Ceph Benchmark

Fast SSDs and network speeds in a Proxmox VE Ceph Reef cluster

Current fast SSD disks provide great performance, and fast network cards are becoming more affordable. Hence, this is a good point to reevaluate how quickly different network setups for Ceph can be saturated depending on how many OSDs are present in each node.

EXECUTIVE SUMMARY

In this paper we will present the following three key findings regarding hyper-converged Ceph setups with fast disks and high network bandwidth:

- Our benchmarks show that a 10 Gbit/s network can be easily overwhelmed. Even when only using one very fast disk the network becomes a bottleneck quickly.
- A network with a bandwidth of 25 Gbit/s can also become a bottleneck. Nevertheless, some improvements can be gained through configuration changes. Routing via FRR is preferred for a full-mesh cluster over Rapid Spanning Tree Protocol (RSTP). If no fallback is needed, a simple routed setup may also be a (less resilient) option.
- When using a 100 Gbit/s network the bottleneck in the cluster seems to finally shift away from the actual hardware and toward the Ceph client. Here we observed write speeds of up to 6000 MiB/s and read speeds of up to 7000 MiB/s for a single client. However, when using multiple clients in parallel, writing at up to 9800 MiB/s and reading at 19 500 MiB/s was possible.

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TABLE OF CONTENTS

1. INTRODUCTION

Our intention with this benchmark paper is to provide guidance for questions that will arise when acquiring new hardware. The network plays a central role in a Ceph cluster and needs to be well planned. This is especially true since modern disks can provide enormous performance, which can shift the location of typical bottlenecks.

We focus on a small 3-node cluster setup, as it is a common occurrence within the Proxmox VE world. When planning larger clusters, this paper can still prove useful as a starting point.

The benchmarks use the lowest Ceph level, individual objects, directly. We also chose the 4 MiB object size to closely reflect the IO pattern of virtual machines, one of the main use cases of a hyper-converged Proxmox VE Ceph cluster. As the Ceph RBD (Rados Block Device) layer, which provides the functionality used to store disk images, typically also splits disk images into 4 MiB objects.

1.1. DISCLAIMER

When reading this paper, please keep in mind that the numbers presented are averaged and meant as a guideline. Many factors can affect the performance of a Ceph cluster. For example, software and firmware versions/settings, background workload or differences in hardware (different production runs). Hence, if you run your own benchmarks, your results might differ, even between different benchmark runs.

The performance that can be expected in a single virtual machine will be less than the results shown in this paper. This is due to a few additional layers, such as RBD, QEMU/KVM, and the guest OS also playing a role. But taking these layers and their possible configuration options into account will be the scope of another benchmark white-paper.

1.2. CREDITS

The hardware used for the benchmarks was a Proxmox VE Ceph HCI (RI2112) 3-node cluster assembeled by Thomas Krenn, a leading European manufacturer of customized server and storage systems. We would like to thank them for assissting us with choosing and acquiring the cluster used in our tests. They also made us aware of the potential of using a simple routed setup with round-robin bonds. Which we added to our test suit based on their suggestion.

2. TEST BED CONFIGURATION

2.1. HARDWARE

Below are the exact hardware specifications of the **Proxmox VE Ceph HCI (RI2112)** 3-node cluster provided by Thomas Krenn[1]. To test different network speeds easily, multiple NICs were added to the nodes.

Table 1: Node hardware specifications

CPU	2x Intel Xeon Gold 6426Y, 16 cores, 32 threads
Chassis	ASUS RS700-E11-RS12U
Mainboard	ASUS Z13PP-D32
Memory	256 GiB, 16x 16 GiB ECC Reg ATP DDR5 4800 RAM
Network	2x 10 GbE (Intel X710-AT2) RJ45 (onboard) 1x 1 Gigabit Broadcom BCM5719-4P RJ45 Quad Port 1x 25 Gigabit Broadcom P425G SFP28 Quad Port 1x 100 Gigabit Broadcom P2100G QSFP56 Dual Port
OS disks	2x 480 GB ATP N600Sc Superior M.2 NVMe SSD (2280 -T25)
Ceph OSD disks	4x 1.6 TB Kioxia CM7-V U.3 NVMe SSD

2.2. OSD DISKS

The disks used for our benchmarks are Kioxia CM7-V 1.6 TiB U3 SSDs. According to the specifications[2] they achieve 310 k random 4 k IOPS and a bandwidth of 3500 MB/s when writing.

