read job file

```
[global]
ioengine=libaio
direct=1
group_reporting
runtime=60
time_based
```

```
[random_read_job]
rw=read
bs=4k
iodepth=64
filename=/root/testfile
size=10G
```

BASH code to generate lots of different commands

```
for fio_sync in 0 1; do
    for fio_bs in 4KB 16KB 1MB; do
        for fio_rw in read write randwrite randread; do
            echo "fio --name=${fio_rw}_${fio_bs}_${fio_sync} --size=16g --bs=$fio_bs --
rw=$fio_rw --ioengine=libaio --sync=$fio_sync --iodepth=32 --numjobs=1 --direct=1 --
end_fsync=1 --gtod_reduce=1 --time_based --runtime=60"
        done
    done
done
```

Hardware: DELL Latitude 5520 (Laptop)

CPU: 11th Gen Intel(R) Core(TM) i5-1145G7 @ 2.60GHz
Disk: 2 x 256GB
Filesystem: ZFS Raid-1 Mirror

PVE benchmark

```
# Disk information
root@pve:~# smartctl -a /dev/nvme0n1
Model Number:                       Micron 2450 NVMe 256GB
Temperature:                        43 Celsius
Percentage Used:                    15%

root@pve:~# smartctl -a /dev/nvme1n1
Model Number:                       PC SN520 NVMe WDC 256GB
Temperature:                        45 Celsius
Percentage Used:                    28%
```

```
# CPU Information
root@pve:~# cat /proc/cpuinfo | grep "model name"
model name      : 11th Gen Intel(R) Core(TM) i5-1145G7 @ 2.60GHz
model name      : 11th Gen Intel(R) Core(TM) i5-1145G7 @ 2.60GHz
model name      : 11th Gen Intel(R) Core(TM) i5-1145G7 @ 2.60GHz
model name      : 11th Gen Intel(R) Core(TM) i5-1145G7 @ 2.60GHz
model name      : 11th Gen Intel(R) Core(TM) i5-1145G7 @ 2.60GHz
model name      : 11th Gen Intel(R) Core(TM) i5-1145G7 @ 2.60GHz
model name      : 11th Gen Intel(R) Core(TM) i5-1145G7 @ 2.60GHz
model name      : 11th Gen Intel(R) Core(TM) i5-1145G7 @ 2.60GHz



# Benchmark - write
root@pve:~# fio --name=sequential_write --rw=write --bs=1M --size=10G --filename=testfile --
direct=1
sequential_write: (g=0): rw=write, bs=(R) 1024KiB-1024KiB, (W) 1024KiB-1024KiB, (T) 1024KiB-
1024KiB, ioengine=psync, iodepth=1
fio-3.39
Starting 1 process
sequential_write: Laying out IO file (1 file / 10240MiB)
Jobs: 1 (f=1): [W(1)][100.0%][w=60.1MiB/s][w=60 IOPS][eta 00m:00s]
sequential_write: (groupid=0, jobs=1): err= 0: pid=1838716: Mon Aug 11 13:47:12 2025
  write: IOPS=64, BW=64.1MiB/s (67.2MB/s)(10.0GiB/159737msec); 0 zone resets
    clat (usec): min=1521, max=2857.4k, avg=15554.55, stdev=30350.48
     lat (usec): min=1564, max=2857.4k, avg=15595.47, stdev=30349.98
    clat percentiles (msec):
     |  1.00th=[    3],  5.00th=[    3], 10.00th=[    3], 20.00th=[   15],
     | 30.00th=[   15], 40.00th=[   16], 50.00th=[   17], 60.00th=[   17],
     | 70.00th=[   18], 80.00th=[   18], 90.00th=[   20], 95.00th=[   22],
     | 99.00th=[   32], 99.50th=[   37], 99.90th=[  110], 99.95th=[  226],
     | 99.99th=[  760]
   bw (  KiB/s): min= 4096, max=448512, per=100.00%, avg=66923.14, stdev=44636.99, samples=313
   iops        : min=    4, max=  438, avg=65.35, stdev=43.59, samples=313
  lat (msec)   : 2=0.50%, 4=12.31%, 10=1.23%, 20=77.88%, 50=7.84%
  lat (msec)   : 100=0.13%, 250=0.07%, 500=0.02%, 1000=0.01%, >=2000=0.01%
  cpu          : usr=0.34%, sys=13.49%, ctx=11028, majf=5, minf=10
```

```
  IO depths    : 1=100.0%, 2=0.0%, 4=0.0%, 8=0.0%, 16=0.0%, 32=0.0%, >=64=0.0%
     submit    : 0=0.0%, 4=100.0%, 8=0.0%, 16=0.0%, 32=0.0%, 64=0.0%, >=64=0.0%
     complete  : 0=0.0%, 4=100.0%, 8=0.0%, 16=0.0%, 32=0.0%, 64=0.0%, >=64=0.0%
     issued rwts: total=0,10240,0,0 short=0,0,0,0 dropped=0,0,0,0
     latency   : target=0, window=0, percentile=100.00%, depth=1

Run status group 0 (all jobs):
  WRITE: bw=64.1MiB/s (67.2MB/s), 64.1MiB/s-64.1MiB/s (67.2MB/s-67.2MB/s), io=10.0GiB
(10.7GB), run=159737-159737msec



# Benchmark - read
root@pve:~# fio random_read_test.fio
random_read_job: (g=0): rw=randread, bs=(R) 4096B-4096B, (W) 4096B-4096B, (T) 4096B-4096B,
ioengine=libaio, iodepth=64
fio-3.39
Starting 1 process
Jobs: 1 (f=1): [r(1)][100.0%][r=10.3MiB/s][r=2626 IOPS][eta 00m:00s]
random_read_job: (groupid=0, jobs=1): err= 0: pid=1841119: Mon Aug 11 13:54:44 2025
  read: IOPS=2638, BW=10.3MiB/s (10.8MB/s)(618MiB/60001msec)
    slat (usec): min=167, max=6793, avg=377.03, stdev=155.55
    clat (nsec): min=1728, max=36276k, avg=23873354.46, stdev=1833473.80
     lat (usec): min=458, max=36588, avg=24250.38, stdev=1850.88
    clat percentiles (usec):
     |  1.00th=[20579],  5.00th=[21627], 10.00th=[21890], 20.00th=[22414],
     | 30.00th=[22938], 40.00th=[23200], 50.00th=[23725], 60.00th=[23987],
     | 70.00th=[24511], 80.00th=[25035], 90.00th=[26084], 95.00th=[27132],
     | 99.00th=[29754], 99.50th=[31065], 99.90th=[33162], 99.95th=[33817],
     | 99.99th=[34866]
   bw (  KiB/s): min= 7944, max=11024, per=100.00%, avg=10553.40, stdev=363.11, samples=120
   iops        : min= 1986, max= 2756, avg=2638.35, stdev=90.78, samples=120
  lat (usec)   : 2=0.01%, 500=0.01%, 750=0.01%
  lat (msec)   : 2=0.01%, 4=0.01%, 10=0.01%, 20=0.65%, 50=99.33%
  cpu          : usr=0.64%, sys=6.66%, ctx=158463, majf=0, minf=72
  IO depths    : 1=0.1%, 2=0.1%, 4=0.1%, 8=0.1%, 16=0.1%, 32=0.1%, >=64=100.0%
     submit    : 0=0.0%, 4=100.0%, 8=0.0%, 16=0.0%, 32=0.0%, 64=0.0%, >=64=0.0%
     complete  : 0=0.0%, 4=100.0%, 8=0.0%, 16=0.0%, 32=0.0%, 64=0.1%, >=64=0.0%
     issued rwts: total=158301,0,0,0 short=0,0,0,0 dropped=0,0,0,0
     latency   : target=0, window=0, percentile=100.00%, depth=64
```

```
Run status group 0 (all jobs):
   READ: bw=10.3MiB/s (10.8MB/s), 10.3MiB/s-10.3MiB/s (10.8MB/s-10.8MB/s), io=618MiB (648MB),
run=60001-60001msec
```

Nested VM Benchmark

Ubuntu 24.04

```
root@nested-vm-l2:~$ cat /proc/cpuinfo | grep "model name"
model name      : 11th Gen Intel(R) Core(TM) i5-1145G7 @ 2.60GHz
model name      : 11th Gen Intel(R) Core(TM) i5-1145G7 @ 2.60GHz

root@nested-vm-l2:~$ fio --name=sequential_write --rw=write --bs=1M --size=10G --
filename=testfile --direct=1
sequential_write: (g=0): rw=write, bs=(R) 1024KiB-1024KiB, (W) 1024KiB-1024KiB, (T) 1024KiB-
1024KiB, ioengine=psync, iodepth=1
fio-3.36
Starting 1 process
sequential_write: Laying out IO file (1 file / 10240MiB)
Jobs: 1 (f=1): [W(1)][97.1%][w=178MiB/s][w=177 IOPS][eta 00m:08s]
sequential_write: (groupid=0, jobs=1): err= 0: pid=1820: Mon Aug 11 18:43:38 2025
  write: IOPS=37, BW=37.9MiB/s (39.8MB/s)(10.0GiB/269886msec); 0 zone resets
    clat (nsec): min=0, max=44001M, avg=26294437.47, stdev=800866646.25
     lat (nsec): min=0, max=44001M, avg=26331483.73, stdev=800866317.34
    clat percentiles (usec):
     |  1.00th=[    1270],  5.00th=[    1385], 10.00th=[    1434],
     | 20.00th=[    1516], 30.00th=[    1582], 40.00th=[    1647],
     | 50.00th=[    1745], 60.00th=[    1860], 70.00th=[    2057],
     | 80.00th=[    2606], 90.00th=[    4293], 95.00th=[    5997],
     | 99.00th=[   11600], 99.50th=[   13960], 99.90th=[  826278],
     | 99.95th=[17112761], 99.99th=[17112761]
   bw (  KiB/s): min= 2043, max=610304, per=100.00%, avg=332192.42, stdev=168523.35,
samples=62
   iops        : min=    1, max=  596, avg=324.08, stdev=164.57, samples=62
  lat (nsec)   : 2=0.26%
  lat (usec)   : 20=0.01%, 100=0.01%, 500=0.03%, 750=0.03%, 1000=0.02%
  lat (msec)   : 2=67.67%, 4=20.74%, 10=9.56%, 20=1.42%, 50=0.10%
  lat (msec)   : 100=0.04%, 250=0.01%, 1000=0.01%, >=2000=0.10%
  cpu          : usr=0.23%, sys=1.18%, ctx=10245, majf=0, minf=16
```

```
  IO depths    : 1=100.0%, 2=0.0%, 4=0.0%, 8=0.0%, 16=0.0%, 32=0.0%, >=64=0.0%
     submit    : 0=0.0%, 4=100.0%, 8=0.0%, 16=0.0%, 32=0.0%, 64=0.0%, >=64=0.0%
     complete  : 0=0.0%, 4=100.0%, 8=0.0%, 16=0.0%, 32=0.0%, 64=0.0%, >=64=0.0%
     issued rwts: total=0,10240,0,0 short=0,0,0,0 dropped=0,0,0,0
     latency   : target=0, window=0, percentile=100.00%, depth=1

Run status group 0 (all jobs):
  WRITE: bw=37.9MiB/s (39.8MB/s), 37.9MiB/s-37.9MiB/s (39.8MB/s-39.8MB/s), io=10.0GiB
(10.7GB), run=269886-269886msec

Disk stats (read/write):
  sda: ios=3017/10737, sectors=75792/21008312, merge=253/833, ticks=3237/526767,
in_queue=686667, util=96.37%



# Benchmark - read
root@nested-vm-l2:~# fio random_read_test.fio
random_read_job: (g=0): rw=randread, bs=(R) 4096B-4096B, (W) 4096B-4096B, (T) 4096B-4096B,
ioengine=libaio, iodepth=64
fio-3.36
Starting 1 process
random_read_job: Laying out IO file (1 file / 10240MiB)
Jobs: 1 (f=1): [r(1)][100.0%][r=20.0MiB/s][r=5112 IOPS][eta 00m:00s]
random_read_job: (groupid=0, jobs=1): err= 0: pid=3300: Mon Aug 11 19:02:19 2025
  read: IOPS=4748, BW=18.5MiB/s (19.4MB/s)(1113MiB/60004msec)
    slat (nsec): min=0, max=13840k, avg=116055.33, stdev=350395.40
    clat (usec): min=2917, max=48588, avg=13307.65, stdev=5035.71
     lat (usec): min=2958, max=48739, avg=13423.70, stdev=5063.84
    clat percentiles (usec):
     |  1.00th=[ 5735],  5.00th=[ 6980], 10.00th=[ 7832], 20.00th=[ 8848],
     | 30.00th=[ 9896], 40.00th=[10945], 50.00th=[12125], 60.00th=[13566],
     | 70.00th=[15533], 80.00th=[17695], 90.00th=[20317], 95.00th=[22938],
     | 99.00th=[27657], 99.50th=[29754], 99.90th=[33817], 99.95th=[35390],
     | 99.99th=[39584]
   bw (  KiB/s): min=12645, max=34142, per=100.00%, avg=19000.53, stdev=4050.47, samples=119
   iops        : min= 3161, max= 8535, avg=4749.84, stdev=1012.64, samples=119
  lat (msec)   : 4=0.01%, 10=30.78%, 20=58.31%, 50=10.90%
  cpu          : usr=3.98%, sys=90.23%, ctx=2410, majf=0, minf=74
  IO depths    : 1=0.1%, 2=0.1%, 4=0.1%, 8=0.1%, 16=0.1%, 32=0.1%, >=64=100.0%
```

```
     submit    : 0=0.0%, 4=100.0%, 8=0.0%, 16=0.0%, 32=0.0%, 64=0.0%, >=64=0.0%
     complete  : 0=0.0%, 4=100.0%, 8=0.0%, 16=0.0%, 32=0.0%, 64=0.1%, >=64=0.0%
     issued rwts: total=284908,0,0,0 short=0,0,0,0 dropped=0,0,0,0
     latency   : target=0, window=0, percentile=100.00%, depth=64

Run status group 0 (all jobs):
   READ: bw=18.5MiB/s (19.4MB/s), 18.5MiB/s-18.5MiB/s (19.4MB/s-19.4MB/s), io=1113MiB
(1167MB), run=60004-60004msec

Disk stats (read/write):
  sda: ios=283830/8, sectors=2270640/72, merge=0/1, ticks=1580398/232, in_queue=1580794,
util=49.28%
```