Our tests with a single disk gave the following results:

Table 2: `fio` write benchmark results of a single SSD

SSD	IOPS [IO/s]	Bandwidth [MB/s]
Kioxia CM7-V 1.6 TiB	153 k	3424
Intel Optane P4800x 375 GB	55.1 k	1883
Micron 9300 MAX 3.2 TiB	53.5 k[3]	1473

The commands for the IOPS and Bandwidth tests were:

```
fio --ioengine=libaio --filename=/dev/nvme5n1 --direct=1 --sync=1
    --rw=write --bs=4k --numjobs=1 --iodepth=1 --runtime=60 --time_based
    --name=fio
```

[1] https://www.thomas-krenn.com
[2] https://americas.kioxia.com/en-us/business/ssd/enterprise-ssd/cm7-v.html
[3] This value is considerably worse than in the 2020 Benchmark paper. It might need a full erasure to get back to its initial performance.

```
fio --ioengine=libaio --filename=/dev/nvme5n1 --direct=1 --sync=1
    --rw=write --bs=4M --numjobs=1 --iodepth=1 --runtime=60 --time_based
    --name=fio
```

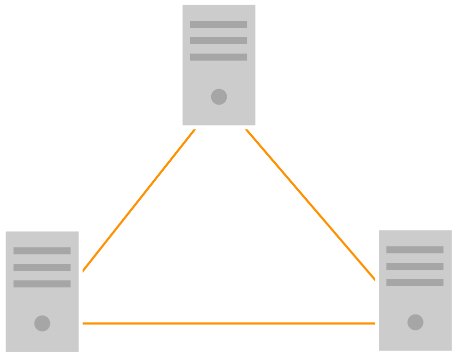
Both commands set the `direct` and `sync` options to avoid any write caches. They also get the acknowledgment of the successful write once the data is persisted in such a way, that a sudden power loss will not cause data loss. With the `numjobs` and `iodepth` set to `1`, we simulate the worst-case scenario. The different block sizes of `4k` and `4M` define if we test for IOPS or bandwidth.

2.3. NETWORK

For most tests, a full-mesh variant was used. The options used were:

- FRR → full-mesh routed (with fallback)[4]
- RSTP → full-mesh RSTP loop setup[5]
- Routed: → full-mesh simple routed setup with round-robin bonds as underlying links[6]

Figure 1: Full-Mesh Network Schema



Additionally, to the full-mesh network, tests were conducted with all three nodes connected via 2x 100 Gbit/s LACP (hash-policy 3+4) to an NVidia (formerly Mellanox) SN2100 100 Gbit/s switch.

[4] https://pve.proxmox.com/wiki/Full_Mesh_Network_for_Ceph_Server#Routed_Setup_.28with_Fallback.29
[5] https://pve.proxmox.com/wiki/Full_Mesh_Network_for_Ceph_Server#RSTP_Loop_Setup
[6] https://pve.proxmox.com/wiki/Full_Mesh_Network_for_Ceph_Server#Routed_Setup_.28Simple.29

Table 3: Tests and their network setup

Test	Network Setup	Connection	Full–Mesh
10 Gbit/s FRR	2x 10 Gbit/s Intel X710-AT2	RJ45 Ethernet	✓
25 Gbit/s RSTP	2x 25 Gbit/s Broadcom P425G	SFP28 DAC	✓
2x 25 Gbit/s RSTP	4x 25 Gbit/s Broadcom P425G Two separate networks for the Ceph public and cluster networks.	SFP28 DAC	✓
25 Gbit/s FRR	2x 25 Gbit/s Broadcom P425G	SFP28 DAC	✓
2x 25 Gbit/s Routed	4x 25 Gbit/s Broadcom P425G Two separate round-robin bonds using two 25 Gbit/s NICs.	SFP28 DAC	✓
100 Gbit/s FRR	2x 100 Gbit/s Broadcom P2100G	QSFP56 DAC	✓
100 Gbit/s RSTP	2x 100 Gbit/s Broadcom P2100G	QSFP56 DAC	✓
100 Gbit/s LACP	2x 100 Gbit/s Broadcom P2100G	QSFP56 DAC	

Each network was verified that it can achieve the advertised speed by running `iperf`[7]. On the 25 Gbit/s network using round-robin bonds and the 100 Gbit/s networks, the `-P` parameter was necessary to run multiple speed tests in parallel to saturate it. In the case of round-robin bonds, multiple parallel connections were also needed to utilize both links making up the bond. Table 3 shows which NICs and connection types were used for each test.

2.4. SOFTWARE

The benchmarks were conducted with Proxmox VE 8.0.7 and kernel *6.5.3-1-pve*. The Firmware for the Broadcom NICs was *227.1.111.0*. Ceph was at version *18.2.0*. No special configurations were applied. See appendix A for more details.

2.5. STORAGE

A single Ceph pool was used. The number of OSDs determinded the number of placement groups (PGs) for the pool for the current test.

Table 4: Relationship of PGs and OSDs

OSDs per node	OSDs in cluster	PGs
1	3	128
2	6	256
3	9	256
4	12	512

[7] `iperf` will run parallel benchmarks in different threads. `iperf3` is single threaded, even with parallel tests, and might not be fast enough to saturate very fast networks.

3. METHODOLOGY

Test runs were done from one node in the cluster. A test run consisted of a write test, followed by a read test. Each test run was performed five times for each number of OSDs per node and network setup variant. The best and worst results were discarded, and the average was calculated from the remaining three results.

The Ceph pool was destroyed and recreated between each test run. The commands for the write and read benchmarks are:

Listing 1: Benchmark command

```
rados -p bench-pool bench 300 write -b 4M -t 16 --no-cleanup -f plain
    --run-name bench_4m
rados -p bench-pool bench 300 seq -t 16 --no-cleanup -f plain --run-name
    bench_4m
```

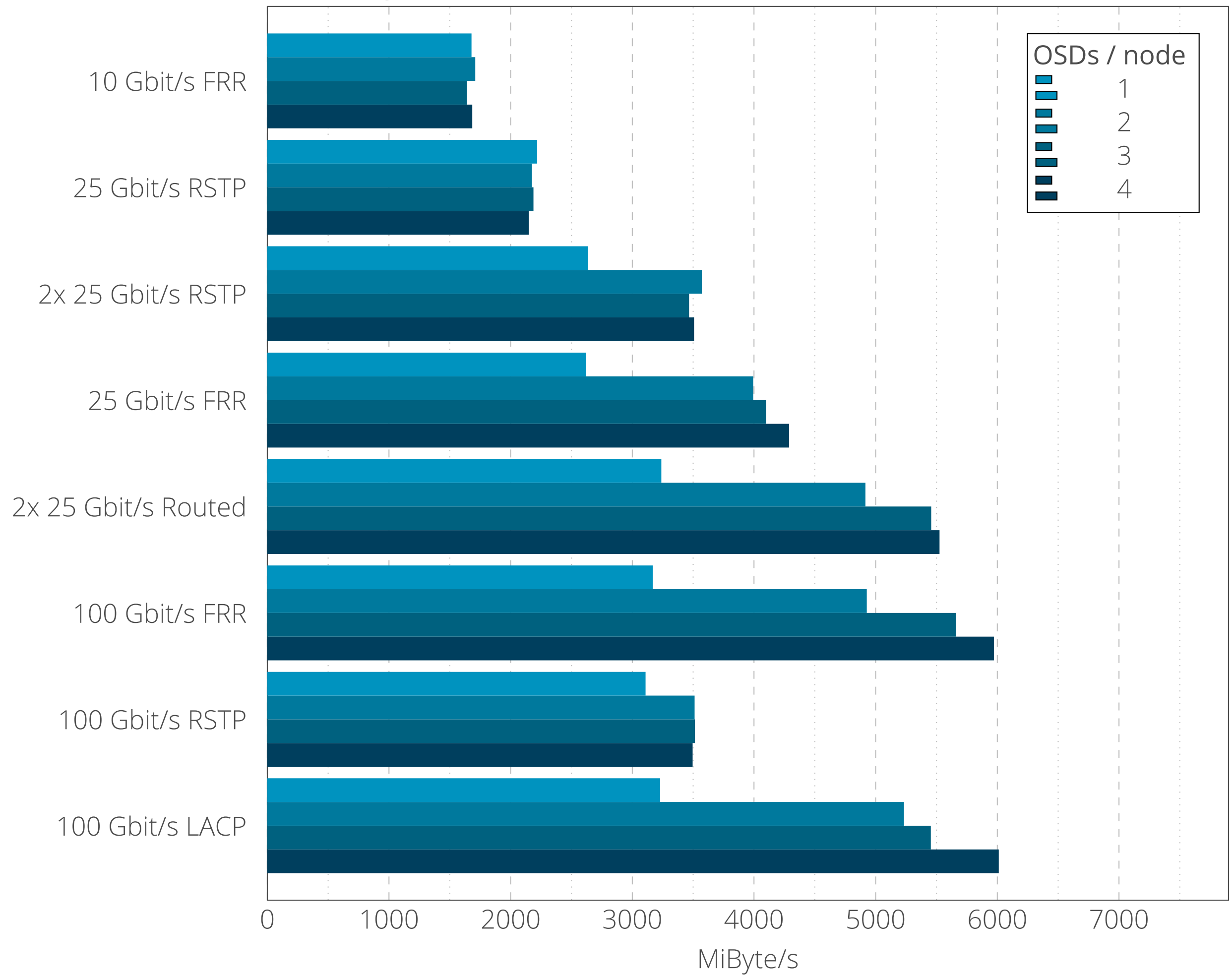
These commands specify a runtime of 300 s or 5 min and 16 threads with an object size of 4 MiB. The reasoning behind the size is explained in the introduction (1).