Hardware: HPE

PVE - Mirrored 15K SAS

```
# CPU
root@btr-pve-c9ne1:~# grep "model name" /proc/cpuinfo
model name      : Intel(R) Xeon(R) CPU E5-2687W v4 @ 3.00GHz
# 2 Sockets, 24 Cores per socket, 48 total cores

# DISK: ZFS Mirrored HP EH0300JDYTH 15k SAS




# Benchmark - write

root@pve-hpe:~# fio --name=sequential_write --rw=write --bs=1M --size=10G --
filename=/root/testfile --direct=1
sequential_write: (g=0): rw=write, bs=(R) 1024KiB-1024KiB, (W) 1024KiB-1024KiB, (T) 1024KiB-
1024KiB, ioengine=psync, iodepth=1
fio-3.39
Starting 1 process
sequential_write: Laying out IO file (1 file / 10240MiB)
Jobs: 1 (f=1): [W(1)][100.0%][w=100MiB/s][w=100 IOPS][eta 00m:00s]
sequential_write: (groupid=0, jobs=1): err= 0: pid=1156898: Mon Aug 11 14:02:36 2025
```

```
  write: IOPS=93, BW=93.5MiB/s (98.0MB/s)(10.0GiB/109530msec); 0 zone resets
    clat (usec): min=8364, max=80908, avg=10618.01, stdev=3390.34
     lat (usec): min=8507, max=80994, avg=10691.62, stdev=3390.64
    clat percentiles (usec):
     |  1.00th=[ 8717],  5.00th=[ 8848], 10.00th=[ 8848], 20.00th=[ 8979],
     | 30.00th=[ 9110], 40.00th=[ 9503], 50.00th=[10028], 60.00th=[10552],
     | 70.00th=[11076], 80.00th=[11469], 90.00th=[11863], 95.00th=[13042],
     | 99.00th=[25035], 99.50th=[32113], 99.90th=[53216], 99.95th=[57934],
     | 99.99th=[80217]
   bw (  KiB/s): min=51200, max=104448, per=100.00%, avg=95758.09, stdev=11129.23, samples=218
   iops        : min=   50, max=  102, avg=93.51, stdev=10.87, samples=218
  lat (msec)   : 10=50.61%, 20=47.46%, 50=1.81%, 100=0.13%
  cpu          : usr=0.74%, sys=65.95%, ctx=10420, majf=5, minf=8
  IO depths    : 1=100.0%, 2=0.0%, 4=0.0%, 8=0.0%, 16=0.0%, 32=0.0%, >=64=0.0%
     submit    : 0=0.0%, 4=100.0%, 8=0.0%, 16=0.0%, 32=0.0%, 64=0.0%, >=64=0.0%
     complete  : 0=0.0%, 4=100.0%, 8=0.0%, 16=0.0%, 32=0.0%, 64=0.0%, >=64=0.0%
     issued rwts: total=0,10240,0,0 short=0,0,0,0 dropped=0,0,0,0
     latency   : target=0, window=0, percentile=100.00%, depth=1

Run status group 0 (all jobs):
  WRITE: bw=93.5MiB/s (98.0MB/s), 93.5MiB/s-93.5MiB/s (98.0MB/s-98.0MB/s), io=10.0GiB
(10.7GB), run=109530-109530msec



# Benchmark - read

root@pve-hpe:~# fio random_read_test.fio
random_read_job: (g=0): rw=randread, bs=(R) 4096B-4096B, (W) 4096B-4096B, (T) 4096B-4096B,
ioengine=libaio, iodepth=64
fio-3.39
Starting 1 process
Jobs: 1 (f=1): [r(1)][100.0%][r=820KiB/s][r=205 IOPS][eta 00m:00s]
random_read_job: (groupid=0, jobs=1): err= 0: pid=1159109: Mon Aug 11 14:09:42 2025
  read: IOPS=217, BW=871KiB/s (892kB/s)(51.0MiB/60001msec)
    slat (usec): min=462, max=40890, avg=4580.11, stdev=1975.13
    clat (usec): min=13, max=531922, avg=288716.77, stdev=40807.24
     lat (msec): min=6, max=535, avg=293.30, stdev=41.16
    clat percentiles (msec):
     |  1.00th=[  251],  5.00th=[  262], 10.00th=[  266], 20.00th=[  271],
```

```
     | 30.00th=[  271], 40.00th=[  275], 50.00th=[  279], 60.00th=[  284],
     | 70.00th=[  288], 80.00th=[  292], 90.00th=[  313], 95.00th=[  393],
     | 99.00th=[  460], 99.50th=[  481], 99.90th=[  527], 99.95th=[  531],
     | 99.99th=[  531]
   bw (  KiB/s): min=  376, max= 1112, per=99.92%, avg=870.73, stdev=99.13, samples=120
   iops        : min=   94, max=  278, avg=217.68, stdev=24.78, samples=120
  lat (usec)   : 20=0.01%
  lat (msec)   : 10=0.01%, 20=0.02%, 50=0.05%, 100=0.09%, 250=0.54%
  lat (msec)   : 500=98.97%, 750=0.32%
  cpu          : usr=0.33%, sys=3.76%, ctx=13070, majf=0, minf=408
  IO depths    : 1=0.1%, 2=0.1%, 4=0.1%, 8=0.1%, 16=0.1%, 32=0.2%, >=64=99.5%
     submit    : 0=0.0%, 4=100.0%, 8=0.0%, 16=0.0%, 32=0.0%, 64=0.0%, >=64=0.0%
     complete  : 0=0.0%, 4=100.0%, 8=0.0%, 16=0.0%, 32=0.0%, 64=0.1%, >=64=0.0%
     issued rwts: total=13061,0,0,0 short=0,0,0,0 dropped=0,0,0,0
     latency   : target=0, window=0, percentile=100.00%, depth=64

Run status group 0 (all jobs):
   READ: bw=871KiB/s (892kB/s), 871KiB/s-871KiB/s (892kB/s-892kB/s), io=51.0MiB (53.5MB),
run=60001-60001msec
```

PVE - RAIDz3: 10 x 7200 rpm (MM1000GBKAL)

```
root@pve:/z-7200-SATA-Rz3# fio --name=sequential_write --rw=write --bs=1M --size=10G --
filename=testfile --direct=1
sequential_write: (g=0): rw=write, bs=(R) 1024KiB-1024KiB, (W) 1024KiB-1024KiB, (T) 1024KiB-
1024KiB, ioengine=psync, iodepth=1
fio-3.39
Starting 1 process
sequential_write: Laying out IO file (1 file / 10240MiB)
Jobs: 1 (f=1): [W(1)][100.0%][w=37.0MiB/s][w=37 IOPS][eta 00m:00s]
sequential_write: (groupid=0, jobs=1): err= 0: pid=1546695: Tue Aug 12 10:18:08 2025
  write: IOPS=54, BW=55.0MiB/s (57.6MB/s)(10.0GiB/186319msec); 0 zone resets
    clat (msec): min=9, max=206, avg=18.11, stdev=10.06
     lat (msec): min=9, max=206, avg=18.19, stdev=10.06
    clat percentiles (msec):
     |  1.00th=[   14],  5.00th=[   15], 10.00th=[   16], 20.00th=[   16],
     | 30.00th=[   17], 40.00th=[   17], 50.00th=[   17], 60.00th=[   17],
     | 70.00th=[   17], 80.00th=[   18], 90.00th=[   18], 95.00th=[   21],
     | 99.00th=[   77], 99.50th=[   93], 99.90th=[  127], 99.95th=[  134],
```

```
     | 99.99th=[  159]
   bw (  KiB/s): min=12288, max=67584, per=100.00%, avg=56300.17, stdev=11089.88, samples=372
   iops        : min=   12, max=   66, avg=54.98, stdev=10.83, samples=372
  lat (msec)   : 10=0.03%, 20=94.98%, 50=2.80%, 100=1.90%, 250=0.28%
  cpu          : usr=0.47%, sys=46.47%, ctx=11448, majf=0, minf=9
  IO depths    : 1=100.0%, 2=0.0%, 4=0.0%, 8=0.0%, 16=0.0%, 32=0.0%, >=64=0.0%
     submit    : 0=0.0%, 4=100.0%, 8=0.0%, 16=0.0%, 32=0.0%, 64=0.0%, >=64=0.0%
     complete  : 0=0.0%, 4=100.0%, 8=0.0%, 16=0.0%, 32=0.0%, 64=0.0%, >=64=0.0%
     issued rwts: total=0,10240,0,0 short=0,0,0,0 dropped=0,0,0,0
     latency   : target=0, window=0, percentile=100.00%, depth=1

Run status group 0 (all jobs):
  WRITE: bw=55.0MiB/s (57.6MB/s), 55.0MiB/s-55.0MiB/s (57.6MB/s-57.6MB/s), io=10.0GiB
(10.7GB), run=186319-186319msec



root@pve:/z-7200-SATA-Rz3# fio random_read_test.fio
random_read_job: (g=0): rw=randread, bs=(R) 4096B-4096B, (W) 4096B-4096B, (T) 4096B-4096B,
ioengine=libaio, iodepth=64
fio-3.39
Starting 1 process
Jobs: 1 (f=1): [r(1)][100.0%][r=436KiB/s][r=109 IOPS][eta 00m:00s]
random_read_job: (groupid=0, jobs=1): err= 0: pid=1578323: Tue Aug 12 10:46:14 2025
  read: IOPS=105, BW=421KiB/s (431kB/s)(24.7MiB/60008msec)
    slat (usec): min=519, max=100246, avg=9492.20, stdev=4271.24
    clat (usec): min=14, max=1314.5k, avg=595573.00, stdev=91957.69
     lat (msec): min=8, max=1323, avg=605.07, stdev=92.62
    clat percentiles (msec):
     |  1.00th=[  550],  5.00th=[  558], 10.00th=[  567], 20.00th=[  567],
     | 30.00th=[  575], 40.00th=[  575], 50.00th=[  575], 60.00th=[  584],
     | 70.00th=[  584], 80.00th=[  592], 90.00th=[  617], 95.00th=[  793],
     | 99.00th=[  927], 99.50th=[ 1301], 99.90th=[ 1318], 99.95th=[ 1318],
     | 99.99th=[ 1318]
   bw (  KiB/s): min=  112, max=  944, per=100.00%, avg=424.40, stdev=73.04, samples=119
   iops        : min=   28, max=  236, avg=106.10, stdev=18.26, samples=119
  lat (usec)   : 20=0.02%
  lat (msec)   : 10=0.02%, 20=0.02%, 50=0.05%, 100=0.08%, 250=0.27%
  lat (msec)   : 500=0.44%, 750=92.46%, 1000=5.69%, 2000=0.97%
  cpu          : usr=0.16%, sys=2.54%, ctx=6315, majf=0, minf=82
```

```
  IO depths    : 1=0.1%, 2=0.1%, 4=0.1%, 8=0.1%, 16=0.3%, 32=0.5%, >=64=99.0%
     submit    : 0=0.0%, 4=100.0%, 8=0.0%, 16=0.0%, 32=0.0%, 64=0.0%, >=64=0.0%
     complete  : 0=0.0%, 4=100.0%, 8=0.0%, 16=0.0%, 32=0.0%, 64=0.1%, >=64=0.0%
     issued rwts: total=6313,0,0,0 short=0,0,0,0 dropped=0,0,0,0
     latency   : target=0, window=0, percentile=100.00%, depth=64

Run status group 0 (all jobs):
   READ: bw=421KiB/s (431kB/s), 421KiB/s-421KiB/s (431kB/s-431kB/s), io=24.7MiB (25.9MB),
run=60008-60008msec
```