For the benchmarks that ran in parallel (section 4.3) on multiple nodes, the `--run-name` parameter was set to the individual hostname.

4. RESULTS

4.1. WRITE PERFORMANCE

Figure 2: Write Performance / OSD count



Summary

The results show that the 10 Gbit/s network gets saturated at about 1680 MiB/s with just one NVMe disk. RSTP on a single 25 Gbit/s network does result in better performance than the 10 Gbit/s one (about 2200 MiB/s), but it will not perform better with additional OSDs.

Once two 25 Gbit/s networks are used in the RSTP variant to separate the Ceph public and cluster networks, adding more OSDs to the nodes does result in better performance. With a single OSD, it achieved 2600 MiB/s. But even with just two OSDs, the limit is reached at around 3500 MiB/s and additional OSDs don't improve the performance.

A single 25 Gbit/s network in the FRR variant did show similar performance for a single OSD as using seperate RSTP networks for Ceph's public and cluster network. By adding a second OSD, we see improved speeds (4000 MiB/s), but adding further OSDs does not come with significant gains.

The routed setup that uses two round-robin bonds performed slightly better in our write tests than the 25 Gbit/s FRR setup. This aligns with our expections, as effectively each connection between two nodes should be capable of handling 50 Gbit/s. At this point the bottleneck seems to shift away from the network and towards the disks, as the 100 Gbit/s network only provides slight additional improvements.

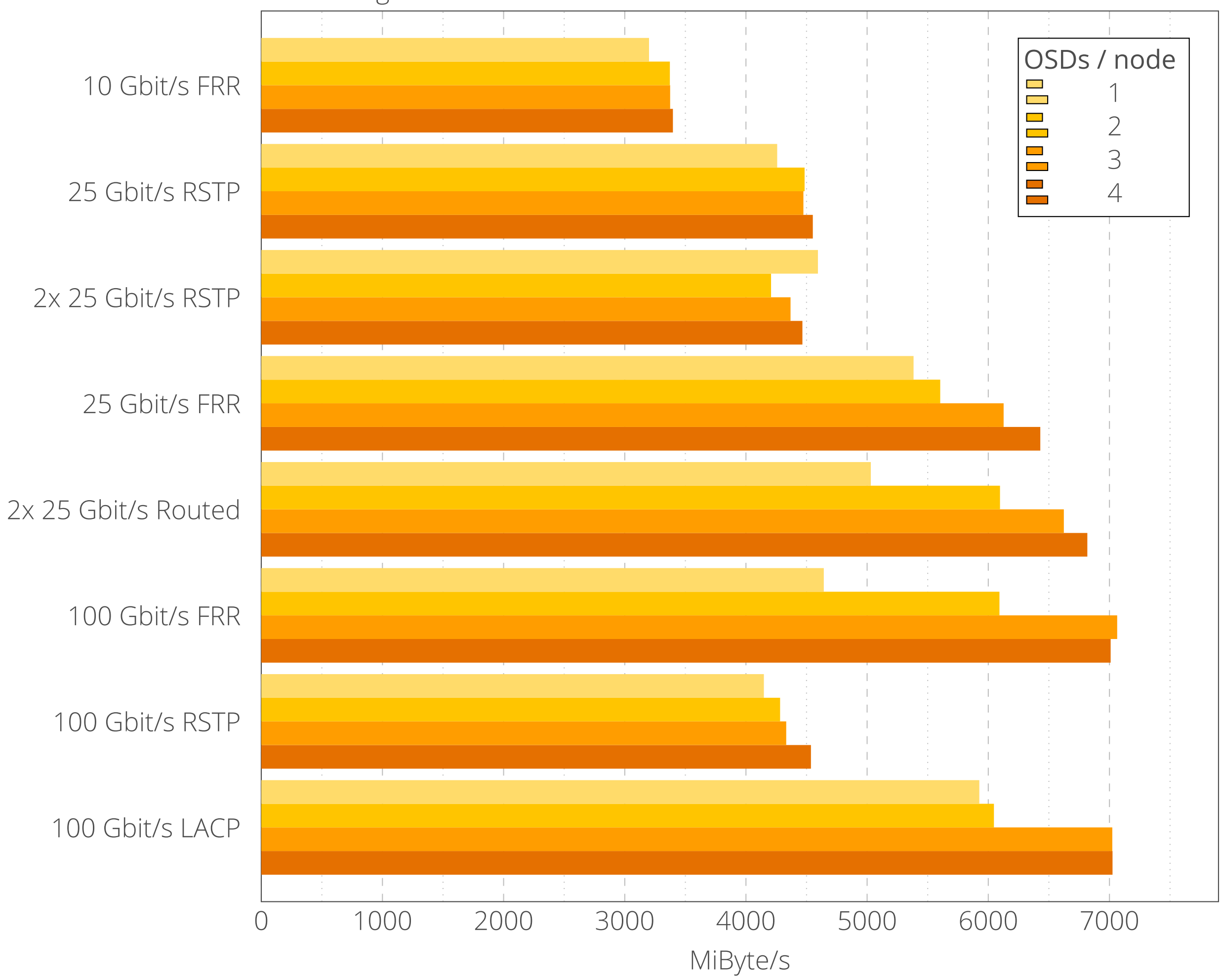
The later tests also show how much more performance a second OSD per node adds. For example, almost 5000 MiB/s are achieved in the routed and 100 Gbit/s FRR tests. Adding a third OSD per node improves the overall performance a bit more (about 5700 MiB/s). With all four OSDs, we see the write performance peaking at 6000 MiB/s in the 100 Gbit/s test. We do seem to run into some limits, though, as the increase is rather small.

While the 100 Gbit/s RSTP variant achieves a similar performance as the 2x 25 Gbit/s RSTP setup. It does perform worse than the 25 Gbit/s FRR!

The 100 Gbit/s LACP setup, where the nodes are connected to a switch, yields similar results as the 100 Gbit/s FRR variant.

4.2. READ PERFORMANCE

Figure 3: Read Performance / OSD count



Summary

Compared to the write performance (4.1), read performance is better throughout. This is because disks are faster at reading data, and in a Ceph cluster, fewer network round trips are needed. The result is, that except for the 25 Gbit/s, 25 Gbit/s routed round-robin bonds, 100 Gbit/s FRR, and LACP setups, additional OSDs do not result in a performance gain.

The 10 Gbit/s network tests max out at 3200 MiB/s to 3400 MiB/s, while the RSTP variants max out between 4200 MiB/s and 4500 MiB/s. With the 25 Gbit/s FRR variant, the read performance does increase with each additional OSD, from 5400 MiB/s to 6400 MiB/s. Similarly, the routed round-robin bond test seems to increase in read performance from one OSD at 5000 MiB/s to four OSDs at 6800 MiB/s. The 100 Gbit/s FRR and LACP setups max out at 7000 MiB/s with three OSDs.

It is also becoming obvious when comparing the read and write results, that network bandwith is less important for read operations. This is expected, as write operations require at least two and possibly three network traversals to write to all OSDs. Read operations at most require one. If the primary OSD is on the same node as the client requesting the operation, no network round trips are needed.

Note

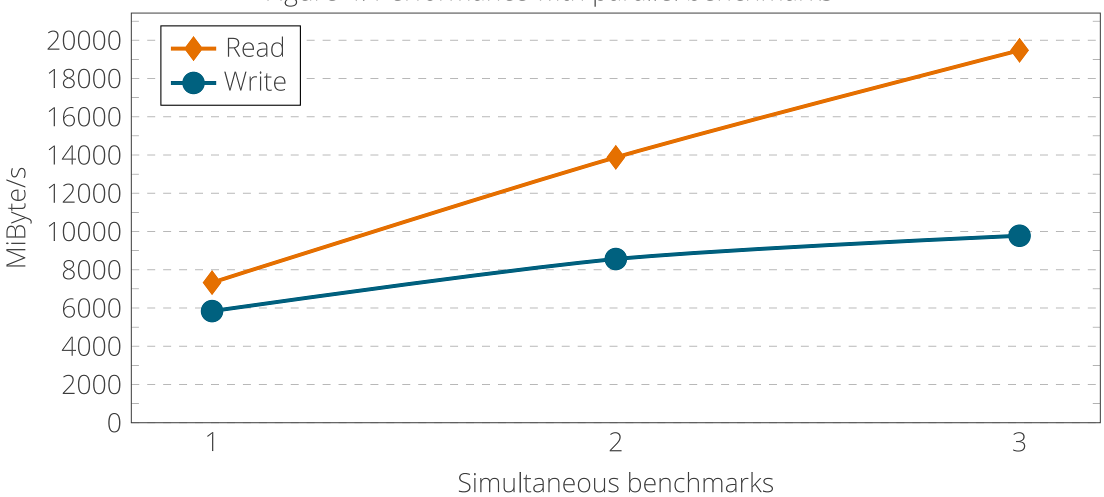
While running these benchmarks, we observed a fair amount of variance between runs. More so with fewer OSDs. We suspect several factors may impact our results, such as, more or less favorable NUMA allocations of the benchmark client and OSD services.