PVE - draid3:6d:10c:1s-0: 10 x 10k SAS (EG1200JEMDA)

```
root@pve:/# cd z-10K-SAS-dRAID3/
root@pve:/z-10K-SAS-dRAID3# fio --name=sequential_write --rw=write --bs=1M --size=10G --
filename=/root/testfile --direct=1
sequential_write: (g=0): rw=write, bs=(R) 1024KiB-1024KiB, (W) 1024KiB-1024KiB, (T) 1024KiB-
1024KiB, ioengine=psync, iodepth=1
fio-3.39
Starting 1 process
sequential_write: Laying out IO file (1 file / 10240MiB)
Jobs: 1 (f=1): [W(1)][100.0%][w=98.0MiB/s][w=98 IOPS][eta 00m:00s]
sequential_write: (groupid=0, jobs=1): err= 0: pid=1550993: Tue Aug 12 10:20:41 2025
  write: IOPS=90, BW=90.8MiB/s (95.2MB/s)(10.0GiB/112818msec); 0 zone resets
    clat (usec): min=7765, max=67166, avg=10939.46, stdev=3638.62
     lat (usec): min=7858, max=67210, avg=11012.52, stdev=3639.09
    clat percentiles (usec):
     |  1.00th=[ 8160],  5.00th=[ 8356], 10.00th=[ 8455], 20.00th=[ 8979],
     | 30.00th=[ 9503], 40.00th=[10028], 50.00th=[10552], 60.00th=[10945],
     | 70.00th=[11469], 80.00th=[11863], 90.00th=[12125], 95.00th=[12387],
     | 99.00th=[28705], 99.50th=[36439], 99.90th=[49021], 99.95th=[56361],
     | 99.99th=[64226]
   bw (  KiB/s): min=45056, max=112640, per=100.00%, avg=93088.43, stdev=12260.36, samples=225
   iops        : min=   44, max=  110, avg=90.91, stdev=11.97, samples=225
  lat (msec)   : 10=39.64%, 20=57.95%, 50=2.31%, 100=0.10%
  cpu          : usr=0.76%, sys=65.33%, ctx=10540, majf=0, minf=7
  IO depths    : 1=100.0%, 2=0.0%, 4=0.0%, 8=0.0%, 16=0.0%, 32=0.0%, >=64=0.0%
     submit    : 0=0.0%, 4=100.0%, 8=0.0%, 16=0.0%, 32=0.0%, 64=0.0%, >=64=0.0%
     complete  : 0=0.0%, 4=100.0%, 8=0.0%, 16=0.0%, 32=0.0%, 64=0.0%, >=64=0.0%
     issued rwts: total=0,10240,0,0 short=0,0,0,0 dropped=0,0,0,0
     latency   : target=0, window=0, percentile=100.00%, depth=1
```

```
Run status group 0 (all jobs):
  WRITE: bw=90.8MiB/s (95.2MB/s), 90.8MiB/s-90.8MiB/s (95.2MB/s-95.2MB/s), io=10.0GiB
(10.7GB), run=112818-112818msec

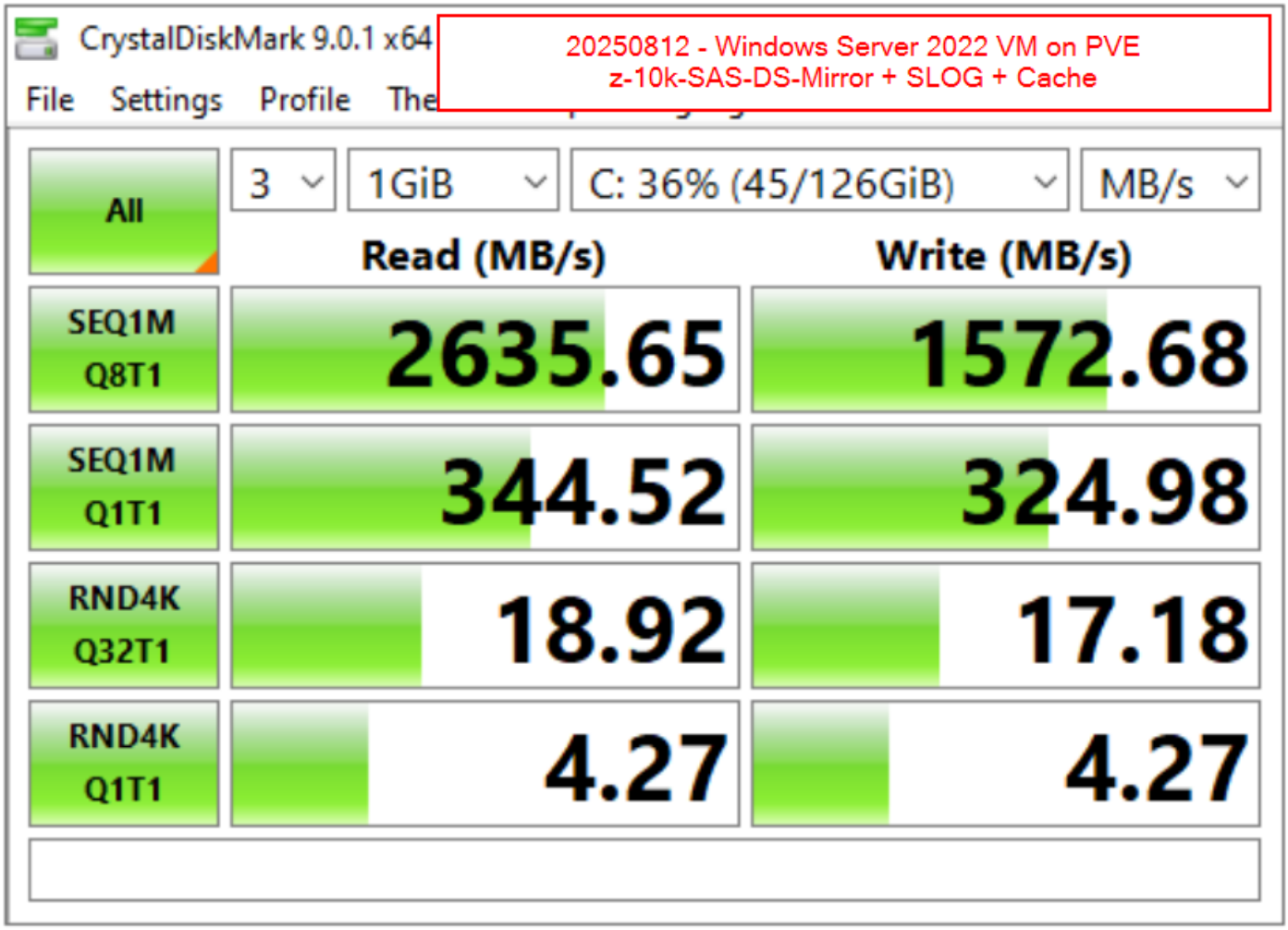


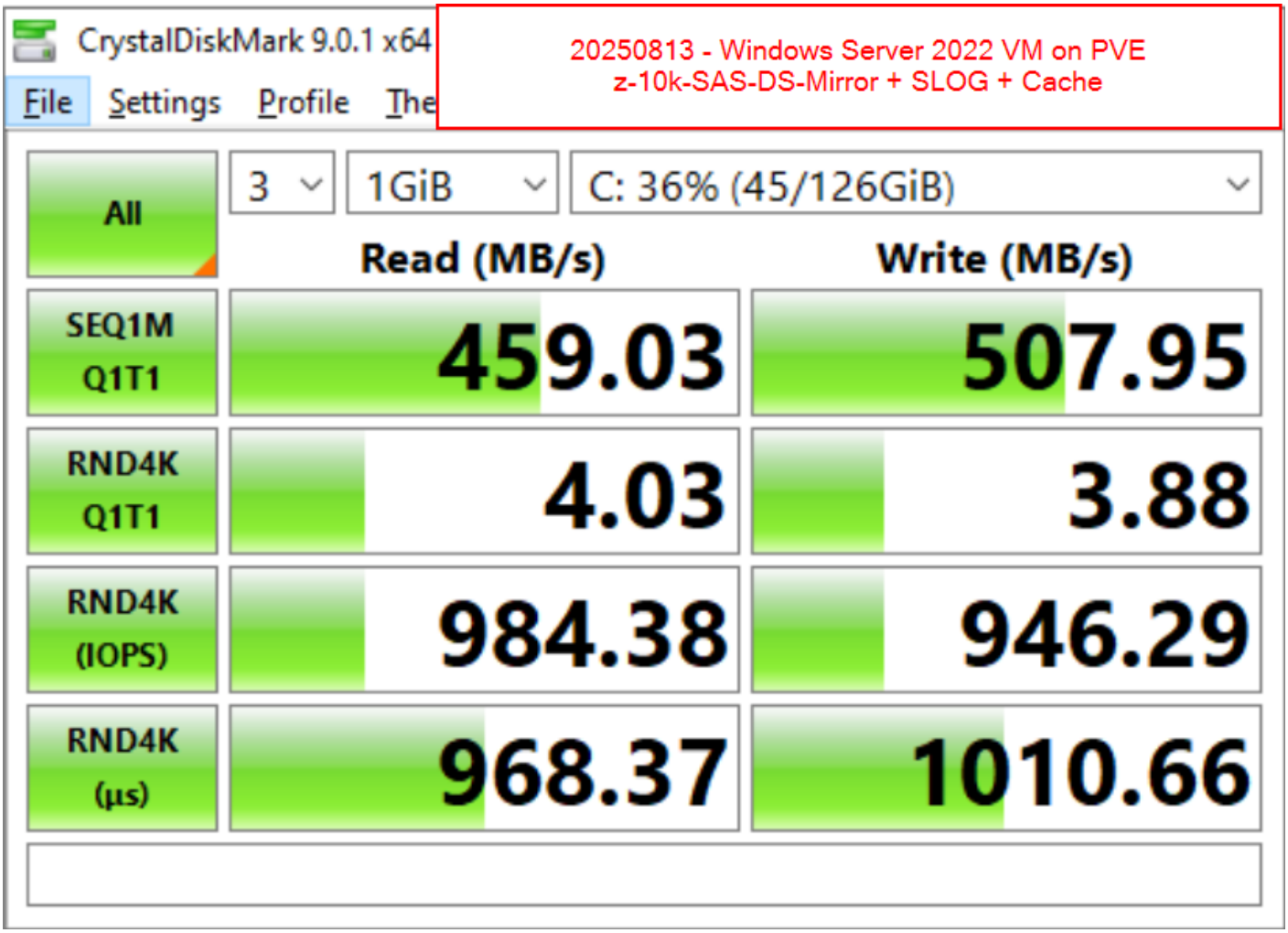
root@pve:/z-10K-SAS-dRAID3# fio random_read_test.fio
random_read_job: (g=0): rw=randread, bs=(R) 4096B-4096B, (W) 4096B-4096B, (T) 4096B-4096B,
ioengine=libaio, iodepth=64
fio-3.39
Starting 1 process
random_read_job: Laying out IO file (1 file / 10240MiB)
Jobs: 1 (f=1): [r(1)][100.0%][r=576KiB/s][r=144 IOPS][eta 00m:00s]
random_read_job: (groupid=0, jobs=1): err= 0: pid=1580837: Tue Aug 12 10:48:22 2025
  read: IOPS=163, BW=655KiB/s (671kB/s)(38.4MiB/60004msec)
    slat (usec): min=13, max=39844, avg=6090.61, stdev=2135.90
    clat (usec): min=12, max=523484, avg=383170.17, stdev=33200.56
     lat (msec): min=6, max=529, avg=389.26, stdev=33.38
    clat percentiles (msec):
     |  1.00th=[  338],  5.00th=[  355], 10.00th=[  363], 20.00th=[  368],
     | 30.00th=[  372], 40.00th=[  376], 50.00th=[  380], 60.00th=[  384],
     | 70.00th=[  388], 80.00th=[  393], 90.00th=[  401], 95.00th=[  409],
     | 99.00th=[  510], 99.50th=[  514], 99.90th=[  523], 99.95th=[  523],
     | 99.99th=[  523]
   bw (  KiB/s): min=  112, max= 1104, per=99.95%, avg=655.40, stdev=75.42, samples=120
   iops        : min=   28, max=  276, avg=163.85, stdev=18.85, samples=120
  lat (usec)   : 20=0.01%
  lat (msec)   : 10=0.01%, 20=0.01%, 50=0.05%, 100=0.08%, 250=0.23%
  lat (msec)   : 500=97.36%, 750=2.25%
  cpu          : usr=0.22%, sys=3.94%, ctx=9518, majf=0, minf=256
  IO depths    : 1=0.1%, 2=0.1%, 4=0.1%, 8=0.1%, 16=0.2%, 32=0.3%, >=64=99.4%
     submit    : 0=0.0%, 4=100.0%, 8=0.0%, 16=0.0%, 32=0.0%, 64=0.0%, >=64=0.0%
     complete  : 0=0.0%, 4=100.0%, 8=0.0%, 16=0.0%, 32=0.0%, 64=0.1%, >=64=0.0%
     issued rwts: total=9831,0,0,0 short=0,0,0,0 dropped=0,0,0,0
     latency   : target=0, window=0, percentile=100.00%, depth=64

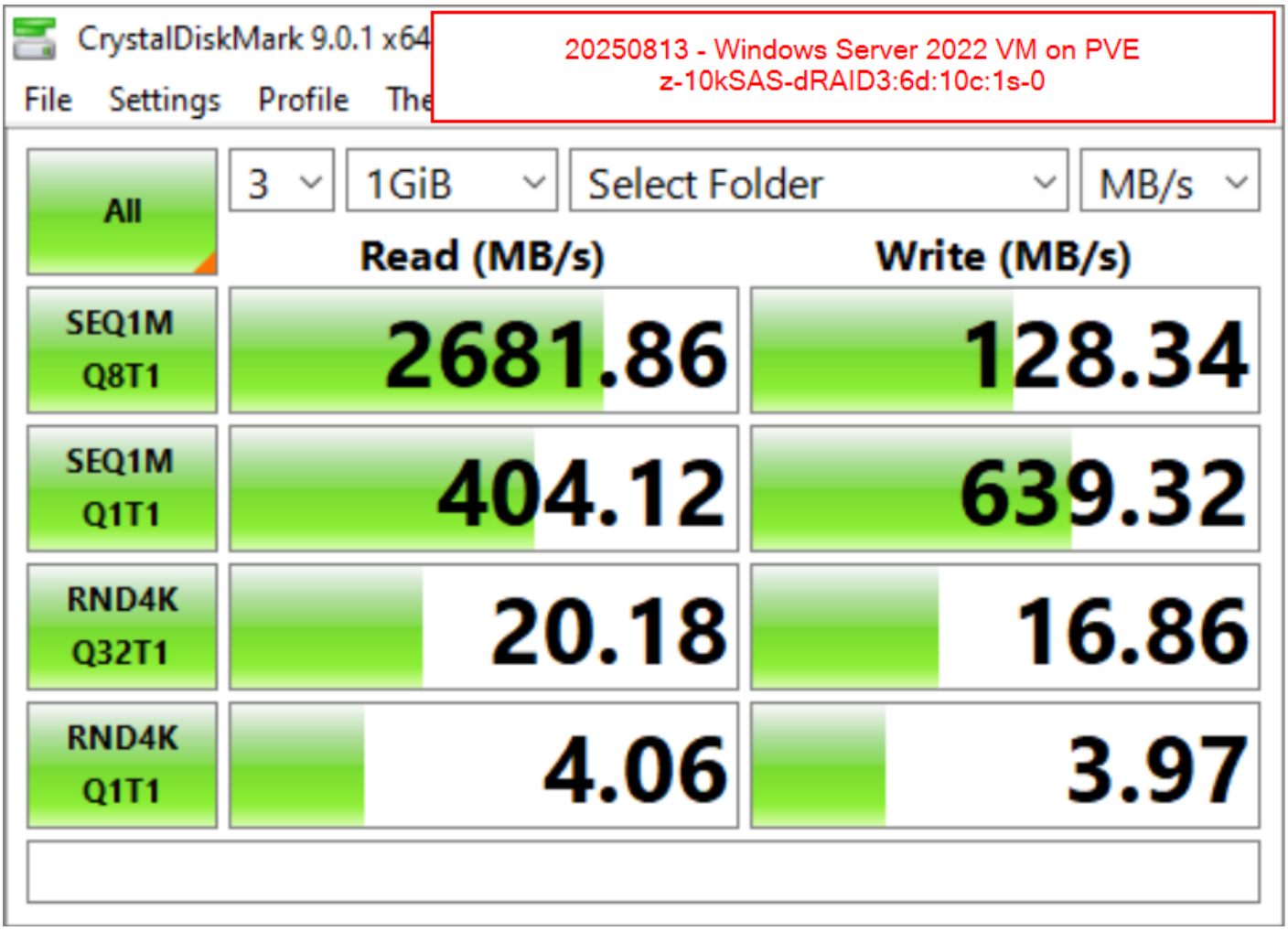
Run status group 0 (all jobs):
   READ: bw=655KiB/s (671kB/s), 655KiB/s-655KiB/s (671kB/s-671kB/s), io=38.4MiB (40.3MB),
run=60004-60004msec
```

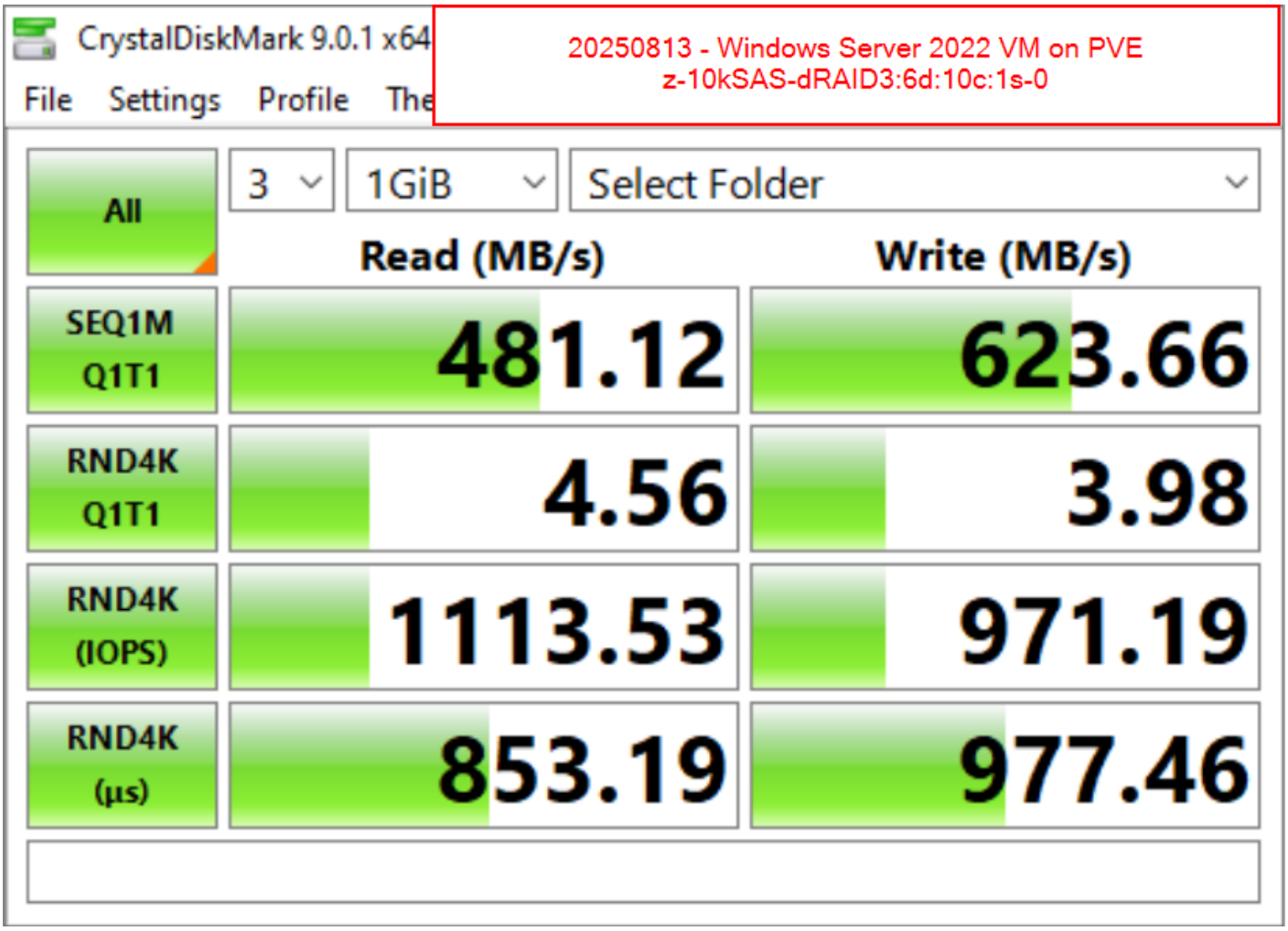
PVE - ZFS Mirror + SLOG + L2ARC (cache)

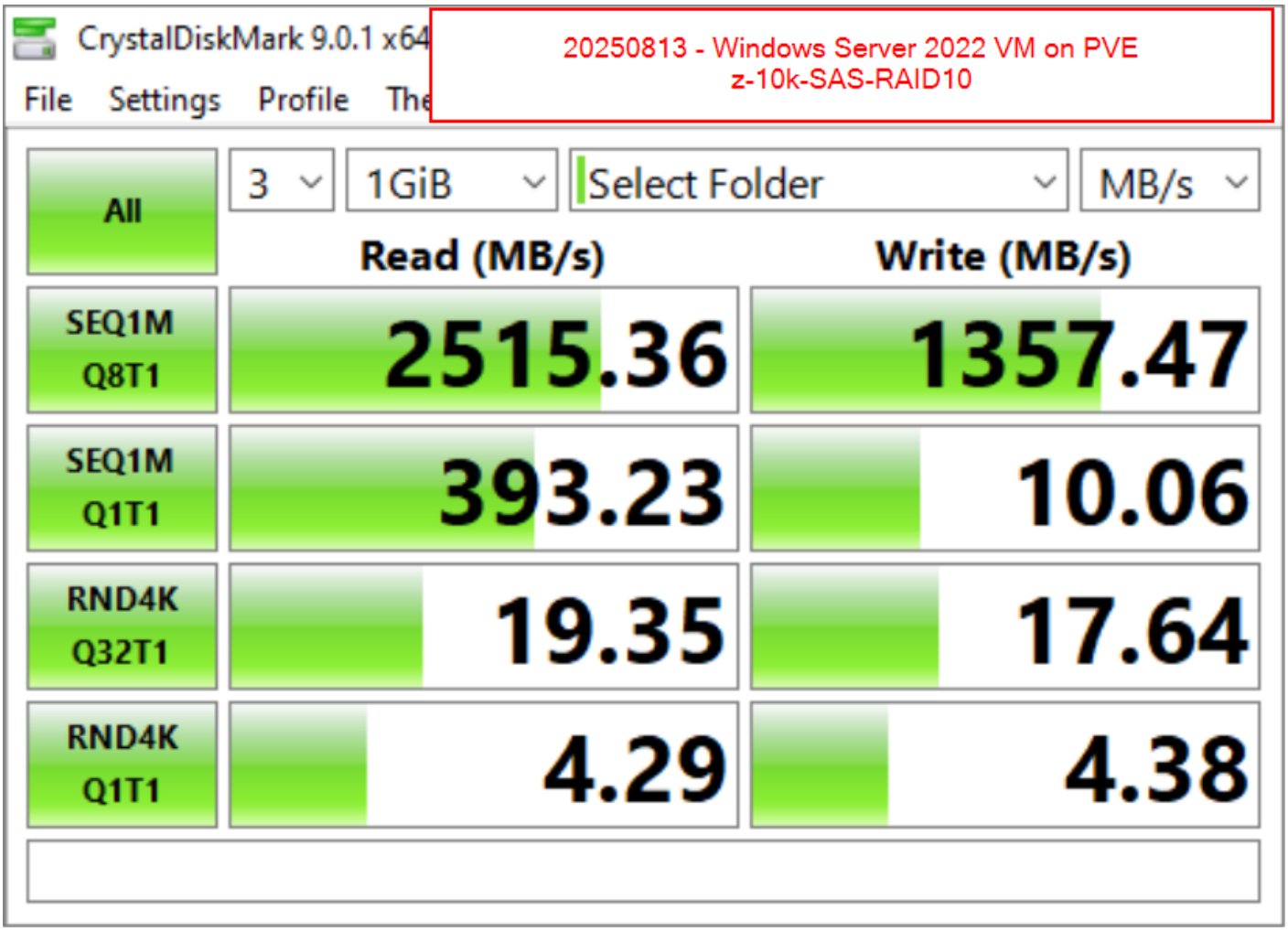
2 x 10K SAS DS EH0300JDYTH + 2 x SSD SLOG + 1 x SSD L2ARC (cache)

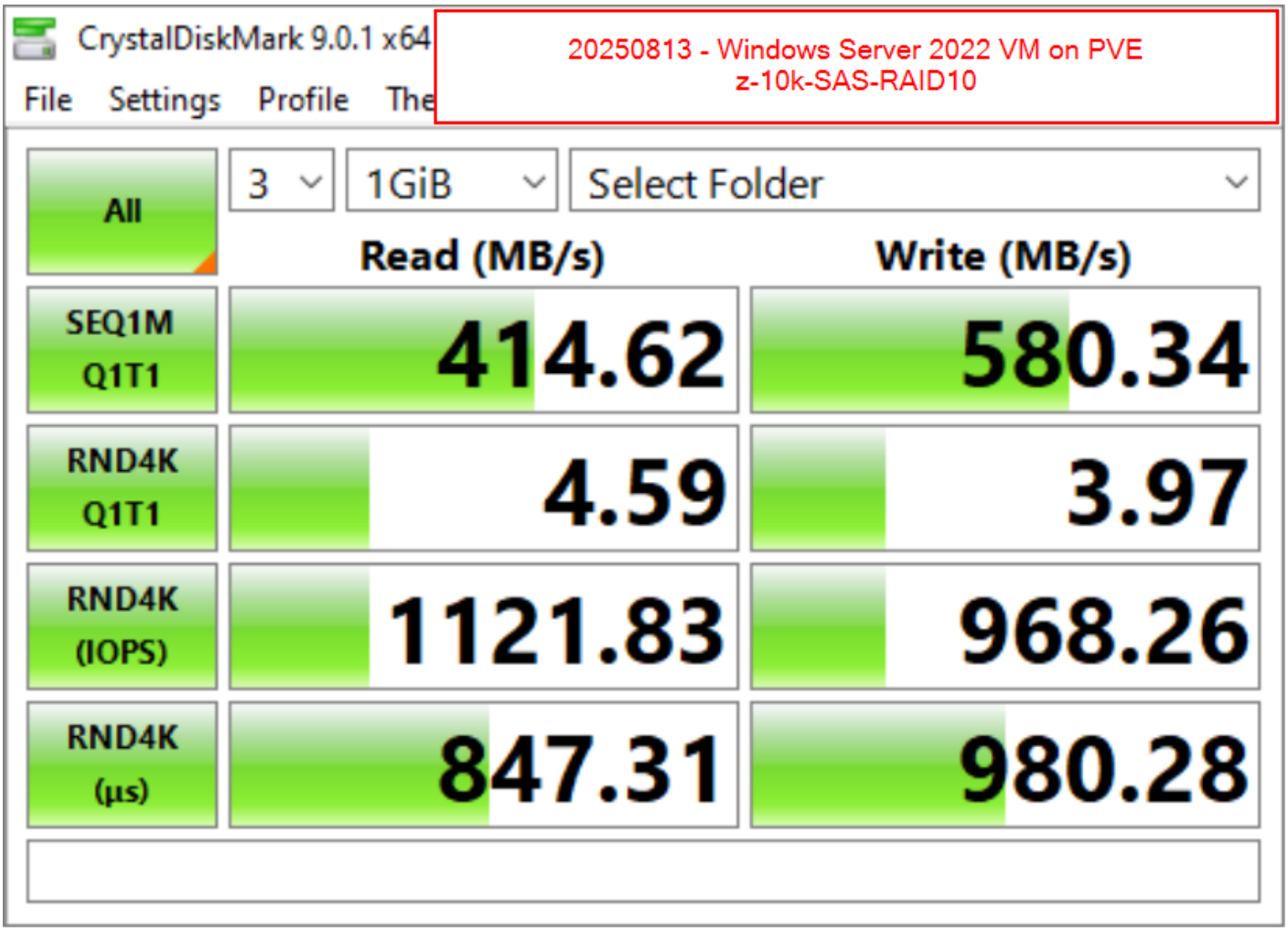



CrystalDiskMark 9.0.1 x64
File
Settings
Profile
The
20250813 - Windows Server 2022 VM on PVE
z-10k-SAS-DS-Mirror + SLOG + Cache
All
3
1GiB
C: 36% (45/126GiB)
Read (MB/s)
Write (MB/s)
SEQ1M Q1T1
459.03
507.95
RND4K Q1T1
4.03
3.88
RND4K (IOPS)
984.38
946.29
RND4K (µs)
968.37
1010.66


CrystalDiskMark 9.0.1 x64
20250813 - Windows Server 2022 VM on PVE
z-10kSAS-dRAID3:6d:10c:1s-0
File
Settings
Profile
All
3
1GiB
Select Folder
MB/s
Read (MB/s)
Write (MB/s)
SEQ1M Q8T1
2681.86
128.34
SEQ1M Q1T1
404.12
639.32
RND4K Q32T1
20.18
16.86
RND4K Q1T1
4.06
3.97


CrystalDiskMark 9.0.1 x64
File Settings Profile The
20250813 - Windows Server 2022 VM on PVE
z-10kSAS-dRAID3:6d:10c:1s-0
All
3
1GiB
Select Folder
Read (MB/s)
Write (MB/s)
SEQ1M Q1T1
481.12
623.66
RND4K Q1T1
4.56
3.98
RND4K (IOPS)
1113.53
971.19
RND4K (µs)
853.19
977.46