The location of the primary PGs likely also matters. If more of them are located on the same node as the client, performance can be expected to be better. After all, the client always talks with the OSD of the primary PG. This effect should become less significant with larger clusters, as chances that the primary PG is located on the same node go down.

4.3. A SINGLE CLIENT IS NOT ENOUGH

The benchmarks in the previous sections were run on one client at a time. The following graph shows the results of running multiple benchmarks simultaneously, one benchmark per node. Four OSDs per node were used with the 100 Gbit/s FRR network setup.

Figure 4: Performance with parallel benchmarks



Summary

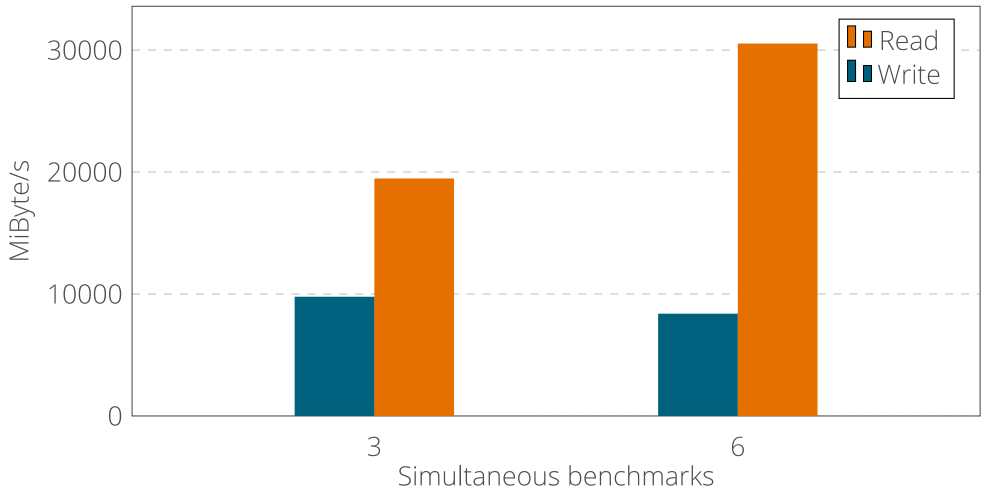
The results for a single node match the results in section 4.1 and 4.2. When additional benchmarks are run on the other nodes at the same time, the overall results improve further. With all three nodes running benchmarks simultaneously, we see a write performance of close to 9800 MiB/s and reads at the 19 500 MiB/s mark.

The conclusion from these results is that a single client or benchmark alone is not enough to utilize the full performance of the overall Ceph cluster.

4.4. SIX NODES - FOR THE FUN OF IT

The hardware used in the 2020 Ceph benchmark paper was still available. So for the fun of it, these servers were connected to the 100 Gbit/s switch and added to the cluster. Each of the older servers has one AMD Epyc 7302P 16-core processor and four Micron 9300 Max 3.2 TB (MTFDHAL3T2TDR) disks. They were connected via a single 100 Gbit/s connection to the switch. Benchmarks were run on all six nodes with four OSDs at the same time. With 24 OSDs in total, the pool was configured to have 1024 PGs.

Figure 5: Simultaneous performance, mixed 6 node cluster. For easier comparison, the results for three nodes from section 4.3 are shown too.



Summary

The write performance is not as good as with just three nodes, at about 8400 MiB/s. Some reasons for that are probably:

- The older nodes are connected via just a single 100 Gbit/s connection, not via 2x LACP 100 Gbit/s as the newer nodes.
- They have larger disks; therefore, Ceph stores more data on them than on the newer nodes with smaller disks.
- The CPUs are not as powerful as in the new nodes.

The read performance, on the other hand, does benefit from the added nodes, as a bit over 30 500 MiB/s were measured.

5. CONCLUSION

It is obvious that a 10 Gbit/s network will practically always be a bottleneck, even with just one fast disk. 25 Gbit/s networks can also become bottlenecks very easily. But it depends on how you set them up and which metric matters most to you. They can perform very well for read-intensive loads.

With the 25 Gbit/s round-robind bonds and 100 Gbit/s networks, we see that there is a limit with more OSDs, but additional tests indicate that this is more likely related to the benchmark client. The overall cluster has enough resources available to handle multiple benchmarks at the same time.

When using a full-mesh network, attention needs to be paid to the performance characteristics of the different available variants. RSTP full-mesh networks performed consistently worse than the FRR variants.

Write performance with four OSDs and a single benchmark can reach around 6000 MiB/s with a 100 Gbit/s connection (FRR and LACP). While read performance for the same setups reaches about 7000 MiB/s. With three simultaneous benchmarks, one per node, the overall performance measured was close to 9800 MiB/s writing and 19 500 MiB/s reading.