CrystalDiskMark 9.0.1 x64
20250813 - Windows Server 2022 VM on PVE
z-10k-SAS-RAID10
File
Settings
Profile
All
3
1GiB
Select Folder
MB/s
Read (MB/s)
Write (MB/s)
SEQ1M Q8T1
2515.36
1357.47
SEQ1M Q1T1
393.23
10.06
RND4K Q32T1
19.35
17.64
RND4K Q1T1
4.29
4.38




```
root@pve:/# cd z-10k-SAS-DS-Mirror/
root@pve:/z-10k-SAS-DS-Mirror# fio --name=sequential_write --rw=write --bs=1M --size=10G --
filename=/root/testfile --direct=1
sequential_write: (g=0): rw=write, bs=(R) 1024KiB-1024KiB, (W) 1024KiB-1024KiB, (T) 1024KiB-
1024KiB, ioengine=psync, iodepth=1
fio-3.39
Starting 1 process
Jobs: 1 (f=1): [W(1)][100.0%][w=69.0MiB/s][w=69 IOPS][eta 00m:00s]
sequential_write: (groupid=0, jobs=1): err= 0: pid=1553236: Tue Aug 12 10:22:50 2025
  write: IOPS=89, BW=89.3MiB/s (93.7MB/s)(10.0GiB/114626msec); 0 zone resets
    clat (msec): min=7, max=315, avg=11.11, stdev= 5.53
     lat (msec): min=8, max=315, avg=11.18, stdev= 5.53
    clat percentiles (msec):
     |  1.00th=[    9],  5.00th=[    9], 10.00th=[    9], 20.00th=[    9],
     | 30.00th=[   10], 40.00th=[   11], 50.00th=[   11], 60.00th=[   11],
     | 70.00th=[   12], 80.00th=[   12], 90.00th=[   13], 95.00th=[   14],
     | 99.00th=[   33], 99.50th=[   42], 99.90th=[   68], 99.95th=[   88],
     | 99.99th=[  116]
```

```
   bw (  KiB/s): min=14336, max=108544, per=100.00%, avg=91516.09, stdev=14694.26, samples=229
   iops        : min=   14, max=  106, avg=89.37, stdev=14.35, samples=229
  lat (msec)   : 10=39.91%, 20=57.56%, 50=2.22%, 100=0.28%, 250=0.02%
  lat (msec)   : 500=0.01%
  cpu          : usr=0.71%, sys=64.60%, ctx=10487, majf=0, minf=7
  IO depths    : 1=100.0%, 2=0.0%, 4=0.0%, 8=0.0%, 16=0.0%, 32=0.0%, >=64=0.0%
     submit    : 0=0.0%, 4=100.0%, 8=0.0%, 16=0.0%, 32=0.0%, 64=0.0%, >=64=0.0%
     complete  : 0=0.0%, 4=100.0%, 8=0.0%, 16=0.0%, 32=0.0%, 64=0.0%, >=64=0.0%
     issued rwts: total=0,10240,0,0 short=0,0,0,0 dropped=0,0,0,0
     latency   : target=0, window=0, percentile=100.00%, depth=1

Run status group 0 (all jobs):
  WRITE: bw=89.3MiB/s (93.7MB/s), 89.3MiB/s-89.3MiB/s (93.7MB/s-93.7MB/s), io=10.0GiB
(10.7GB), run=114626-114626msec



root@pve:/z-10k-SAS-DS-Mirror# fio random_read_test.fio
random_read_job: (g=0): rw=randread, bs=(R) 4096B-4096B, (W) 4096B-4096B, (T) 4096B-4096B,
ioengine=libaio, iodepth=64
fio-3.39
Starting 1 process
random_read_job: Laying out IO file (1 file / 10240MiB)
Jobs: 1 (f=1): [r(1)][100.0%][r=824KiB/s][r=206 IOPS][eta 00m:00s]
random_read_job: (groupid=0, jobs=1): err= 0: pid=1583195: Tue Aug 12 10:50:24 2025
  read: IOPS=203, BW=812KiB/s (832kB/s)(47.6MiB/60003msec)
    slat (usec): min=13, max=123917, avg=4911.77, stdev=3207.67
    clat (usec): min=14, max=542655, avg=309167.09, stdev=35242.70
     lat (msec): min=7, max=546, avg=314.08, stdev=35.48
    clat percentiles (msec):
     |  1.00th=[  262],  5.00th=[  279], 10.00th=[  284], 20.00th=[  292],
     | 30.00th=[  296], 40.00th=[  300], 50.00th=[  305], 60.00th=[  309],
     | 70.00th=[  313], 80.00th=[  321], 90.00th=[  334], 95.00th=[  359],
     | 99.00th=[  472], 99.50th=[  498], 99.90th=[  531], 99.95th=[  535],
     | 99.99th=[  542]
   bw (  KiB/s): min=  199, max= 1264, per=99.97%, avg=812.26, stdev=93.13, samples=120
   iops        : min=   49, max=  316, avg=203.06, stdev=23.32, samples=120
  lat (usec)   : 20=0.01%
  lat (msec)   : 10=0.01%, 20=0.01%, 50=0.06%, 100=0.07%, 250=0.27%
  lat (msec)   : 500=99.21%, 750=0.37%
```

```
  cpu          : usr=0.27%, sys=3.39%, ctx=11691, majf=0, minf=84
  IO depths    : 1=0.1%, 2=0.1%, 4=0.1%, 8=0.1%, 16=0.1%, 32=0.3%, >=64=99.5%
     submit    : 0=0.0%, 4=100.0%, 8=0.0%, 16=0.0%, 32=0.0%, 64=0.0%, >=64=0.0%
     complete  : 0=0.0%, 4=100.0%, 8=0.0%, 16=0.0%, 32=0.0%, 64=0.1%, >=64=0.0%
     issued rwts: total=12184,0,0,0 short=0,0,0,0 dropped=0,0,0,0
     latency   : target=0, window=0, percentile=100.00%, depth=64

Run status group 0 (all jobs):
   READ: bw=812KiB/s (832kB/s), 812KiB/s-812KiB/s (832kB/s-832kB/s), io=47.6MiB (49.9MB),
run=60003-60003msec
```

L1 VM - ZFS Mirrored SSD

```
# Benchmark - write

root@us-pve-101-testing:~# fio --name=sequential_write --rw=write --bs=1M --size=10G --
filename=/root/testfile --direct=1
sequential_write: (g=0): rw=write, bs=(R) 1024KiB-1024KiB, (W) 1024KiB-1024KiB, (T) 1024KiB-
1024KiB, ioengine=psync, iodepth=1
fio-3.36
Starting 1 process
sequential_write: Laying out IO file (1 file / 10240MiB)
Jobs: 1 (f=1): [W(1)][96.6%][eta 00m:06s]
sequential_write: (groupid=0, jobs=1): err= 0: pid=7040: Mon Aug 11 22:41:53 2025
  write: IOPS=58, BW=59.0MiB/s (61.8MB/s)(10.0GiB/173676msec); 0 zone resets
    clat (usec): min=647, max=45665k, avg=16898.79, stdev=707938.73
     lat (usec): min=656, max=45665k, avg=16955.22, stdev=707938.94
    clat percentiles (usec):
     |  1.00th=[     988],  5.00th=[    1352], 10.00th=[    1450],
     | 20.00th=[    1582], 30.00th=[    1647], 40.00th=[    1713],
     | 50.00th=[    1762], 60.00th=[    1795], 70.00th=[    1827],
     | 80.00th=[    1860], 90.00th=[    1909], 95.00th=[    1958],
     | 99.00th=[    2278], 99.50th=[    2409], 99.90th=[    4359],
     | 99.95th=[11475616], 99.99th=[17112761]
   bw (  KiB/s): min=26677, max=819200, per=100.00%, avg=486353.63, stdev=170810.86,
samples=43
```

```
   iops        : min=   26, max=  800, avg=474.84, stdev=166.83, samples=43
  lat (usec)   : 750=0.17%, 1000=0.89%
  lat (msec)   : 2=95.51%, 4=3.31%, 10=0.06%, 750=0.01%, >=2000=0.06%
  cpu          : usr=0.51%, sys=0.95%, ctx=10241, majf=0, minf=13
  IO depths    : 1=100.0%, 2=0.0%, 4=0.0%, 8=0.0%, 16=0.0%, 32=0.0%, >=64=0.0%
     submit    : 0=0.0%, 4=100.0%, 8=0.0%, 16=0.0%, 32=0.0%, 64=0.0%, >=64=0.0%
     complete  : 0=0.0%, 4=100.0%, 8=0.0%, 16=0.0%, 32=0.0%, 64=0.0%, >=64=0.0%
     issued rwts: total=0,10240,0,0 short=0,0,0,0 dropped=0,0,0,0
     latency   : target=0, window=0, percentile=100.00%, depth=1

Run status group 0 (all jobs):
  WRITE: bw=59.0MiB/s (61.8MB/s), 59.0MiB/s-59.0MiB/s (61.8MB/s-61.8MB/s), io=10.0GiB
(10.7GB), run=173676-173676msec

Disk stats (read/write):
  sda: ios=0/10537, sectors=0/21021040, merge=0/500, ticks=0/4724709, in_queue=4862347,
util=97.87%



# Benchmark - read

root@us-pve-101-testing:~# fio random_read_test.fio
random_read_job: (g=0): rw=randread, bs=(R) 4096B-4096B, (W) 4096B-4096B, (T) 4096B-4096B,
ioengine=libaio, iodepth=64
fio-3.36
Starting 1 process
Jobs: 1 (f=1): [r(1)][100.0%][r=308MiB/s][r=78.9k IOPS][eta 00m:00s]
random_read_job: (groupid=0, jobs=1): err= 0: pid=7047: Mon Aug 11 22:43:10 2025
  read: IOPS=76.1k, BW=297MiB/s (312MB/s)(17.4GiB/60001msec)
    slat (usec): min=2, max=5361, avg= 8.95, stdev= 8.40
    clat (usec): min=115, max=8190, avg=831.02, stdev=330.81
     lat (usec): min=158, max=8199, avg=839.97, stdev=334.39
    clat percentiles (usec):
     |  1.00th=[  351],  5.00th=[  388], 10.00th=[  416], 20.00th=[  486],
     | 30.00th=[  562], 40.00th=[  619], 50.00th=[  898], 60.00th=[ 1057],
     | 70.00th=[ 1090], 80.00th=[ 1123], 90.00th=[ 1172], 95.00th=[ 1221],
     | 99.00th=[ 1663], 99.50th=[ 1745], 99.90th=[ 1876], 99.95th=[ 2008],
     | 99.99th=[ 2540]
   bw (  KiB/s): min=213812, max=539568, per=100.00%, avg=305124.23, stdev=72008.27,
```

```
samples=119
   iops        : min=53453, max=134892, avg=76281.10, stdev=18002.05, samples=119
  lat (usec)   : 250=0.01%, 500=21.93%, 750=26.28%, 1000=4.38%
  lat (msec)   : 2=47.36%, 4=0.05%, 10=0.01%
  cpu          : usr=32.95%, sys=65.00%, ctx=11406, majf=0, minf=77
  IO depths    : 1=0.1%, 2=0.1%, 4=0.1%, 8=0.1%, 16=0.1%, 32=0.1%, >=64=100.0%
     submit    : 0=0.0%, 4=100.0%, 8=0.0%, 16=0.0%, 32=0.0%, 64=0.0%, >=64=0.0%
     complete  : 0=0.0%, 4=100.0%, 8=0.0%, 16=0.0%, 32=0.0%, 64=0.1%, >=64=0.0%
     issued rwts: total=4564316,0,0,0 short=0,0,0,0 dropped=0,0,0,0
     latency   : target=0, window=0, percentile=100.00%, depth=64

Run status group 0 (all jobs):
   READ: bw=297MiB/s (312MB/s), 297MiB/s-297MiB/s (312MB/s-312MB/s), io=17.4GiB (18.7GB),
run=60001-60001msec

Disk stats (read/write):
  sda: ios=4557508/19, sectors=36460064/176, merge=0/5, ticks=758830/37038, in_queue=832901,
util=68.19%
```

L1 VM - ZFS Mirrored 10K SAS + SLOG + Cache

```
root@us-pve-101-testing:~# fio --name=sequential_write --rw=write --bs=1M --size=10G --
filename=/root/testfile --direct=1
sequential_write: (g=0): rw=write, bs=(R) 1024KiB-1024KiB, (W) 1024KiB-1024KiB, (T) 1024KiB-
1024KiB, ioengine=psync, iodepth=1
fio-3.36
Starting 1 process
Jobs: 1 (f=1): [W(1)][100.0%][w=185MiB/s][w=185 IOPS][eta 00m:00s]
sequential_write: (groupid=0, jobs=1): err= 0: pid=997: Tue Aug 12 14:53:40 2025
  write: IOPS=253, BW=253MiB/s (265MB/s)(10.0GiB/40449msec); 0 zone resets
    clat (usec): min=1113, max=188603, avg=3871.65, stdev=2642.15
     lat (usec): min=1149, max=188642, avg=3943.94, stdev=2641.43
    clat percentiles (usec):
     |  1.00th=[ 1500],  5.00th=[ 1631], 10.00th=[ 1745], 20.00th=[ 1827],
     | 30.00th=[ 1942], 40.00th=[ 2311], 50.00th=[ 4817], 60.00th=[ 5211],
     | 70.00th=[ 5407], 80.00th=[ 5604], 90.00th=[ 5932], 95.00th=[ 6128],
     | 99.00th=[ 6652], 99.50th=[ 6849], 99.90th=[ 7177], 99.95th=[ 7898],
     | 99.99th=[64750]
   bw (  KiB/s): min=149504, max=610304, per=100.00%, avg=260124.17, stdev=140385.29,
```

```
samples=80
   iops        : min=  146, max=  596, avg=253.86, stdev=137.09, samples=80
  lat (msec)   : 2=32.85%, 4=15.03%, 10=52.07%, 20=0.03%, 100=0.01%
  lat (msec)   : 250=0.01%
  cpu          : usr=3.08%, sys=3.15%, ctx=10243, majf=0, minf=13
  IO depths    : 1=100.0%, 2=0.0%, 4=0.0%, 8=0.0%, 16=0.0%, 32=0.0%, >=64=0.0%
     submit    : 0=0.0%, 4=100.0%, 8=0.0%, 16=0.0%, 32=0.0%, 64=0.0%, >=64=0.0%
     complete  : 0=0.0%, 4=100.0%, 8=0.0%, 16=0.0%, 32=0.0%, 64=0.0%, >=64=0.0%
     issued rwts: total=0,10240,0,0 short=0,0,0,0 dropped=0,0,0,0
     latency   : target=0, window=0, percentile=100.00%, depth=1

Run status group 0 (all jobs):
  WRITE: bw=253MiB/s (265MB/s), 253MiB/s-253MiB/s (265MB/s-265MB/s), io=10.0GiB (10.7GB),
run=40449-40449msec

Disk stats (read/write):
  sda: ios=1/10259, sectors=8/20959881, merge=0/12, ticks=3/58119, in_queue=77002, util=93.49%



root@us-pve-101-testing:~# fio random_read_test.fio
random_read_job: (g=0): rw=randread, bs=(R) 4096B-4096B, (W) 4096B-4096B, (T) 4096B-4096B,
ioengine=libaio, iodepth=64
fio-3.36
Starting 1 process
Jobs: 1 (f=1): [r(1)][100.0%][r=486MiB/s][r=124k IOPS][eta 00m:00s]
random_read_job: (groupid=0, jobs=1): err= 0: pid=1000: Tue Aug 12 14:54:52 2025
  read: IOPS=93.0k, BW=363MiB/s (381MB/s)(21.3GiB/60001msec)
    slat (usec): min=2, max=525, avg= 7.23, stdev= 7.05
    clat (usec): min=106, max=4144, avg=679.83, stdev=343.27
     lat (usec): min=166, max=4152, avg=687.06, stdev=346.99
    clat percentiles (usec):
     |  1.00th=[  355],  5.00th=[  383], 10.00th=[  400], 20.00th=[  420],
     | 30.00th=[  437], 40.00th=[  457], 50.00th=[  486], 60.00th=[  537],
     | 70.00th=[  832], 80.00th=[ 1139], 90.00th=[ 1188], 95.00th=[ 1254],
     | 99.00th=[ 1532], 99.50th=[ 1762], 99.90th=[ 1876], 99.95th=[ 1909],
     | 99.99th=[ 2089]
   bw (  KiB/s): min=211328, max=580672, per=99.82%, avg=371243.65, stdev=97421.62,
samples=119
   iops        : min=52832, max=145168, avg=92810.87, stdev=24355.37, samples=119
```

```
  lat (usec)   : 250=0.01%, 500=54.35%, 750=14.73%, 1000=2.17%
  lat (msec)   : 2=28.73%, 4=0.02%, 10=0.01%
  cpu          : usr=35.72%, sys=62.92%, ctx=11510, majf=0, minf=76
  IO depths    : 1=0.1%, 2=0.1%, 4=0.1%, 8=0.1%, 16=0.1%, 32=0.1%, >=64=100.0%
     submit    : 0=0.0%, 4=100.0%, 8=0.0%, 16=0.0%, 32=0.0%, 64=0.0%, >=64=0.0%
     complete  : 0=0.0%, 4=100.0%, 8=0.0%, 16=0.0%, 32=0.0%, 64=0.1%, >=64=0.0%
     issued rwts: total=5578560,0,0,0 short=0,0,0,0 dropped=0,0,0,0
     latency   : target=0, window=0, percentile=100.00%, depth=64

Run status group 0 (all jobs):
   READ: bw=363MiB/s (381MB/s), 363MiB/s-363MiB/s (381MB/s-381MB/s), io=21.3GiB (22.8GB),
run=60001-60001msec

Disk stats (read/write):
  sda: ios=5562235/9, sectors=44497880/80, merge=0/2, ticks=1046679/49508, in_queue=1124064,
util=53.76%
```

Nested VM Benchmark - ZFS Mirrored SSD

```
# Benchmark - Write

root@us-hv-nested:~# fio --name=sequential_write --rw=write --bs=1M --size=10G --
filename=/root/testfile --direct=1
sequential_write: (g=0): rw=write, bs=(R) 1024KiB-1024KiB, (W) 1024KiB-1024KiB, (T) 1024KiB-
1024KiB, ioengine=psync, iodepth=1
fio-3.36
Starting 1 process
sequential_write: Laying out IO file (1 file / 10240MiB)
Jobs: 1 (f=1): [W(1)][99.1%][w=165MiB/s][w=165 IOPS][eta 00m:02s]
sequential_write: (groupid=0, jobs=1): err= 0: pid=1439: Mon Aug 11 22:26:29 2025
  write: IOPS=44, BW=44.5MiB/s (46.6MB/s)(10.0GiB/230323msec); 0 zone resets
    clat (usec): min=9, max=28370k, avg=22023.80, stdev=535433.32
     lat (usec): min=9, max=28370k, avg=22285.21, stdev=535432.32
    clat percentiles (msec):
     |  1.00th=[    4],  5.00th=[    5], 10.00th=[    6], 20.00th=[    6],
     | 30.00th=[    6], 40.00th=[    6], 50.00th=[    7], 60.00th=[    7],
```

```
     | 70.00th=[    7], 80.00th=[    8], 90.00th=[    9], 95.00th=[   10],
     | 99.00th=[   16], 99.50th=[   25], 99.90th=[ 1838], 99.95th=[14429],
     | 99.99th=[17113]
   bw (  KiB/s): min= 4079, max=176761, per=100.00%, avg=132012.25, stdev=31904.93,
samples=157
   iops        : min=    3, max=  172, avg=128.38, stdev=31.21, samples=157
  lat (usec)   : 10=0.01%, 500=0.01%
  lat (msec)   : 2=0.06%, 4=0.99%, 10=94.77%, 20=3.56%, 50=0.33%
  lat (msec)   : 100=0.06%, 250=0.08%, 500=0.01%, 750=0.01%, 2000=0.02%
  lat (msec)   : >=2000=0.10%
  cpu          : usr=0.91%, sys=8.89%, ctx=12455, majf=0, minf=16
  IO depths    : 1=100.0%, 2=0.0%, 4=0.0%, 8=0.0%, 16=0.0%, 32=0.0%, >=64=0.0%
     submit    : 0=0.0%, 4=100.0%, 8=0.0%, 16=0.0%, 32=0.0%, 64=0.0%, >=64=0.0%
     complete  : 0=0.0%, 4=100.0%, 8=0.0%, 16=0.0%, 32=0.0%, 64=0.0%, >=64=0.0%
     issued rwts: total=0,10240,0,0 short=0,0,0,0 dropped=0,0,0,0
     latency   : target=0, window=0, percentile=100.00%, depth=1

Run status group 0 (all jobs):
  WRITE: bw=44.5MiB/s (46.6MB/s), 44.5MiB/s-44.5MiB/s (46.6MB/s-46.6MB/s), io=10.0GiB
(10.7GB), run=230323-230323msec

Disk stats (read/write):
  sda: ios=111/10313, sectors=3728/20900664, merge=90/235, ticks=2312/790448, in_queue=937669,
util=89.85%
```

Benchmark - Read

```
root@us-hv-nested:~# fio random_read_test.fio
random_read_job: (g=0): rw=randread, bs=(R) 4096B-4096B, (W) 4096B-4096B, (T) 4096B-4096B,
ioengine=libaio, iodepth=64
fio-3.36
Starting 1 process
Jobs: 1 (f=1): [r(1)][100.0%][r=3498KiB/s][r=874 IOPS][eta 00m:00s]
random_read_job: (groupid=0, jobs=1): err= 0: pid=1454: Mon Aug 11 22:27:43 2025
  read: IOPS=1151, BW=4608KiB/s (4718kB/s)(270MiB/60009msec)
    slat (nsec): min=1200, max=30439k, avg=506941.31, stdev=1047300.59
    clat (msec): min=2, max=335, avg=54.75, stdev=34.49
```

```
     lat (msec): min=3, max=335, avg=55.26, stdev=34.75
    clat percentiles (msec):
     |  1.00th=[   15],  5.00th=[   16], 10.00th=[   17], 20.00th=[   19],
     | 30.00th=[   24], 40.00th=[   37], 50.00th=[   61], 60.00th=[   68],
     | 70.00th=[   73], 80.00th=[   80], 90.00th=[   93], 95.00th=[  111],
     | 99.00th=[  157], 99.50th=[  176], 99.90th=[  215], 99.95th=[  288],
     | 99.99th=[  326]
   bw (  KiB/s): min= 2003, max=11768, per=100.00%, avg=4613.21, stdev=1889.89, samples=118
   iops        : min=  500, max= 2942, avg=1152.94, stdev=472.50, samples=118
  lat (msec)   : 4=0.01%, 10=0.01%, 20=24.47%, 50=21.04%, 100=46.64%
  lat (msec)   : 250=7.75%, 500=0.08%
  cpu          : usr=5.15%, sys=81.55%, ctx=7548, majf=0, minf=76
  IO depths    : 1=0.1%, 2=0.1%, 4=0.1%, 8=0.1%, 16=0.1%, 32=0.1%, >=64=99.9%
     submit    : 0=0.0%, 4=100.0%, 8=0.0%, 16=0.0%, 32=0.0%, 64=0.0%, >=64=0.0%
     complete  : 0=0.0%, 4=100.0%, 8=0.0%, 16=0.0%, 32=0.0%, 64=0.1%, >=64=0.0%
     issued rwts: total=69124,0,0,0 short=0,0,0,0 dropped=0,0,0,0
     latency   : target=0, window=0, percentile=100.00%, depth=64

Run status group 0 (all jobs):
   READ: bw=4608KiB/s (4718kB/s), 4608KiB/s-4608KiB/s (4718kB/s-4718kB/s), io=270MiB (283MB),
run=60009-60009msec

Disk stats (read/write):
  sda: ios=69121/20, sectors=552968/288, merge=0/5, ticks=583586/133, in_queue=583767,
util=67.38%
```

Hardware: PVE: MeLE Overclock 4C

```
# sequential_write
 bw (  KiB/s): min=397312, max=444416, per=100.00%, avg=429994.67, stdev=10951.34, samples=48
 iops        : min=  388, max=  434, avg=419.92, stdev=10.69, samples=48
# random_read
 bw (  KiB/s): min=15336, max=16192, per=100.00%, avg=15984.67, stdev=114.94, samples=120
 iops        : min= 3834, max= 4048, avg=3996.17, stdev=28.74, samples=120
# sequential_read
 bw (  KiB/s): min=10184, max=24472, per=100.00%, avg=19554.20, stdev=1018.25, samples=120
 iops        : min= 2546, max= 6118, avg=4888.53, stdev=254.56, samples=120
```

```
root@pmvh2501:~# fio --name=sequential_write --rw=write --bs=1M --size=10G --
filename=/root/testfile --direct=1
sequential_write: (g=0): rw=write, bs=(R) 1024KiB-1024KiB, (W) 1024KiB-1024KiB, (T) 1024KiB-
1024KiB, ioengine=psync, iodepth=1
fio-3.39
Starting 1 process
sequential_write: Laying out IO file (1 file / 10240MiB)
Jobs: 1 (f=1): [W(1)][100.0%][w=418MiB/s][w=418 IOPS][eta 00m:00s]
sequential_write: (groupid=0, jobs=1): err= 0: pid=2040323: Tue Aug 12 21:03:13 2025
  write: IOPS=419, BW=420MiB/s (440MB/s)(10.0GiB/24394msec); 0 zone resets
    clat (usec): min=1719, max=48467, avg=2336.25, stdev=896.61
     lat (usec): min=1764, max=48512, avg=2380.72, stdev=896.69
    clat percentiles (usec):
     |  1.00th=[ 2147],  5.00th=[ 2180], 10.00th=[ 2212], 20.00th=[ 2278],
     | 30.00th=[ 2278], 40.00th=[ 2311], 50.00th=[ 2311], 60.00th=[ 2311],
     | 70.00th=[ 2311], 80.00th=[ 2311], 90.00th=[ 2376], 95.00th=[ 2409],
     | 99.00th=[ 2573], 99.50th=[ 2802], 99.90th=[17957], 99.95th=[21365],
     | 99.99th=[38536]
   bw (  KiB/s): min=397312, max=444416, per=100.00%, avg=429994.67, stdev=10951.34,
samples=48
   iops        : min=  388, max=  434, avg=419.92, stdev=10.69, samples=48
  lat (msec)   : 2=0.04%, 4=99.70%, 10=0.10%, 20=0.10%, 50=0.07%
  cpu          : usr=2.16%, sys=92.04%, ctx=12136, majf=5, minf=10
  IO depths    : 1=100.0%, 2=0.0%, 4=0.0%, 8=0.0%, 16=0.0%, 32=0.0%, >=64=0.0%
     submit    : 0=0.0%, 4=100.0%, 8=0.0%, 16=0.0%, 32=0.0%, 64=0.0%, >=64=0.0%
     complete  : 0=0.0%, 4=100.0%, 8=0.0%, 16=0.0%, 32=0.0%, 64=0.0%, >=64=0.0%
     issued rwts: total=0,10240,0,0 short=0,0,0,0 dropped=0,0,0,0
     latency   : target=0, window=0, percentile=100.00%, depth=1

Run status group 0 (all jobs):
  WRITE: bw=420MiB/s (440MB/s), 420MiB/s-420MiB/s (440MB/s-440MB/s), io=10.0GiB (10.7GB),
run=24394-24394msec



root@pmvh2501:~# fio random_read_test.fio
random_read_job: (g=0): rw=randread, bs=(R) 4096B-4096B, (W) 4096B-4096B, (T) 4096B-4096B,
ioengine=libaio, iodepth=64
fio-3.39
```

```
Starting 1 process
Jobs: 1 (f=1): [r(1)][100.0%][r=15.6MiB/s][r=3989 IOPS][eta 00m:00s]
random_read_job: (groupid=0, jobs=1): err= 0: pid=2040401: Tue Aug 12 21:04:13 2025
  read: IOPS=3996, BW=15.6MiB/s (16.4MB/s)(937MiB/60001msec)
    slat (usec): min=151, max=4918, avg=248.40, stdev=43.31
    clat (usec): min=2, max=21443, avg=15762.61, stdev=450.75
     lat (usec): min=257, max=21696, avg=16011.01, stdev=454.68
    clat percentiles (usec):
     |  1.00th=[15008],  5.00th=[15139], 10.00th=[15270], 20.00th=[15401],
     | 30.00th=[15533], 40.00th=[15664], 50.00th=[15664], 60.00th=[15795],
     | 70.00th=[15926], 80.00th=[16057], 90.00th=[16188], 95.00th=[16450],
     | 99.00th=[17433], 99.50th=[17695], 99.90th=[18220], 99.95th=[18744],
     | 99.99th=[21103]
   bw (  KiB/s): min=15336, max=16192, per=100.00%, avg=15984.67, stdev=114.94, samples=120
   iops        : min= 3834, max= 4048, avg=3996.17, stdev=28.74, samples=120
  lat (usec)   : 4=0.01%, 500=0.01%, 750=0.01%
  lat (msec)   : 2=0.01%, 4=0.01%, 10=0.01%, 20=99.96%, 50=0.02%
  cpu          : usr=0.72%, sys=9.61%, ctx=240318, majf=0, minf=72
  IO depths    : 1=0.1%, 2=0.1%, 4=0.1%, 8=0.1%, 16=0.1%, 32=0.1%, >=64=100.0%
     submit    : 0=0.0%, 4=100.0%, 8=0.0%, 16=0.0%, 32=0.0%, 64=0.0%, >=64=0.0%
     complete  : 0=0.0%, 4=100.0%, 8=0.0%, 16=0.0%, 32=0.0%, 64=0.1%, >=64=0.0%
     issued rwts: total=239770,0,0,0 short=0,0,0,0 dropped=0,0,0,0
     latency   : target=0, window=0, percentile=100.00%, depth=64

Run status group 0 (all jobs):
   READ: bw=15.6MiB/s (16.4MB/s), 15.6MiB/s-15.6MiB/s (16.4MB/s-16.4MB/s), io=937MiB (982MB),
run=60001-60001msec



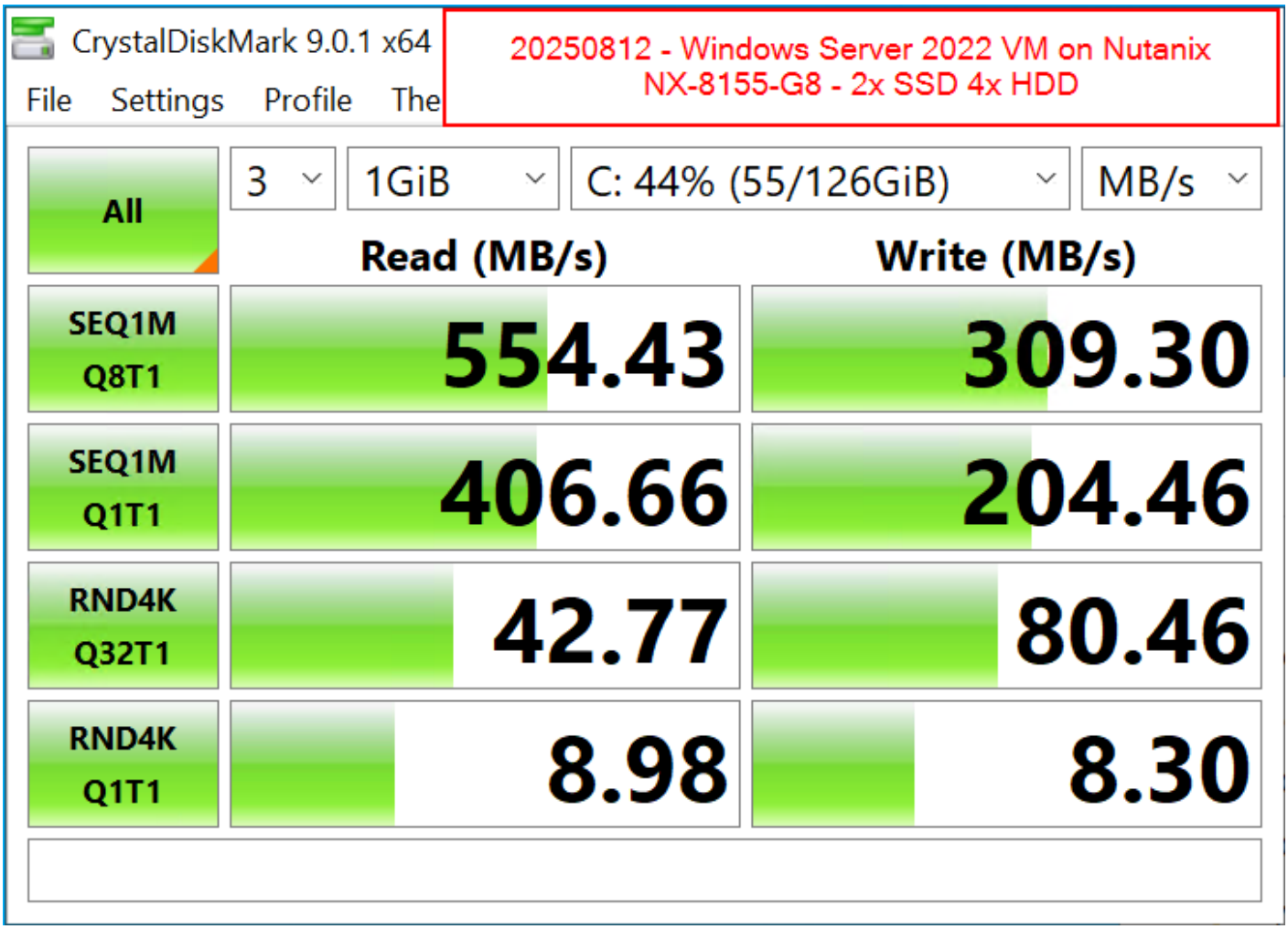
random_read_job: (g=0): rw=read, bs=(R) 4096B-4096B, (W) 4096B-4096B, (T) 4096B-4096B,
ioengine=libaio, iodepth=64
fio-3.39
Starting 1 process
Jobs: 1 (f=1): [R(1)][100.0%][r=18.8MiB/s][r=4820 IOPS][eta 00m:00s]
random_read_job: (groupid=0, jobs=1): err= 0: pid=2041137: Tue Aug 12 21:07:41 2025
  read: IOPS=4888, BW=19.1MiB/s (20.0MB/s)(1146MiB/60001msec)
    slat (usec): min=135, max=32402, avg=202.85, stdev=82.92
    clat (usec): min=2, max=39730, avg=12873.56, stdev=959.97
     lat (usec): min=206, max=67804, avg=13076.41, stdev=978.59
```