6. QUESTIONS & ANSWERS

HOW MANY OSDS SHOULD I PUT INTO A NODE?

Performance is not the only parameter that goes into this decision. You will also have to consider different failure scenarios, especially in small clusters. A 3-node cluster is the absolute minimum for Ceph and a special case since the number of nodes is equal to the number of replicas (`size = 3`).

This means that each replica is stored on one of the nodes. If a node fails, Ceph cannot recover from that, as there is no node available, that does not already have one replica. But if only a single OSD in a node fails, Ceph can recover the lost data on the same node. This, in turn, means that the remaining OSDs in the node can easily be filled up.

Thus, for such small clusters, we recommend either only using one OSD or at least four. With just one OSD per node, the loss of it is similar to the loss of a full node. Ceph will only be able to recover from it if the OSD gets fixed or replaced. With at least four OSDs per node, the data that needs to be recovered from the lost OSD can be split up across the remaining OSDs. This reduces the chances that one OSD will run full.

Having more, but smaller, OSDs is a good decision to give Ceph better options to recover, but it needs to be balanced by the additional CPU and memory resources needed.

HOW MANY NODES SHOULD I PLAN FOR MY CLUSTER?

Three nodes are the bare minimum to run a Ceph cluster. It can be a cost-effective way of running a hyper-converged infrastructure, especially when used with a full-mesh network. But there are more edge cases to be considered.

If possible, using more, potentially smaller-sized nodes is preferable, as it gives Ceph more options to recover if a node or OSD fails.

CAN I USE CONSUMER OR PROSUMER SSDS, AS THESE ARE MUCH CHEAPER THAN ENTERPRISE-CLASS SSDS?

No. Never. These SSDs are optimized for desktop use, which comes in bursts. For your Ceph cluster, you want SSDs that can handle long, sustained writes without losing performance. Additionally, consumer and prosumer SSDs don't have the endurance and might fail in a short time. The power-loss protection (PLP) of datacenter SSDs enables them to acknowledge sync writes much quicker, without losing data in case of a sudden power loss.

CAN I MIX VARIOUS DISK TYPES?

It is possible, but the cluster performance will be harder to predict, as the slower disks will bring down the overall performance.

CAN I MIX DIFFERENT DISK SIZES?

No, it's not recommended to use different disk sizes in small clusters because this will provoke unbalanced data distribution

A. VERSIONS

PROXMOX VE & CEPH

```
$ pveversion -v
proxmox-ve: 8.0.2 (running kernel: 6.5.3-1-pve)
pve-manager: 8.0.7 (running version: 8.0.7/2018dc0774619ba1)
pve-kernel-6.2: 8.0.5
proxmox-kernel-helper: 8.0.3
proxmox-kernel-6.5: 6.5.3-1
proxmox-kernel-6.5.3-1-pve: 6.5.3-1
proxmox-kernel-6.2.16-19-pve: 6.2.16-19
proxmox-kernel-6.2: 6.2.16-19
proxmox-kernel-6.2.16-15-pve: 6.2.16-15
pve-kernel-6.2.16-3-pve: 6.2.16-3
ceph: 18.2.0-pve2
ceph-fuse: 18.2.0-pve2
corosync: 3.1.7-pve3
criu: 3.17.1-2
glusterfs-client: 10.3-5
ifupdown2: 3.2.0-1+pmx5
ksm-control-daemon: 1.4-1
libjs-extjs: 7.0.0-4
libknet1: 1.28-pve1
libproxmox-acme-perl: 1.4.6
libproxmox-backup-qemu0: 1.4.0
libproxmox-rs-perl: 0.3.1
libpve-access-control: 8.0.5
libpve-apiclient-perl: 3.3.1
libpve-common-perl: 8.0.9
libpve-guest-common-perl: 5.0.5
libpve-http-server-perl: 5.0.5
libpve-rs-perl: 0.8.6
libpve-storage-perl: 8.0.3
libspice-server1: 0.15.1-1
lvm2: 2.03.16-2
lxc-pve: 5.0.2-4
lxcfs: 5.0.3-pve3
novnc-pve: 1.4.0-2
openvswitch-switch: 3.1.0-2
proxmox-backup-client: 3.0.4-1
proxmox-backup-file-restore: 3.0.4-1
proxmox-kernel-helper: 8.0.3
proxmox-mail-forward: 0.2.0
proxmox-mini-journalreader: 1.4.0
proxmox-widget-toolkit: 4.0.9
pve-cluster: 8.0.4
pve-container: 5.0.5
pve-docs: 8.0.5
pve-edk2-firmware: 3.20230228-4
pve-firewall: 5.0.3
```

```
pve-firmware: 3.8-5
pve-ha-manager: 4.0.2
pve-i18n: 3.0.7
pve-qemu-kvm: 8.1.2-1
pve-xtermjs: 5.3.0-2
qemu-server: 8.0.7
smartmontools: 7.3-pve1
spiceterm: 3.3.0
swtpm: 0.8.0+pve1
vncterm: 1.8.0
zfsutils-linux: 2.2.0-pve1
```