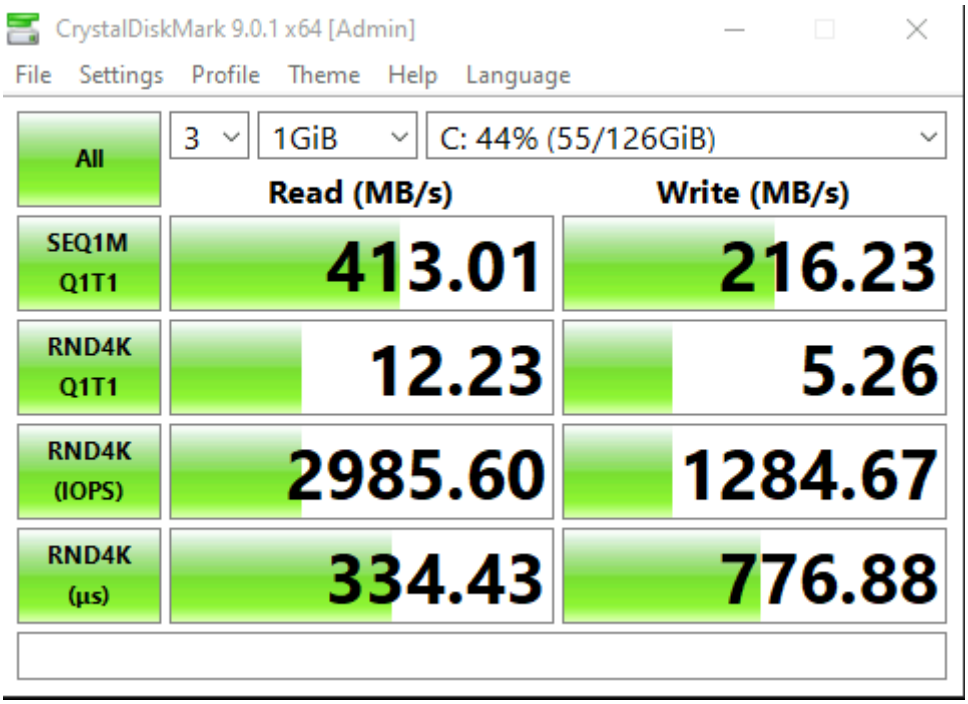
```
    clat percentiles (usec):
     |  1.00th=[10159],  5.00th=[12387], 10.00th=[12518], 20.00th=[12518],
     | 30.00th=[12649], 40.00th=[12780], 50.00th=[12780], 60.00th=[12911],
     | 70.00th=[13042], 80.00th=[13042], 90.00th=[13304], 95.00th=[13566],
     | 99.00th=[15008], 99.50th=[15795], 99.90th=[30278], 99.95th=[34866],
     | 99.99th=[38011]
   bw (  KiB/s): min=10184, max=24472, per=100.00%, avg=19554.20, stdev=1018.25, samples=120
   iops        : min= 2546, max= 6118, avg=4888.53, stdev=254.56, samples=120
  lat (usec)   : 4=0.01%, 250=0.01%, 500=0.01%, 750=0.01%, 1000=0.01%
  lat (msec)   : 2=0.01%, 4=0.01%, 10=0.87%, 20=98.95%, 50=0.17%
  cpu          : usr=0.86%, sys=11.28%, ctx=293962, majf=0, minf=71
  IO depths    : 1=0.1%, 2=0.1%, 4=0.1%, 8=0.1%, 16=0.1%, 32=0.1%, >=64=100.0%
     submit    : 0=0.0%, 4=100.0%, 8=0.0%, 16=0.0%, 32=0.0%, 64=0.0%, >=64=0.0%
     complete  : 0=0.0%, 4=100.0%, 8=0.0%, 16=0.0%, 32=0.0%, 64=0.1%, >=64=0.0%
     issued rwts: total=293313,0,0,0 short=0,0,0,0 dropped=0,0,0,0
     latency   : target=0, window=0, percentile=100.00%, depth=64

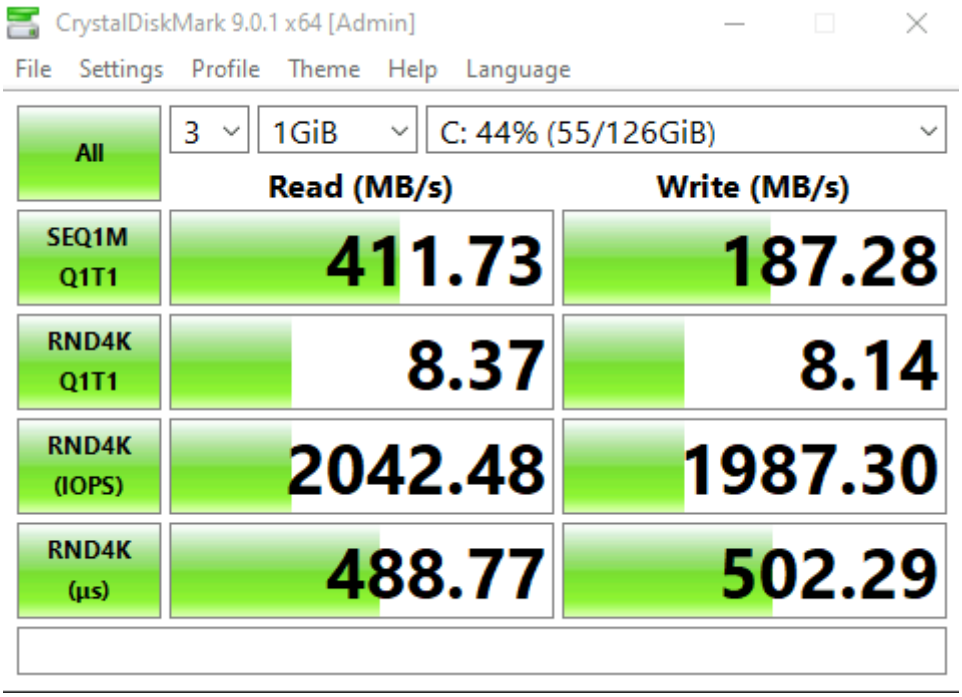
Run status group 0 (all jobs):
   READ: bw=19.1MiB/s (20.0MB/s), 19.1MiB/s-19.1MiB/s (20.0MB/s-20.0MB/s), io=1146MiB
(1201MB), run=60001-60001msec
```

Hardware: Nutanix NX-8155-G8

2 x SSD + 4 HDD
Benchmark was run during business hours with normal production workloads occurring.


CrystalDiskMark 9.0.1 x64
20250812 - Windows Server 2022 VM on Nutanix
NX-8155-G8 - 2x SSD 4x HDD
File Settings Profile The
All
3
1GiB
C: 44% (55/126GiB)
MB/s
Read (MB/s)
Write (MB/s)
SEQ1M Q8T1
554.43
309.30
SEQ1M Q1T1
406.66
204.46
RND4K Q32T1
42.77
80.46
RND4K Q1T1
8.98
8.30


CrystalDiskMark 9.0.1 x64 [Admin]
File Settings Profile Theme Help Language
All
3
1GiB
C: 44% (55/126GiB)
Read (MB/s)
Write (MB/s)
SEQ1M Q1T1
413.01
216.23
RND4K Q1T1
12.23
5.26
RND4K (IOPS)
2985.60
1284.67
RND4K (µs)
334.43
776.88




```
root@nutanix-l1-vm:~# fio --name=sequential_write --rw=write --bs=1M --size=10G --
filename=/root/testfile --direct=1
sequential_write: (g=0): rw=write, bs=(R) 1024KiB-1024KiB, (W) 1024KiB-1024KiB, (T) 1024KiB-
1024KiB, ioengine=psync, iodepth=1
fio-3.28
Starting 1 process
sequential_write: Laying out IO file (1 file / 10240MiB)
Jobs: 1 (f=1): [W(1)][100.0%][w=143MiB/s][w=143 IOPS][eta 00m:00s]
sequential_write: (groupid=0, jobs=1): err= 0: pid=129336: Tue Aug 12 10:51:08 2025
  write: IOPS=155, BW=155MiB/s (163MB/s)(10.0GiB/66001msec); 0 zone resets
    clat (usec): min=4496, max=56501, avg=6377.43, stdev=2162.18
     lat (usec): min=4542, max=56536, avg=6438.83, stdev=2164.59
    clat percentiles (usec):
     |  1.00th=[ 4686],  5.00th=[ 4752], 10.00th=[ 4817], 20.00th=[ 4948],
     | 30.00th=[ 5080], 40.00th=[ 5276], 50.00th=[ 5669], 60.00th=[ 6128],
     | 70.00th=[ 6718], 80.00th=[ 7373], 90.00th=[ 8717], 95.00th=[10290],
     | 99.00th=[14222], 99.50th=[16057], 99.90th=[21365], 99.95th=[25035],
     | 99.99th=[54789]
   bw (  KiB/s): min=120832, max=198656, per=100.00%, avg=159134.29, stdev=25598.04,
samples=131
   iops        : min=  118, max=  194, avg=155.40, stdev=25.00, samples=131
  lat (msec)   : 10=94.29%, 20=5.58%, 50=0.12%, 100=0.02%
  cpu          : usr=1.30%, sys=1.36%, ctx=10368, majf=0, minf=11
  IO depths    : 1=100.0%, 2=0.0%, 4=0.0%, 8=0.0%, 16=0.0%, 32=0.0%, >=64=0.0%
```

```
     submit    : 0=0.0%, 4=100.0%, 8=0.0%, 16=0.0%, 32=0.0%, 64=0.0%, >=64=0.0%
     complete  : 0=0.0%, 4=100.0%, 8=0.0%, 16=0.0%, 32=0.0%, 64=0.0%, >=64=0.0%
     issued rwts: total=0,10240,0,0 short=0,0,0,0 dropped=0,0,0,0
     latency   : target=0, window=0, percentile=100.00%, depth=1

Run status group 0 (all jobs):
  WRITE: bw=155MiB/s (163MB/s), 155MiB/s-155MiB/s (163MB/s-163MB/s), io=10.0GiB (10.7GB),
run=66001-66001msec

Disk stats (read/write):
  sda: ios=0/20672, merge=0/278, ticks=0/122765, in_queue=122764, util=99.93%



root@nutanix-l1-vm:~# fio random_read_test.fio
random_read_job: (g=0): rw=randread, bs=(R) 4096B-4096B, (W) 4096B-4096B, (T) 4096B-4096B,
ioengine=libaio, iodepth=64
fio-3.28
Starting 1 process
Jobs: 1 (f=1): [r(1)][100.0%][r=43.5MiB/s][r=11.1k IOPS][eta 00m:00s]
random_read_job: (groupid=0, jobs=1): err= 0: pid=129344: Tue Aug 12 10:53:31 2025
  read: IOPS=15.3k, BW=59.7MiB/s (62.6MB/s)(3582MiB/60009msec)
    slat (nsec): min=1483, max=352698, avg=2964.05, stdev=2532.94
    clat (usec): min=256, max=236442, avg=4184.75, stdev=4942.01
     lat (usec): min=258, max=236447, avg=4187.82, stdev=4942.20
    clat percentiles (usec):
     |  1.00th=[   537],  5.00th=[   832], 10.00th=[  1090], 20.00th=[  1467],
     | 30.00th=[  1778], 40.00th=[  2114], 50.00th=[  2606], 60.00th=[  3326],
     | 70.00th=[  4424], 80.00th=[  5997], 90.00th=[  8979], 95.00th=[ 12387],
     | 99.00th=[ 21365], 99.50th=[ 25822], 99.90th=[ 47973], 99.95th=[ 62653],
     | 99.99th=[110625]
   bw (  KiB/s): min=11144, max=151008, per=100.00%, avg=61258.53, stdev=26522.54, samples=119
   iops        : min= 2786, max=37752, avg=15314.62, stdev=6630.65, samples=119
  lat (usec)   : 500=0.72%, 750=3.00%, 1000=4.50%
  lat (msec)   : 2=28.65%, 4=29.85%, 10=25.19%, 20=6.85%, 50=1.16%
  lat (msec)   : 100=0.08%, 250=0.01%
  cpu          : usr=2.75%, sys=8.08%, ctx=475071, majf=0, minf=75
  IO depths    : 1=0.1%, 2=0.1%, 4=0.1%, 8=0.1%, 16=0.1%, 32=0.1%, >=64=100.0%
     submit    : 0=0.0%, 4=100.0%, 8=0.0%, 16=0.0%, 32=0.0%, 64=0.0%, >=64=0.0%
```

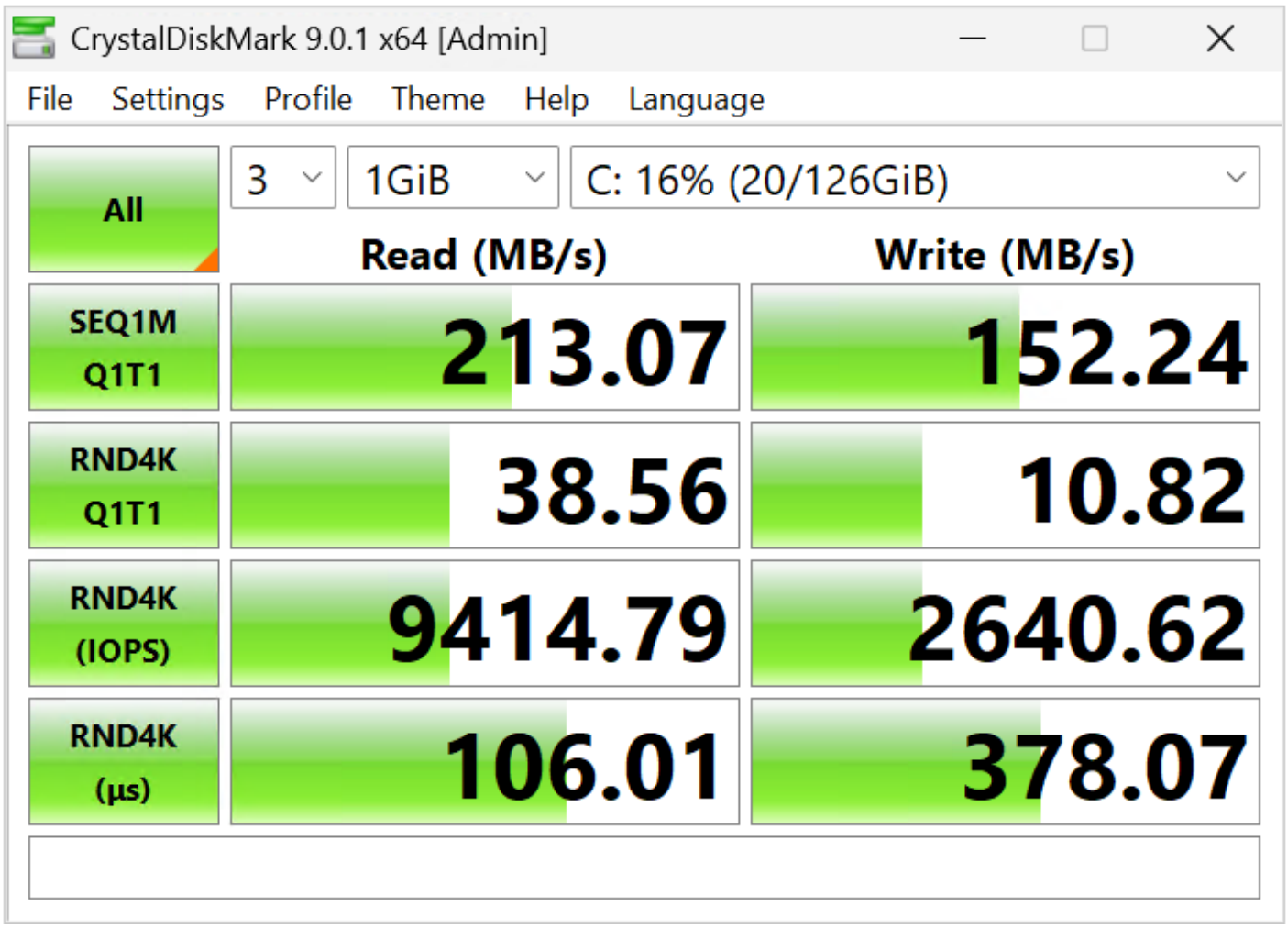
```
      complete  : 0=0.0%, 4=100.0%, 8=0.0%, 16=0.0%, 32=0.0%, 64=0.1%, >=64=0.0%
      issued rwts: total=916907,0,0,0 short=0,0,0,0 dropped=0,0,0,0
      latency   : target=0, window=0, percentile=100.00%, depth=64

Run status group 0 (all jobs):
   READ: bw=59.7MiB/s (62.6MB/s), 59.7MiB/s-59.7MiB/s (62.6MB/s-62.6MB/s), io=3582MiB
(3756MB), run=60009-60009msec

Disk stats (read/write):
  sda: ios=915429/91, merge=0/14, ticks=3817950/1460, in_queue=3819410, util=99.91%
```

Hardware: Azure VM

Standard D2as v6 (2 vcpus, 8 GiB memory)
Storage: Premium SSD LRS



-end

Troubleshooting

Various notes for random troubleshooting

List all block devices with model

```
lsblk -o NAME,MODEL,SERIAL,SIZE,TYPE,MOUNTPOINT
```

Backup to NAS mount via SMB - stale file handle

Testing backups to a QNAP via SMB resulted in failures with the message ***stale file handle***. Setting the option below may have been what fixed the glitch, or it was just unmounting and letting PVE remount. Further testing needed.

```
pvesm set <storage_ID> --options noserverino
umount /mnt/pve/<storage_ID>
```

Notifications via Discord

If your test notifications fail with a 400/500 message, make sure you've added the header Content-Type with value application/json. Below is the Body value I'm using currently.

Discord has a limit to the length of messages that can be sent, and PVE likes to send long messages sometimes. If your test messages are still failing with a status 400 message, they're probably too long. Need a way to limit the number of characters.

```
{
    "content": null,
    "embeds": [
```

```
        {
            "title": "{{ escape title }}",
            "url": "https://[IP]:8006",
            "description": "```{{ escape message }}```",
            "color": null,
            "author": {
                "name": "Proxmox Cluster / Node - [cluster / node name]",
                "url": "https://[IP]:8006"
            },
            "footer": {
                "text": "Proxmox - [cluster/node name]"
            }
        }
    ],
    "attachments": []
}
```

-end

Useful additions

Packages to add

```
apt install lldpd snmpd
```

snmpd.conf

Minimal configuration for `/etc/snmpd/snmpd.conf` to enable monitoring physical host resources via snmp.

```
# file:/etc/snmp/snmpd.conf
sysLocation    Undisclosed location
sysContact     Ghostbusters! <ghost@busters.loc>
sysServices    72

# master  agentx
agentaddress  udp:161

rocommunity  localmon 10.0.0.0/8
rocommunity  localmon 172.16.0.0/12
rocommunity  localmon 192.168.0.0/16
#rocommunity6 localmon fe80::/10

includeDir /etc/snmp/snmpd.conf.d
```

```
cp /etc/snmp/snmpd.conf /etc/snmp/snmpd.backup.conf

cat << EOF > /etc/snmp/snmpd.conf
# file:/etc/snmp/snmpd.conf
sysLocation    Undisclosed location
sysContact     Ghostbusters! <ghost@busters.loc>
```

```
sysServices    72

# master  agentx
agentaddress  udp:161

rocommunity  localmon 10.0.0.0/8
rocommunity  localmon 172.16.0.0/12
rocommunity  localmon 192.168.0.0/16
#rocommunity6 localmon fe80::/10

includeDir /etc/snmp/snmpd.conf.d
EOF
```

-end

ZFS

Upgrade single disk rpool to mirrored rpool

I added a second M.2 drive to a laptop already running Proxmox VE. From the zpool-attach man page:

> If the existing device is a mirror or plain device (e.g. specified as "sda" or "mirror-7"), the new device will be mirrored with the existing device, a resilver will be initiated, and the new device will contribute to additional redundancy once the resilver completes.

Steps:

1. Use gdisk or sgdisk to copy the partition table from the existing drive to the new drive and change the GUID.
2. Make the second disk bootable
3. Attach the new disk to the existing disk using zpool attach.

```
# backup partition table from the existing disk nvme0n1
gdisk /dev/nvme0n1
  b
  gdisk.part.nvme0n1
  q

# restore the backed up partition table to the new disk nvme1n1
gdisk /dev/nvme1n1
  r
  l
```

```
  gdisk.part.nvme0n1
  x
  g
  R
  w
```

```
# same result as using gdisk above
# I have not actually used this method yet
sgdisk --replicate=/dev/nvme1n1 /dev/nvme0n1
sgdisk --randomize-guids /dev/nvme1n1
```

```
pve-efiboot-tool status

# Setup the UEFI bootloader
pve-efiboot-tool format /dev/nvme1n1p2 --force
pve-efiboot-tool init /dev/nvme1n1p2

pve-efiboot-tool status
```

```
#
# BEFORE
#
root@pve1:~# zpool status
  pool: rpool
 state: ONLINE
status: Some supported and requested features are not enabled on the pool.
        The pool can still be used, but some features are unavailable.
action: Enable all features using 'zpool upgrade'. Once this is done,
        the pool may no longer be accessible by software that does not support
        the features. See zpool-features(7) for details.
config:

        NAME                                                    STATE     READ WRITE
CKSUM
        rpool                                                   ONLINE       0
0     0
          nvme-BC711_NVMe_SK_hynix_256GB____FYB1N066013901U4N-part3    ONLINE       0
0     0
```

```
zpool attach rpool nvme-BC711_NVMe_SK_hynix_256GB____FYB1N066013901U4N-part3 nvme-
KBG40ZNS256G_NVMe_KIOXIA_256GB_Y96PC1TDPTLL-part3
```

```
#
# AFTER
#
root@pve1:~# zpool status
  pool: rpool
 state: ONLINE
status: Some supported and requested features are not enabled on the pool.
        The pool can still be used, but some features are unavailable.
action: Enable all features using 'zpool upgrade'. Once this is done,
        the pool may no longer be accessible by software that does not support
        the features. See zpool-features(7) for details.
  scan: resilvered 30.6G in 00:03:12 with 0 errors on Thu Aug  7 16:40:11 2025
config:

        NAME                                                    STATE     READ WRITE
CKSUM
        rpool                                                   ONLINE       0
0     0
          mirror-0                                              ONLINE       0
0     0
            nvme-BC711_NVMe_SK_hynix_256GB____FYB1N066013901U4N-part3  ONLINE       0
0     0
            nvme-KBG40ZNS256G_NVMe_KIOXIA_256GB_Y96PC1TDPTLL-part3     ONLINE       0
0     0
```

Add SLOG

```
# identify the disk(s) you want to use
lsblk -o NAME,MODEL,SERIAL,SIZE,TYPE,MOUNTPOINT

# find the disk / partitions by id
find /dev/disk/by-id/ | grep -e VK0240GFDKF -e MTFDDAK960TCB
```

```
# add the log mirror
zpool add z-10k-SAS-DS-Mirror log mirror /dev/disk/by-id/ata-VK0240GFDKF_S269NX0H703269-part1
/dev/disk/by-id/ata-MTFDDAK960TCB_18181C3C1F61-part1

# verify
zpool status
```

```
# check usage
zpool iostat -v

# watch usage
zpool iostat -v 1
# or
watch zpool iostat -v
```

Add cache (L2ARC)

```
zpool add z-10k-SAS-DS-Mirror cache /dev/disk/by-id/ata-MTFDDAK960TCB_18181C3C1F61-part2
```

HPE Proliant

Install VirtIO Drivers

From the Windows Recovery Console

```
# load drivers into memory
drvload vioscsi.inf
drvload viostor.inf

# check to see if disks are now accessible
wmic logicaldisk get deviceid, volumename, description
# or
diskpart list disk
diskpart list volume
```

```
# load the drivers into the mounted operating system, assuming its on E:\
dism /Image:E:\ /Add-Driver:D:\vioscsi\2k16\amd64\vioscsi.inf
dism /Image:E:\ /Add-Driver:D:\viostor\2k16\amd64\viostor.inf
```