BIOS

```
$ dmidecode -t bios
# dmidecode 3.4
Getting SMBIOS data from sysfs.
SMBIOS 3.5.0 present.

Handle 0x0000, DMI type 0, 26 bytes
BIOS Information
        Vendor: American Megatrends Inc.
        Version: 0702
        Release Date: 05/19/2023
        Address: 0xF0000
        Runtime Size: 64 kB
        ROM Size: 32 MB
        Characteristics:
                PCI is supported
                BIOS is upgradeable
                BIOS shadowing is allowed
                Boot from CD is supported
                Selectable boot is supported
                BIOS ROM is socketed
                EDD is supported
                ACPI is supported
                BIOS boot specification is supported
                Targeted content distribution is supported
                UEFI is supported
        BIOS Revision: 7.2
```

NIC FIRMWARE

Broadcom

- Device #1 → Broadcom P425G
- Device #2 → Broadcom P2100G

```
$ ./bnxtnvm list

Device #1
---------
Device: enp42s0f0np0
item type          ord.ext    data/length  attr version
1 update          0.0    2595052/2826240 0000
2 SRTImage        0.0     499648/499712  0000 227.0.131.0
3 factoryCfg      2.0      36864/36864   0001
4 SBIImage        0.0     278944/524288  0000 222.0.24.0
5 iSCSIboot       0.0      64096/69632   0010 221.0.109.0
6 CCM             0.0      63704/65536   0010 221.0.109.0
7 MBA             1.0     375072/376832  0010 227.0.133.0
8 Unknown[86]     0.0       8192/8192    0001
9 Unknown[84]     0.0       4144/8192    0000
10 SRTImage        1.0     499648/499712  0000 227.0.131.0
11 CRTImage        1.0    1392016/1392640 0000 227.0.131.0
12 VPD             0.0        324/4096    0000
13 pkgLog          0.0        648/4096    0000 227.1.111.0
14 SBIImage        1.0     278944/524288  0000 222.0.24.0
15 MBA             0.0     375072/376832  0010 227.0.133.0
16 systemCfg       0.0      36864/36864   0001
17 systemCfg       2.0      36864/36864   0001
18 CrashDmpData    0.0    1048576/1048576 0001
19 CrashDmpData    1.0    1048576/1048576 0001
20 factoryCfg      0.0      36864/36864   0001
21 CRTImage        0.0    1392016/1392640 0000 227.0.131.0

Device #2
---------
Device: enp61s0f0np0
item type          ord.ext    data/length  attr version
1 VPD             0.0        324/4096    0000
2 systemCfg       0.0      36864/36864   0001
3 pkgLog          0.0        568/4096    0000 227.1.111.0
4 SRTImage        0.0     499648/499712  0000 227.0.131.0
5 factoryCfg      0.0      36864/36864   0001
6 SBIImage        0.0     278944/524288  0000 222.0.24.0
7 iSCSIboot       0.0      64048/69632   0010 216.0.2.0
8 SRTImage        1.0     499648/499712  0000 227.0.131.0
9 CRTImage        0.0    1392016/1392640 0000 227.0.131.0
10 CCM             0.0      62264/65536   0010 216.0.49.1
11 Unknown[86]     0.0       8192/8192    0001
12 MBA             0.0     375072/376832  0010 227.0.133.0
13 SBIImage        1.0     278944/524288  0000 222.0.24.0
```

```
14 CrashDmpData    0.0   1048576/1048576 0001
15 CrashDmpData    1.0   1048576/1048576 0001
16 update          0.0   2593820/2596864 0001
17 Unknown[84]     0.0      4144/8192    0000
18 CRTImage        1.0   1392016/1392640 0000 227.0.131.0
19 factoryCfg      2.0     36864/36864   0001
20 systemCfg       2.0     36864/36864   0001
```

Intel

```
$ ethtool -i eno1
driver: i40e
version: 6.5.3-1-pve
firmware-version: 8.15 0x8000a3e0 1.2829.0
expansion-rom-version:
bus-info: 0000:19:00.0
supports-statistics: yes
supports-test: yes
supports-eeprom-access: yes
supports-register-dump: yes
supports-priv-flags: yes
```

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ABOUT PROXMOX

Proxmox Server Solutions GmbH is a software provider, dedicated to developing powerful and efficient open-source server solutions. The privately held company is based in Vienna (Europe).